

**N.S.BIBUTOV**

**TEXNIK  
MEXANIKA  
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**TOSHKENT - 2020 yil**

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*O'zbekiston Respublikasi Oliy va o'rta maxsus ta'lim vazirligi tomonidan  
o'quv yurtlarining 5320400 – Kimyoviy texnologiya,  
5321000– oziq - ovqat texnologiyasi bakalavriat ta'lim yo'nalishlari uchun  
o'quv qo'llanma sifatida tavsiya etilgan.*

**TOSHKENT - 2020 yil**

# O'QUV ADABIYOTLARI GRIFI

GUVOHNOMASI № 0301

O'zbekiston Respublikasi Oliy va o'rta maxsus ta'lim vazirligining 2006 yil "18" iyul dagi 166-buyrug'iga asosan \_\_\_\_\_

Bibutor

(muallifning familiyasi ismi-sharifi)

Salimovich

ning

3540040-Yengil sanoat mashinalari va jihozlari tayyorlov yo'nalishi

(ta'lim yo'nalishi, mutaxassisligi, ixtisosligi)

talabalari (o'quvchilari) uchun tavsiya etilgan

"Mexruk mexanikaga asoslangan amaliy mash-ruflar" nomli o'quv qo'llanmasi ga

(o'quv adabiyotining nomi va turi: darslik, o'quv qo'llanmasi)

O'zbekiston Respublikasi Vazirlar Mahkamasi tomonidan litsenziya berilgan nashriyotlarda nashr qilish uchun ruxsat berildi.



Vazir

[Signature]

R. Qosimov

Darslik Buxoro muxandislik - texnologiya instituti uslubiy kengashida  
(28.11. 2020 yil, 4 bayon ) qayta nashrga tavsiya etilgan.

Taqrizchilar: t.f.d. N.M.Murodov Toshkent irrigatsiya va qishloq  
xo'jaligini mexanizatsiyalash injenerlari instituti  
Buxoro filiali direktori, «Umumkasbiy fanlar»  
kafedrası professori

t.f.d. X.Q.Raxmonov–Buxoro muxandislik-texnologiya  
instituti “ Texnologiyalar va jihozlar ” kafedrası  
professori

«Texnik mexanika» - oliy o'quv yurtlarining kimyoviy va oziq-ovqat mahsulotlari texnologiyasi va boshqa texnologik yo'nalishlari bo'yicha ta'lim olayotgan bakalavrlarga umummuxandislik fanlarining asoslari – «Nazariy mexanika», «Mexanizm va mashinalar nazariyasi», «Materiallar qarshiligi», «Mashina detallari » da bayon qilinadigan – mexanizm va inshoot qismlarini kinematikasi, ta'sirlashuvi, mustahkamligi, yuritmalar, ko'tarish – tashish va tushirish mexanizmlarini hisoblash va loyihalash usullarini o'rganishda yordam beradi.

«Техническая механика» предназначена для подготовки бакалавров в высших учебных заведениях по направлениям пищевая технология и другие. Книга предус-матривает изучение основных разделов прикладной механики: «Теоретическая механика», «Теория механизмов и машин», «Сопротивление материалов» и «Детали машин», где излагаются закономерности расчета напряженно – кинематических соотношений и работоспособности деталей машин и сооружений.

«Applied mechanist» will help to the bachelors of higher institutions on specially of food technology to study the principles of general engineering in sphere of «Theoretical mechanics», «Theory of mechanisms and machines», «Material resistance», «Details of machine» It will help to learn the ways of projecting and calculating of mechanisms and constructive parts; kinematics; influencing, steadiness, gears, lifting – transporting and unloading mechanisms. “The aim of studying” the “applied mechanics” is to prepare students to their subjects on their specialty, to implement their knowledge as a technologist or investigator into practice.



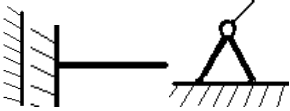
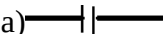
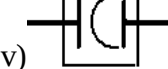
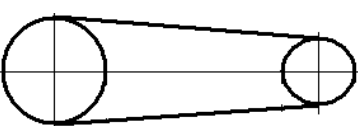
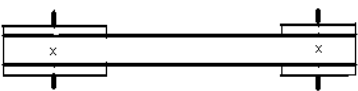
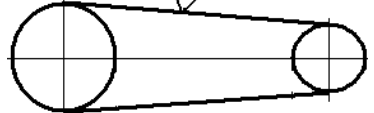
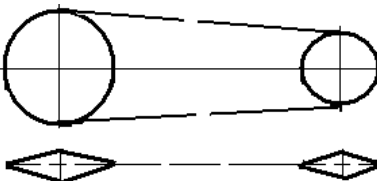
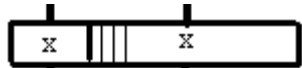
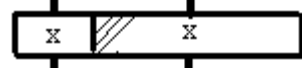
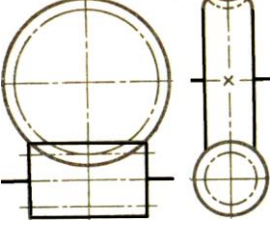
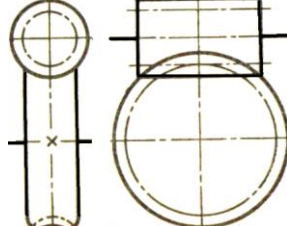
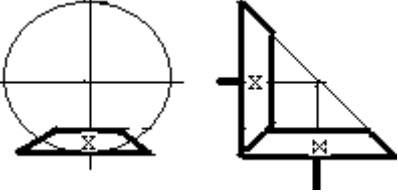
### Barcha misollar uchun umumiy ma'lumotlar

|                    |                                                           |                                  |
|--------------------|-----------------------------------------------------------|----------------------------------|
| UMUMIY MA'LUMOTLAR | Po'latning elastiklik moduli                              | $E = 2 \cdot 10^5 \text{ MPa}$   |
|                    | Alyuminiyning elastiklik moduli                           | $E = 0,7 \cdot 10^5 \text{ MPa}$ |
|                    | Cho'yanning elastiklik moduli                             | $E = 1,2 \cdot 10^5 \text{ MPa}$ |
|                    | Misning elastiklik moduli                                 | $E = 1 \cdot 10^5 \text{ MPa}$   |
|                    | Yog'ochning tolalari bo'ylab elastiklik moduli            | $E = 1 \cdot 10^4 \text{ MPa}$   |
|                    | Po'latning siljishdagi elastiklik moduli                  | $G = 8 \cdot 10^4 \text{ MPa}$   |
|                    | Po'latning temperaturaviy chiziqli kengayish koefitsienti | $\alpha = 125 \cdot 10^{-7}$     |
|                    | Misning temperaturaviy chiziqli kengayish koefitsienti    | $\alpha = 165 \cdot 10^{-7}$     |

### Ayrin materiallar uchun cho'zilish va siqilishda ruxsat etilgan kuchlanish

| Material                                                  | Ruxsat etilgan kuchlanish $\frac{\kappa \Gamma}{\text{cm}^2}$ |            |
|-----------------------------------------------------------|---------------------------------------------------------------|------------|
|                                                           | siqilish                                                      | cho'zilish |
| Qurilish uchun po'lat                                     | 1600                                                          | 1600       |
| Po'lat St.2                                               | 1400                                                          | 1400       |
| Sosna tola bo'ylab                                        | 100                                                           | 70         |
| Dub tola bo'ylab                                          | 130                                                           | 90         |
| Tekstolit                                                 | 500 - 900                                                     | 300 - 400  |
| Kul rang cho'yon                                          | 1200...1500                                                   |            |
| Beton $R = 110 \frac{\kappa \Gamma}{\text{cm}^2}$ markali | 38                                                            | 4,5        |
| Beton $R = 170 \frac{\kappa \Gamma}{\text{cm}^2}$ markali | 60                                                            | 7          |

Plastik materiallar uchun  $n = 1,2 \dots 1,8$ ; beton uchun  $n = 3$ , tosh uchun  $n = 10$ ; cho'yan uchun  $n = 2,5 \dots 3$  ga teng. Ehtiyotlik koefitsientini tanlashda mashinaning ahamiyati va ishlash muddatiga e'tibor beriladi. Masalan: qurilish sohasida  $n = 2 \dots 5$  va aviatsiya texnikasida  $n = 1,5 \dots 2$

|                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                             |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Mashina agregatlari kinematik sxemasining shartli belgilari</b></p>                                                                                                                                                                                                                | <br>Val, o'q, sterjen                                                                                                                                                                                                                                                                                                   | <br>Qo'zg'almas bo'g'in                                                                                                                                                                                                                                                                                                  |
| <p>a) </p> <p>b) </p> <p>Sirpanuvchi va dumalovchi podshipniklar:<br/> a) radial , radial- tirakli<br/> b) tirakli</p> | <p>a) </p> <p>b) </p> <p>v) </p> <p>Dumalash podshipniklari:<br/> a) radial; b) bir tomonlama radial– tirakli; v) ikki tomonlama radial - tirakli</p> | <p>a) </p> <p>b) </p> <p>v) </p> <p>Sirpanish podshipniklari<br/> a)radial; b) bir tomonlama radial–tirakli; v) ikki tomonlama radial- tirakli</p> |
| <p>a) </p> <p>b) </p> <p>v) </p>     | <p>Mufta:</p> <p>a) turi yo'q;<br/> b) elastik<br/> v)zanjirli</p>                                                                                                                                                                                                                                                                                                                                       | <p>Remenli uzatma</p> <br><br>Yassi remenli<br><br>Ponasimon remenli                                                                            |
| <p></p> <p>Motor ( elektrodvigatel)</p>                                                                                                                                                               | <br>Zanjirli uzatma                                                                                                                                                                                                                                                                                                  | <p>a) </p> <p>b) </p> <p>Tsilindrik tishli uzatma:<br/> a) to'g'ri tishli;<br/> b) qiyshiq tishli</p>                                                                                                                             |
| <p>Chervyakli uzatma: a) chervyak pastda; b) chervyak tepada</p>                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                             |
| <p>a) </p>                                                                                                                                                                                            | <p>b) </p>                                                                                                                                                                                                                                                                                                            | <br>Konussimon tishli uzatma                                                                                                                                                                                                                                                                                           |

## SO'Z BOSH

Oliy ta'lim muassasalarida o'qitilayotgan "Texnik mexanika" umummuxandislik fanlaridan biri bo'lib "Nazariy mexanika", "Materiallar qarshiligi", "Mexanizm va mashinalar nazariyasi" va "Mashina detallari" kabi alohida mustaqil fanlardan tashkil topgan. Amalda "Texnik mexanika" fanidan masalalar to'plami va mustaqil ish topshiriqlari ham bo'lmaganligi uchun amaliy mashg'ulotlarda turli adabiyotlardan foydalanib kelinmoqda.

Tavsiya etilayotgan "Texnik mexanika" dan amaliy mashg'ulotlar o'quv qo'llanmasi 5320400 - "Kimyoviy texnologiya" va "Oziq ovqat mahsulotlari texnologiyasi" bakalavriat ta'lim yo'nalishlarining o'quv rejasi va namunaviy dasturlari asosida yozildi.

«Oziq-ovqat texnologiyasi» va «Kimyoviy texnologiya» yo'nalishlarida ta'lim olayotgan talabalarga «Texnik mexanika» - o'qitiladi va «Nazariy mexanika», «Materiallar qarshiligi», «Mexanizm va mashinalar nazariyasi» va «Mashina detallari» fanlaridan tashkil topgan. «Texnik mexanika» ning tarkibiy qismlarini bunday ketma –ketlikda o'qitilishi birinchidan, uni qisqa va aniq, mazmunan to'lik bayon qilinishini taqozo qilsa; ikkinchidan undagi ayrim mavzularni takrorlanmasligini talab etadi.

Mashg'ulotlar to'plamini tuzishda har bir fanning o'z strukturasi va yo'nalishi saqlab qolindi. [1,2,3,4,5,6,7,8,9,10,11,12,21,22,23] adabiyotlardan foydalanildi.

Mazkur o'quv qo'llanmaning birinchi nashri "Texnik mexanikadan amaliy mashg'ulotlar" nomi bilan "Ilm ziyo" nashriyotida 2006 yil Toshkentda 196 b. da chop etilgan.

O'zbekiston Respublikasi Oliy va o'rta maxsus ta'lim vazirligi, «Iste'dod» jamg'armasining 2007 yil 5 – oktyabr №205-25-93 sonli qo'shma qaroriga asosan «Yilning eng yaxshi darsligi va o'quv adabiyoti muallifi» 2007 yil Respublika tanlovida umum-kasbiy fanlar bo'yicha «Texnik mexanikadan amaliy mashg'ulotlar» o'quv qo'llanmasi faxrli uchinchi o'rinni egalladi.

O'quv qo'llanmaning ikkinchi nashrida texnik mexanikadan amaliy mashg'ulotlarda echiladigan masalalar soni ko'paydi, texnik mexanikadan kurs loyihasini echish metodikasi hamda fanga tegishli tayanch so'zlar uchun glossariy keltirildi.

# KIRISH

Ushbu fan mashinasozlikni rivojlantirishida muhim o'rin tutib, talabalarga jismlarni kuchlar ta'siriga chidamligi, mashina va mexanizmlarini tuzilishi, kinematik va dinamik xarakteristikalarini hamda mashina detallarining mustahkamligi va ishga layoqatligini aniqlash masalalarini, texnika va texnologik jarayonlarni hisobga olgan holda yangi ilmiy masalalarni echish nihoyat darajada dolzarb muammo ekanligini o'rgatadi.

Sifatli maxsulot ishlab chiqaradigan mashinalarga ega bo'lish uchun ularni loyihalashda fan va texnikaning eng oxirgi va samarali yutuqlaridan unumli foydalanish kerak. Shuning uchun har bir muxandis loyihadagi mexanizm va mashinalarni tuzilishi, kinematikasi va dinamikasini va ularni mustahkamligini ta'minlashni bilishi kerak.

«Texnik mexanika»ni vazifasi talabalarga mos ravishda «Nazariy mexanika», «Materiallar qarshiligi», «Mashina va mexanizmlar nazariyasi», «Mashina detallari»ning asosiy qonuniyatlari, loyihalash jarayonidagi zaruriy hisoblashlarni bajarish usularini o'rgatishdan iborat.

«Texnik mexanika» fanini o'rganishdan maqsad talabalarni mutaxassislik fanlariga tayyorlash, shuningdek olgan bilimlarni ishlab chiqarishda texnolog yoki tadqiqotchi sifatida tadbqiq etishdan iboratdir.

## **Texnik mexanikadan amaliy mashg'ulotlar.**

**Misol echishning maqsadi.** Mexanizm, mashina va muxandislik inshootlarini mustahkamlikka, birklikka va ustuvorlikka hisoblash usullari bilan birga mexanik uzatmalarni loyihalash asoslarini o'rgatish texnik mexanikaning asosiy vazifasi hisoblanadi. Fanni o'rganishga ajratilgan vaqtning taxminan yarmi misollar echish uchun sarflanishi kerak. Ushbu vaqtni samarali sarflash uchun maqsadli misollarni tanlash, ularni ratsional echish usulini belgilash va albatta nazariy bilim tayyorgarligi bo'lishi lozim. Misol echishning maqsadi quyidagilardan tashkil topadi:

1. Fizik hodisalarni tushunish, mustaqil ijobiy ishlash, texnikaviy o'ylash va analiz qilish qobiliyatini rivojlantirish.
2. Amaliy savollarni echishda nazariy bilimlar yangiliklarini va ko'nikmalarini tadbqiq etish. Bu erda real konstruktsiyalardan nazariy izlanishlar usullari va hisoblashlarida qabul qilingan hamda ruxsat etilgan hisoblash sxemalariga o'tish tushuniladi.
3. O'rganilayotgan fandan olingan bilimlarni chuqurlashtirish va mustahkamlash.
4. Hisoblash texnikasini rivojlantirish.
5. Texnik adabiyot va ma'lumotlar bilan ishlashni rivojlantirish.
6. Texnik hisoblashlarni bajarish bilan tanishish.
7. Texnik savollarni echishda ustuvor qobiliyatni shakllantirish.



**Misollarni tanlash.** Qo'yilgan maqsadni amalga oshirishda auditoriyada yoki uyda echiladigan misollarni tanlash katta ahamiyatga ega.

Tanlangan misollar ushbu mavzuning barcha savollarini qamrab olishi kerak. Masalalarni tanlash va echish uchun ko'rsatilgan adabiyotlar talabalarga texnik mexanika muammolarini to'liqligicha o'rganish va echimini topishga yordam beradi. Bir qism savollar dars vaqtida o'rganilsa, ayrim savollar uyga vazifa tarkibida ko'rib chiqilishi mumkin.

Texnik mexanikaning tarkibiga kiruvchi fanlardan masalalar to'plamida ko'p variantli misollar ham keltirilgan. Bunday misollarni uy vazifasi yoki hisoblash-grafik ishi ko'rinishida bajarish qulaydir.

Misollarni mavzusi, ya'ni echilishi shart bo'lgan muammoni qo'yilishi murakkab emas. Lekin quyidagi fikrlarni keltirish lozim deb o'ylaymiz:

**Birinchidan,** bakalavrlar tayyorlaydigan oliy ta'lim muassasalarida nazariy (mutaxassislikka bog'liq) material to'liq va chuqur yoritilmasligi mumkin, ko'p vaqt talabalarning uy vazifasi yoki hisoblash-grafik ishiga yaqin mavzular bo'yicha misollar echiladi.

**Ikkinchidan,** ayrim vaqtlarda asosan nazariy materiallarga e'tibor beriladi va aniq bitta tahlil yoki ikkinchi formula bilan echiladigan misollar tahlil etiladi.

Tajriba shuni ko'rsatadiki, hajmi kichik yoki oddiy misollarni tanlash va nazariy materiallarni chuqur o'zlashtirmaslik natijasida, talaba tanish va oddiy misollar turkumiga o'rganib oladi va u murakkabroq misollardan hadiksirab qoladi. Masalan, materiallar qarshiligidan misol echishni mustaqil bajara olgan talaba mashina detallari fanidan misol echishda qiyinchilikka uchrab qolishi mumkin.

**Uchinchidan,** amaliy mashg'ulotlarda tadbiq etilmagan nazariy bilimlar chuqur va mustahkam emas. Bunday sharoitda talaba ham, o'qituvchi ham og'ir vaziyatda qoladi.

Misollarni murakkabligi yoki boshqa ko'rsatkichlarga binoan tanlash hamma vaqt ham samarali bo'lavermasligi mumkin. Shuning uchun misollarni quyidagi guruhlariga ajratishni tavsiya etamiz:

**I guruh.** Bu guruhdagi misollar hech qanday qiyinchilik tug'dirmaydi, hajmi kichik va oddiy bo'lib, maqsadi formulalarni takrorlash, turli o'lchov birlikdagi kattaliklar bilan hisoblashni o'rganish. Masalan, buralishda mustahkamlik shartidan foydalanib val diametrini aniqlang.

**II guruh.** Bu guruhdagi misollar oddiy, savolning fizik mohiyati va echish usuli aniq. Masalan, yuklanishni har xil turlarida statik aniq misollarda mustahkamlikka hisoblash. Bu guruhdagi misollarni ham murakkabligi turlicha bo'lgan misollarga ajratish mumkin. Masalan, cho'zilish yoki siqilishda ichki bo'ylama kuchni aniqlash va epyurasini ko'rish, egilish deformatsiyasida ko'ndalang kuch va eguvchi moment epyuralarini qurishdan ancha oson. Bundan tashqari, ko'ndalang kuch va eguvchi momentini aniqlash qoidasi, bo'ylama kuchni aniqlash qoidasidan mutlaqo farq qiladi va murakkabdir.

**III guruh.** Bu guruh misollarning murakkabligi turlicha bo'lib, ular mavzuga bog'liq. Masalan, statik noaniq misollarda murakkablik, misolni echishni

individuallashtirish va uning fizik-geometrik mohiyatini aniq tushunish va tasavvur etishdadir. Misolni individuallashtirish har bir statik noaniq misolni echishning o'ziga xos usulni tadbiiq etishligida. Bu guruh misollariga mo'rt materiallardan tayyorlangan balkalarni mustahkamlikka hisoblash, o'zgaruvchan balkalarda kesimni tanlash kiritilishi mumkin.

**IV guruh.** O'ta murakkab misollar bo'lib, ularni echish uchun nostandart usullar tadbiiq etiladi. Bunday misollarga fanlar olimpiadalaridagi yoki fan to'garaklarida echiladigan misollar kiritiladi.

**V guruh.** Og'zaki echiladigan misollar, hozirgi vaqtda tadbiiq etilayotgan oddiy ko'rinishdagi test savollari.

Misollarni tanlash to'g'risida mulohaza yuritganda shuni nazarda tutish kerakki, misollar rivojlanadigan, yangilik kiritilishi mumkin bo'lgan bo'lishi lozim. Juda katta matematik hisoblashlari bo'lgan misollarni tanlamaslik kerak. Chunki bunday misollarni echishda talaba matematik hisoblashga e'tiborini kuchaytirib, misolning fizik yoki geometrik mohiyatini esidan chiqarib qo'yishi mumkin.

**Auditoriyada misol echishni tashkillashtirish.** Misol echishning shakllari va ular to'g'risida qisqa fikr bildiramiz.

O'qituvchining o'zi misol echsa. Bu shakl fanning har bir mavzusida tadbiiq etiladi. O'qituvchi doskada mavzu bo'yicha birinchi misolni qanday echsa, talabalar ushbu yoki boshqa misolni echish usulini shunday tushunib oladi.

O'qituvchi misol shartini yozib olishdan va tushunishdan boshlab, uni echish usulini to'liq yoritishi, matematik hisoblashlarni bajarib, misol natijalarini analiz etish bilan tugatishi lozim. Misolni echishda o'qituvchi talabalarga savollar bilan murojaat qilib, ularni ham misol echishda qatnashayotganligini bildirishi va mustahkamlashi hamda bu vaziyatni talaba mustaqil misol echishida o'qituvchining uslubini takrorlanishini ta'minlashi lozim.

O'qituvchi talabada misol echishni ijobiy shakllantirishi kerak.

Doskada talaba misol echsa. Bu shakl to'liq o'qituvchining nazoratida bo'ladi va ayrim hollarda uning yordami seziladi. Bunda barcha talabalarning faolligi talab etiladi, ulardan misol echish tartibini tushuntirishni, hisoblash natijalarini tekshirishni talab etish kerak.

Talaba o'tirgan joyida misol echsa. Bu shakl albatta misol tahlil qilingan va u doskada talaba yoki o'qituvchi tomonidan ishlanayotgan bo'lsa, tadbiiq etiladi. Bunday paytda o'qituvchi talabalarning faoliyatini nazorat qilib turadi. Lekin ushbu shakl vaqtni kamligi uchun tadbiiq etilishi cheklangan.

Tajriba qurilmasidan foydalanib misol echish. Talaba nazariy misolni echadi va tajribada sinab ko'radi. Nazariy va tajriba natijalari solishtiriladi. Bu shakl katta ahamiyatga ega va u tajriba ishini o'tkazish darsidir. Uning samarasini oshirish uchun tajriba qurilmalari to'liq va benuqson ishlashi kerak.

**Misol shartini yozish va tahlil qilish.** Qo'yilgan maqsadga erishish uchun faqat misolni tanlash va uni echish emas, balki misolning shartini muhokama va tahlil qila bilish lozim. Bu esa talabaning texnik mushohada qilish qobiliyatini yaxshilaydi. Misol tariqasida shkiqlar o'rnatilgan transmission valni hisoblashni

olamiz. Terminni tushuntirish, tasmalarning taranglik kuchlari, ularning yo'nalishi va taranglik kuchlarining valga bosimi to'g'risida tushuncha berish lozim. Misolning amaliy mohiyati, balki hali o'rganilmagan mashina detallari fani asosida transmission vallarning qo'llanilish sohasi to'g'risida talabalarga ma'lumot berish usuli bilan, ularda misolga nisbatan qiziqish uyg'otiladi va bu holat misolni echishda o'z aksini topadi. Misolni echishda lozim bo'lgan ayrim qisqartirish va cheklanishlar hamda o'zgarishlarni talabalarga oldindan tushuntirish o'ta ahamiyatlidir.

Misol shartini muhokama qilish yoki tahlili ham rivojlanuvchan, ham tarbiyaviy xarakterga ega bo'lishi kerak. Masalan: mustahkamlikka ehtiyotlik koeffitsienti birlamchi qabul qilingan qiymatiga ko'ra 10% ga kamaytirilsa, balkaning og'irligi qanday o'zgaradi. Bu misolda ehtiyotlik koeffitsientini kamaytirish katta qurilishlarda qanday ahamiyatga ega ekanligini tushuntirish mumkin.

Misolni ortiqcha va etishmaydigan shartlari to'g'risida. Ayrim misollarda uni echish uchun kerak bo'lmagan, ya'ni ortiqcha shartlar berilgan bo'ladi. Masalan, buralishda mustahkamlikka hisoblanayotgan valning uzunligi yoki detalning materiali bilan birga ruxsat etilgan kuchlanishining qiymati berilgan.

Misolni shartida ortiqcha ma'lumot yoki qiymatlar berilishi foydalidir, chunki talabani o'ylab tahlil qilishga o'rgatadi, texnik muammoni echishda ular kerak emas, lekin konstruksiyani to'liq tasavvur qilish uchun hamda misol echish davomida talaba tegishli formulani izlab topishida ushbu ma'lumot samara beradi.

Ayrim hollarda to'liq ma'lumot bo'lmagani ma'qul, chunki real loyihalashda konstruktorning o'zi bir qancha kerak bo'lgan ma'lumotlarni tanlashini talaba bilib oladi. Bunday misollar mashina detallari fanida uchraydi. Materiallar qarshiligida qo'shimcha ma'lumotlarni kitoblardan qidirib topiladi. Bunda yuklanish xarakteri va material ko'rsatilgan, lekin ruxsat etilgan kuchlanish berilmagan. Masalan, ichi g'ovak valning uzatayotgan quvvati va uning aylanish chastotasi berilgan. Valning diametri hisoblansin. Buning uchun valning o'rtacha diametrini, uning ichki va tashqi diametrlari bilan tashkil qilgan nisbatidan foydalaniladi.

Misolni faqat sharti ahamiyatli deb tushunmaslik kerak, balki uni to'liq ma'nosini saqlagan holda qisqa yozish kerakki, talaba har daqiqa to'liq shartni tiklay olsun. Kitobda misolning sharti to'liq yozilganligi uchun, uni yozish shart emas deyish noto'g'ri. Ayrim hollarda yozish elementi deb, sxema yoki chizmani tuzish tushuniladi. Eng yomon holat chizmani yozuv asosida tushuntirish yoki uning mazmunini yoritish. Oddiy misollarda shartni o'qib, uni yozib (doskada yoki daftarda) talaba tegishli chizmani bajara olishi kerak. Murakkab misollarda bu savolni echimi juda qiyinlashadi. Chizmalarda o'lchamlarning shartli belgilarini berilishi yozuvni qisqartiradi. Konstruktiv yoki yarim konstruktiv sxemalardan hisoblash sxemalariga o'tish yozuv asosida emas, balki misolni echish elementi sifatida bajariladi. Masalan, valni buralish bilan egilishga hisoblash.

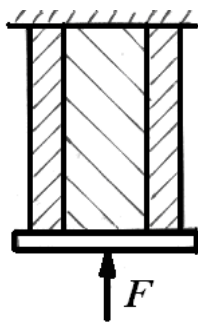
**Misol echish usulining asosiy tamoyillari.** Auditoriyada o'qituvchi yoki talaba tomonidan misol echishni asosiy tamoyillariga: shartni yozish, misol echishni yozishning shakli va ketma-ketligi, hisoblash ishlarining bajarilishiga

rioya qilishlari kerak.

Ushbu uslubiy tamoyillar ketma-ket va astoydil bajarilishi kerakki, natijada talaba uyda yoki doskada misolni mustaqil echishda quyida keltiriladigan uslubiy ko'rsatmani tadbiq etsin.

Misolni sharti yozilgan va tahlil qilingan vaziyat uchun quyidagi uslubiy tamoyillarni keltiramiz:

1. Misol «sifatli echilgan» bo'lishi kerak. Misolni echish boshlanishida, talabada «Qaysi formula bilan misolni echish mumkin» degan savol paydo bo'ladi. Agar bu savolni talabaga o'qituvchi bersa, eng yomon vaziyat sodir bo'ladi. «Sifatli echilgan» misol deganda, mohiyati tahlil qilingan va echish tartibi so'zma-so'z izohlangan misol, formula esa bildirilgan fikrning matematik ifodalanishi va u tegishli hisoblashlardan keyin sonli echimga olib keladi.



**misol.** Siquvchi  $F$  kuch po'lat va bronza sterjenlarga  $\Pi$ -detali orqali ta'sir qiladi. Sterjen ko'ndalang kesimining o'lchamlari topilsin ( $A_p = 2A_b$ ).

Po'lat va bronza materiallarining elastiklik modullari bir xil emas, ya'ni po'lat materialining elastiklik moduli  $E_p$ , bronza materialining elastiklik moduli  $E_b$  dan katta. Demak, po'lat sterjen bo'lmaganida bronza sterjeni  $F$  kuch ta'siridan ko'proq siqilar edi. Lekin ikkita

sterjenlar ham bir xil uzayadi.  $F$ - siquvchi kuchning har kaysi sterjenga ta'sirini topish uchun bitta tenglama tuzish mumkin:  $F_\sigma + F_n = F$  Bitta tenglamada ikkita noma'lum kuch bor. Demak, misol statik noaniq.  $F_b$  va  $F_p$  kuchlarni topish uchun qo'shimcha deformatsiya tenglamasini tuzamiz. Tashqi siquvchi kuch ta'sirida har ikkala sterjen ham bir xil masofaga siqiladi. Guk qonuniga asosan:

$$\Delta \ell = \frac{F_\sigma \ell}{E_\sigma A_\sigma} = \frac{F_n \ell}{E_n A_n}$$

Endi muvozanat va deformatsiya tenglamalarini birgalikda echib, misolning shartiga tegishli savollariga javob topiladi.

2. Misol umumiy holda echilgandan keyin matematik hisoblashga o'tamiz. Hisoblash bandma-band ketma-ketlikda olib boriladi va har bir band uchun oldindan hisoblanishi lozim bo'lgan formula belgilanadi, hisoblash natijalari alohida ajratib yoziladi.

Murakkab va hajmi katta matematik hisoblashni bajarishda yordamchi hisoblashlar olib boriladi. Yordamchi hisoblashlar umumiyashtiriladi (mujassamlashadi) va sonli natijaviy qiymat kelib chiqadi.

Bu erda misol echishni usuli va uni tashkil etish muammosi to'g'risida to'xtalib o'tamiz. Gap shundaki, mustaqil misol echishda talabalarni birdaniga oq varaqda (chernoviksiz) bajarishga o'rgatish kerak, chunki birlamchi hisoblash qora qog'ozda (chernovik) bajarilsa, ortiqcha vaqt va ish talab etiladi. Formulaga barcha kattaliklarning son qiymatlarini qo'yishdan oldin, ularning o'lchov birliklarini bir xil sistemaga keltirilishi lozim. Buni og'zaki bajarish kerak. Masalan, 100 kN kuch

bilan cho'zilayotgan sterjenning uzayishi aniqlansin, agar  $l = 2m, d = 60mm$   
 $E = 2 \cdot 10^5 mPa$  bo'lsa, hisoblash formulasi

$$\Delta l = \frac{N \cdot l}{EA} \text{ ni } \Delta l = \frac{100000 H \cdot 2m}{2 \cdot 10^{11} Pa \left( 3,14 \cdot \frac{0,06^2}{4} \right) m^2} - \text{ko'rinishda yozmaslik kerak.}$$

$$\text{To'g'ri yozuv } \Delta l = \frac{100 \cdot 10^3 \cdot 2}{2 \cdot 10^5 \cdot 10^6 \cdot \frac{3,14 \cdot (60 \cdot 10^{-3})^2}{4}} = 0,354m$$

Sterjen kesim yuzasini alohida hisoblash shart emas, vaholanki, ayrim hollarda, masalan, murakkab shaklli kesim yuzalarining geometrik xarakteristiklari alohida hisoblanib, natijasini formulaga keltirib qo'yish mumkin. Hisoblash jarayoniga juda katta e'tibor berish bilan birga quyidagilarga amal qilish lozim:

- hisoblash natijasini juda katta aniqlik bilan yakunlashni izidan quvlaslik. Bunga o'zingizni ham talabalarni ham o'rgatish kerak. Xususiyl hollarda verguldan keyin uch xonali aniqlik bilan hisoblash amalini bajarish lozim. Asosan, yaxlitlash va yaqinroq rakamlar hisoblansa bo'ladi;

- talabalarni og'zaki hisoblashga o'rgatish kerak;
- olingan natijalarni tahlil qilishni, ularni to'g'ri ekanligini muhokama etishni o'rgatish lozim;

- hisoblash amaliga rioya qilish, ya'ni kasrni surati va maxrajini ketma-ketlikda bajarish kerak.

Hisoblashni aniqlik bilan bajarilishiga izoh berish talab etilishi mumkin. Masalan, cho'zilish yoki siqilish, egilish deformatsiyalarida statik noaniq misollarni echishda tayanch nuqtalardagi deformatsiyalarni nolga teng bo'lishini keltirib chiqarishda, nazariy hisoblash va tajriba ishlarining natijalarini taqqoslashda aniq hisoblash natijasiga erishish talab etiladi. Chunki noaniqlik bilan bajarilgan hisoblash natijasi xatolikni olib keladi.

3. Misol echimining sonli qiymatlari hisoblash natijasiga ko'ra, uni xulosa qilishni talab etadi.

Natijani tekshirish va tahlili quyidagilardan tashkil topadi:

a) echimni to'g'ri va aniqligini baholash, talabaga texnik misollarni echishni va ularning natijalarini baholashni, ayrim hollarda, tanqidiy mushohada yuritishni o'rgatadi;

b) echimni nazorat etish usullarini ishlab chiqish va mushohada qilish. Masalan, ko'ndalang kuch va eguvchi moment epyurlari asosida ular orasidagi differentsial bog'lanishlarni bajarilishi nazorati. Agar misol mustahkamlikni tekshirish nuqtai nazaridan olib borilayotgan bo'lsa, ichki kuch faktorlarining epyuralari va differentsial bog'lanishlarini tekshirishni misol echimining natijasini kutib o'tirmasdan, balki epyura qurilishi bilan amalga oshirilishi kerak;

v) nazariy, amaliy va texnik qoidalarni tahlil qilish nuqtai nazaridan echimni mushohadasi. Masalan, val minutiga  $n$  marotaba aylanib  $N, K$  va  $i$  quvvatni

uzatadi. Berilgan ruxsat etilgan kuchlanishdan foydalanib, val kesimining uch xil shakli topilsin: aylana, halqa ( $c = \frac{d_o}{d}$  berilgan), kvadrat; har bir valning massalari solishtirilsin. Agar valning markaziy kesimidagi materialini olib, uning og'irligini 16% kamaytirsak, hosil bo'lgan halqasimon kesimning sirtidagi eng katta kuchlanish 26% oshar ekan. Radiusi  $R=350 \text{ mm}$  bo'lgan halqasimon val radiusi  $R=300 \text{ mm}$  bo'lgan valdan 53,4 % ga engildir. Shunga qaramasdan halqasimon kesim kam ishlatiladi. Kvadrat kesimli val ishlatilmaydi. Bu erda ishlatilmaslik mustahkamlik va texnologik nuqtai nazardan isbotlanmoqda;

g) ayrim detal va o'lchamlarni standartlashtirilishini esdan chiqarmaslik kerak. Natijaviy qiymatlarni yaxlitlamasdan va GOST bilan solishtirmasdan qabul qilmaslik kerak. Masalan, valning diametri  $d=44,2 \text{ mm}$ , GOST bo'yicha  $d=45 \text{ mm}$  qabul qilamiz.

Yuqorida keltirilgan mulohazalar, shak-shubhasiz «Texnik mexanika» fanida misol echish usullarini to'liq kamrab olmaydi. Ma'lumki, har bir misolni echishda o'zining xususiy usullarini tadbqiq etishni talab etadi. Shuning uchun o'qituvchilar fanning alohida bo'limlarida misol echish usullarini ishlab chiqishlari va tadbqiq etishlari mumkin.

## 2. Mustaqil ish mashg'ulotlarini tashkil etish va o'tkazish

**Mustaqil ishini tashkil etishning maqsad va vazifalari.** Talaba mustaqil ishini tashkil etishdan asosiy maqsad:

- o'qituvchining rahbarligi va nazorati ostida talabada muayyan o'quv ishlarini mustaqil ravishda bajarish uchun zarur bo'lgan bilim va ko'nikmalarni shakllantirish va rivojlantirish;
- talabalarda dialektik dunyoqarashni tarkib toptirish;
- tahsil oluvchilarning o'quv-bilish faolligi va mustaqilligini tarkib toptirish; ta'lim-tarbiya jarayonini maqbullashtirish;
- predmetlararo aloqadorlikni ta'minlash;
- ta'lim va tarbiya jarayonini individuallashtirish;
- fan-texnika taraqqiyotini jadallashtirish talablari asosida kasbiy tayyorgarlikni takomillashtirish;
- fanlar va kasblarning majmuaviy uslubiy ta'minlanishi;
- darsning samaradorligini oshirish yo'llari;
- yangi pedagogik texnologiyalarni joriy etish;
- ta'lim-tarbiya jarayonini faollashtirish.

Talabaning mustaqil ishi o'quv rejasida muayyan fanni o'zlashtirish uchun belgilangan o'quv ishlarining ajralmas qismi bo'lib, u uslubiy va axborot resurslari jihatidan ta'minlanadi hamda bajarilishi reyting tizimi talablari asosida nazorat qilinadi. Talaba mustaqil ishini vazifalari quyidagilardan iborat:

- yangi bilimlarni mustaqil tarzda puxta o'zlashtirish ko'nikmalariga ega bo'lish;



- kerakli ma'lumotlarni izlab topishning qulay usullari va vositalarini aniqlash;
- axborot manbalari va manzillaridan samarali foydalanish;
- an'anaviy o'quv va ilmiy adabiyotlar, me'yoriy hujjatlar bilan ishlash;
- elektron o'quv adabiyotlar va ma'lumotlar bilan ishlash;
- internet tarmog'idan ratsional echimini belgilash;
- ma'lumotlar bazasini tahlil etish;
- topshiriqlarni bajarishda tizimli va ijodiy yondoshish;

**Mustaqil ishning tashkiliy shakllari va turlari.** Talaba mustaqil ishini tashkil etishda muayyan fanning xususiyatlari, shuningdek, har bir talabaning o'zlashtirish darajasi va qobiliyatini hisobga olgan holda quyidagi shakllardan foydalaniladi.

- ayrim nazariy mavzularni o'quv adabiyotlari yordamida mustaqil o'zlashtirish;
- berilgan mavzu bo'yicha axborot (referat) tayyorlash;
- seminarlar va amaliy mashg'ulotlarga tayyorgarlik ko'rish;
- laboratoriya ishlarini bajarishga tayyorgarlik ko'rish;
- loyihalar va amaliy topshiriqlarni bajarish;
- maket, model va namunalar yaratish;
- hisoblashlar va grafik ishlarni bajarish;
- berilgan mavzu bo'yicha kompyuterlardan kerakli ma'lumotlarni mustaqil izlab topish va referat tayyorlash;
- elektron darsliklardan foydalanib topshiriqlarni bajarish.

O'qitilayotgan fanning xususiyatlaridan kelib chiqqan holda, talaba mustaqil ishini tashkil etishda boshqa shakllardan ham foydalanilishi mumkin. O'quv dasturlarida talaba mustaqil ishining shakli, mazmuni va hajmi ifoda etiladi. Talaba mustaqil ishi uchun ajratilgan vaqt byudjetiga mos ravishda, har bir fan bo'yicha tegishli bo'limlarda mustaqil ishning tashkiliy shakllari, savollar va topshiriqlar majmui ishlab chiqiladi. Mustaqil ishni bajarish uchun fanlar bo'yicha talabalarga zaruriy uslubiy ko'rsatma va tavsiyalar tayyorlanadi.

Og'zaki mustaqil topshiriqlar:

-darslik bo'yicha materialni o'rganish va takrorlash, chizmalar va sxemalarni o'qish, turli texnik adabiyotlar, hujjatlar va materiallarni o'rganish asosida o'qituvchi savollariga javoblar tayyorlash, ishlab chiqarish faoliyati tahlili kabilar kiradi. Materiallarni anglab mustahkamlash va yodlashga mo'ljallangan.

Yozma mustaqil topshiriqlar:

-hisoblash uchun berilgan vazifalarni bajarish, umumlashtiruvchi va takrorlanuvchi jadvallarni to'ldirish, laboratoriya, amaliy ishlar to'g'risida hisobotlar tuzish va shunga o'xshash vazifalarni o'z ichiga oladi.

Grafik mustaqil topshiriqlar:

- ularga turli chizmachilik ishlarini eskizlashtirish, kesmalar va kesishmalarni tasvirlash, sxemalar, grafiklar, diagrammalarni tuzish, kuzatish natijalarini tasvirlash va shunga o'xshash vazifalarni o'z ichiga oladi.

Amaliy xarakterdagi mustaqil topshiriqlar:

- talabalar o'qituvchi topshirig'i asosida mustaqil ishni bajarish jarayonida ma'lum maket va modellar, namunalarni tayyorlash kabi ishlarni amalga oshiradilar.

**Mustaqil ishlarni tashkil etish va o'tkazish.** Har bir fan bo'yicha talaba mustaqil ishiga rahbarlik qilish yuklamasi o'qituvchi shaxsiy ish rejasida qayd etiladi.

Mustaqil ishlarni samarali tashkil etish uchun quyidagilarga asosiy e'tiborni qaratish kerak:

- ta'lim, tarbiya va rivojlantirish maqsadlarining birligi, umumilmiy, umumkasbiy va maxsus tayyorgarlikning uzviyligini ta'minlash;
- ilg'or pedagogik va ishlab chiqarish tajribalarini, fan va texnika yutuqlarini o'rganish, umumlashtirish hamda ta'lim-tarbiya jarayoniga joriy etishdan iborat.

Mustaqil ishlarda ishtirok etish barcha rahbarlar, o'qituvchilar, muhandis-pedagoglar pedagogik faoliyatini ajralmas qismi hisoblanadi. Mustaqil ishlarning mazmuni Oliy va o'rta maxsus ta'lim vazirligi tomonidan tasdiqlangan mustaqil ishlar to'g'risidagi Nizom bilan belgilanadi.

**Mustaqil ish topshiriqlari.** *Uyga vazifa.* Talabalarni uyga vazifasi besh xil ko'rinishda bo'ladi.

1. Ma'ruza yoki mustaqil tayyorgarlik davomida o'tilgan nazariy materiallarni o'rganish va tajriba ishiga tayyorgarlik topshiriqlari.

2. Hisoblash-grafik topshiriqlari.

3. Kurs loyixasi

Tabiiyki, har bir darsdan keyin nazariy materialni darslikdan o'zlashtirish uchun talabaga uyga vazifa beriladi. Takrorlash konspekt xarakteriga ko'ra, uni uyda yozish, yoki yozilgan konspektni darslikdan to'ldirish, yoki darslikdan materialni o'qish topshiriladi.

Ayrim mavzularni darsda o'tmaslik mumkin, bu vaziyatda uni talabalarga mustaqil ish sifatida uyga vazifa beriladi. Gohida o'tilgan mavzu yoki amaliy mashg'ulotdan keyin uyda mustaqil echish uchun misollar berilishi mumkin. Tajribalar shuni ko'rsatadiki, texnik mexanikani o'rganish uchun talaba o'rtacha hisoblash-grafik ishidan tashqari ancha misol echishi kerak. Uy vazifasi tarkibiga kiruvchi misollar matematik hisoblashlarining hajmi uncha katta bo'lmasligi shart. Masalan, cho'zilish yoki siqilishdagi ayrim oddiy statik noaniq sistemalar, buralish va egilish deformatsiyalarida ichki kuch faktorlarini aniqlash, oddiy birikmalarni hisoblash. Uyga vazifa sifatida kitobda ishlash usuli ko'rsatilgan misolni tahlil qilish ham topshirilsa bo'ladi. Bunday vaziyatda talaba ushbu misolni daftarga konspektlashtiradi.

Uyga vazifani hamma turlari talabada mustaqil ishni bajarishga puxta zamin tayyorlaydi va uning samarasi beqiyosdir.

**Kurs loyihasi.** Kurs loyihasining asosiy maqsadi – talabalarning shu fan bo'yicha o'zlashtirgan bilimlarini mustahkamlash, ularni mustaqil ravishda

mashina va qurilmalarni loyihalash qobiliyatlarini shakllantirishdan iborat.

### **Kurs loyixasining tarkibi**

*Mashina va mexanizmlar nazariyasi fani buyicha:*

Besh bo'g'inli mexanizmni strukturaviy va kinematikaviy taxlili

*Mashina detallari fani buyicha:*

- Osma konveyer uchun yuritma
- Lentali konveyer uchun yuritma
- Shtampovkadan keyin galtovka qiladigan barani uchun yuritma
- Skrebokli konveyer uchun yuritma
- Shnekli qorishtirma uchun yuritma
- Elektrik lebedka uchun yuritma
- Aralashtirgich uchun yuritma
- Osma konveyer yuritmasi
- Kovshli elevator yuritmasi

### **3.Ta'lim muassasasidan tashqari mashg'ulotlar.**

**Fan to'garaklari.** Talabalarga o'quv-tarbiyaviy ishni olib borishni samarali shakli-fan to'garaklari, shu jumladan, texnik mexanikadan to'garak. Texnik mexanikadan to'garaklarda ikki yo'nalishda ish olib borilishi mumkin:

1) qo'shimcha materiallarni o'rganish, dokladlar tayyorlash, murakkab misollarni echish, turli konstruktsiyalarni loyihalash asoslarini tadbqiq etish;

2) turli tajriba qurilmalarini tayyorlash, qo'shimcha tajriba ishlarini o'tkazish.

Shunday qilib, birinchi yo'nalish nazariy va ikkinchisi tajribaviy edi. Qaysi yo'nalishni tanlash bilan birga o'qituvchi yoki to'garak a'zolarining qiziqishi va texnik holatiga bog'liq. To'garakda amaliy jihatdan - ishlab chiqarishda mavjud mexanizm, mashina va muhandislik inshootlarining mustahkamligi va bikirligini hisoblash hamda loyihalash asoslarini va etaplarini tahlil etish mumkin shuningdek, bir misolni bir necha usulda echishni o'rganish mumkin. Masalan, Mor usuli bilan cho'zilish va siqilishda, buralishda, egilishda statik noaniq masalalarni echish, egilishda ko'chishni boshlang'ich parametrlar usuli, grafoanalitik usul yoki Mor usuli bilan aniqlash va h.k.

To'garakda fakultativ dars ko'rinishidagi qisqa ma'ruzalar (15-20 soat) o'qilishi mumkin. Ma'ruzaning mavzusi talabaning bilimini chuqurlashtiradi hamda ularning mutaxassisligiga bog'liq bo'ladi. Ayrim hollarda maxsus fanlarda uchraydigan mustahkamlikka hisoblashni isbotlash asoslari o'rganilishi mumkin.

Fakultativ darsning taxminiy tematikasi:

1. Mexanika tarixiga oid mavzular;
2. Turli shaklli kesim yuzalarining og'irlik markazlari, inertsia va qarshilik momentlari.
3. Lame formulasi: ichki va tashqi bosim ta'sirida ochiq va yopiq qalin devorli tsilindrni hisoblash; yuqori devorli aylanuvchi qobiqlar.

4. Kuch usulining kanonik tenglamasi, statik noaniq balka va ramalarni hisoblash.
5. Oddiy tirsakli valni hisoblash va loyihalash asoslari (misol).

#### 4. Talabalar bilimi va ko'nikmalarini nazorat qilish va baholash

Talabalar bilimini nazorat qilish va baholashning reyting tizimi  
O'ZBEKISTON RESPUBLIKASI OLIY VA O'RTA MAXSUS TA'LIM  
VAZIRINING 2018 yil 9 avgustdagi "Oliy ta'lim muassa-salarida talabalar bilimini nazorat qilish va baholashning reyting tizimi to'g'risidagi Nizom" haqidagi 19–2018 sonli buyruqi asosida olib boriladi.

Talabaning fan bo'yicha o'zlashtirishini baholashda quyidagi namunaviy mezonlardan foydalanish mumkin:

|                                                                                                                                                                                                                                          |                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>5 (a'lo) baho</b><br>xulosa va qaror qabul qili<br>ijodiy fikrlay olish<br>mustaqil mushog'ada yurita olish<br>olgan bilimlarini amalda qo'llay olish, mohiyatini tushunish bilish, ifodalash, aytib berish<br>tasavvurga ega bo'lish | <b>4 (yaxshi) baho</b><br>mustaqil mushog'ada yurita olish<br>olgan bilimlarini amalda qo'llay olish<br>mohiyatini tushunish bilish, ifodalash, aytib berish<br>tasavvurga ega bo'lish |
| <b>3 (qoniqarli) baho</b><br>mohiyatini tushunish<br>bilish, ifodalash, aytib berish<br>tasavvurga ega bo'lish                                                                                                                           | <b>2 (qoniqarsiz) baho</b><br>dasturni o'zlashtirmaganlik<br>fanning mohiyatini bilmaslik<br>mustaqil fikrlay olmaslik                                                                 |

#### 5. Loyihalash va konstruktsiyalash to'g'risida ma'lumot.

Yaratiladigan mashina ishlab chiqarish talablariga javob berishi, yuqori iqtisodiy samara va ekspluatatsiya ko'rsatkichlariga ega bo'lishi lozim.

Mexanizm, mashina va muxandislik inshootlariga qo'yiladigan ishga layoqatlilik, mustahkamlik, bikrlilik, ustuvorlik, issiqbardoshlik, tejamliligi, oddiyligi va davlat standartiga moyilligi kabi barcha talablar hisobga olingan holda konstruktsiya qismlarini loyihasi tuziladi. Loyihalash bir necha etapda bajariladi:

1. **Eskizli loyihalash** – bo'lajak mashinaga tushadigan kuchlarni hisobga olgan holda konstruktor mashina yoki inshoot qismlarining o'lchamlarini hisoblaydi va tanlaydi;

2. **Texnik loyihalash** – hisoblashlar asosida mashina umumiy ko'rinishining chizmasi tuziladi.

3. **Ishchi loyiha** – tekshirilgan va oxirgi hisoblashlar asosida mashinaning alohida detallari va mexanizmlari umumiy ko'rinishining chizmasi tayyorlanadi; ishchi loyiha mashinani yig'ish uchun kerak bo'lgan barcha ma'lumotlarga ega bo'ladi.

Mashinaga qo'yilgan talablarni hammasi loyihalash va konstruksiyalash jarayonida e'tiborga olinadi.

**Loyihalash**—buyumni umumiy konstruksiyasini ishlab chiqish

**Konstruksiyalash**—printsipial sxemadan real konstruksiyaga o'tish uchun barcha savollarga ketma-ket javob berish (ishlab chiqish )

**Loyiha** – loyihalash va konstruksiyalash natijasida hosil bo'ladigan hujjat.

**Loyihaga texnik topshiriq**—yaratiladigan konstruksiyaning vazifasi va ekspluatatsiya qilish, ishlash rejimi, uning asosiy xarakteristikalariga ( geometrik, yuklanish va kinematik ) qo'yiladigan talablarni ishlab chiqish.

**Eskizli loyiha**—bir necha variantda bajarilishi mumkin, bunda to'liq va aniq hisoblash asosidagi tahlili bajariladi va eng qulay variant qabul qilinadi.

**Texnik loyiha** – optimal eskizli loyiha variantini konstruktiv ishlab chiqish va ayrim aniqlashtirilgan o'zgartirishlar kiritish. Ishchi hujjatlashtirish—konstruksiyalashni oxirgi etapi, barcha detallarni va yig'ma birliklar ishlab chiqarish uchun chizmalarni tayyorlash

# I-BOB. NAZARIY MEXANIKA

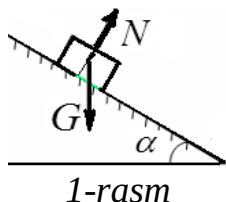
## STATIKA

Statikada absolyut qattiq jism o'rganiladi. Statikada kuch masalasi o'rganiladi: jismga ta'sir qiluvchi kuchlar sistemasini oddiy ko'rinishga keltirish va ixtiyoriy kuchlar sistemasi ta'siridagi jismning muvozanat shartlarini tuzish.

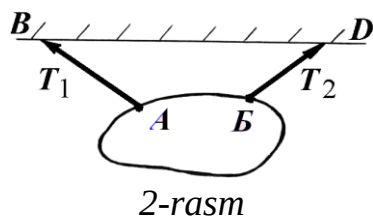
Statikada erkin bo'lmagan qattiq jismlarning muvozanati kuch aksiomalari asosida tekshiriladi. Har qanday erkin bo'lmagan qattiq jismda, agar bog'lanish yo'qotilib uning ta'siri ushbu bog'lanish reaksiya kuchining ta'siri bilan almashtirilsa erkin jism deb qaralishi mumkin. Bu aksioma bog'lanishlar aksiomasi deyiladi.

**Bog'lanishlar aksiomasi.** *Jism yoki jismlar muvozanatini o'zgartirmasdan, bog'lanishlarning berilgan jismga ta'sirini reaksiya kuchi bilan almashtirib, har qanday bog'lanishdagi jismni erkin jism deb qarash mumkin.* Texnik mexanikada misol echishda quyidagi bog'lanish turlarini o'rganamiz:

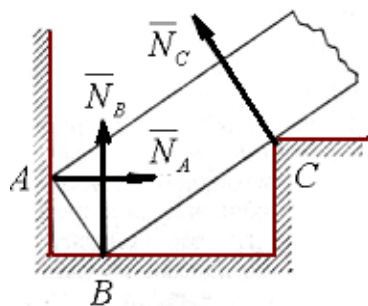
**Silliq qo'zg'almas tekislik.** Jism silliq qo'zg'almas tekislik ustida muvozanatda tursa, yoki shu tekislikka nisbatan harakatlansa, silliq qo'zg'almas tekislik jismni tekislikka perpendikulyar yo'nalishda harakat qilishiga to'sqinlik qiladi.



Silliq qo'zg'almas tekislikning reaksiya kuchi  $N$  tekislikka perpendikulyar bo'lib, jism qaysi tomonga harakat qila olmasa, shunga teskari tomonga yo'nalgan bo'ladi (1-rasm). Agar sirt silliq bo'lmasa sirt bilan tekislikning tegishish nuqtasida normal va urinma reaksiya kuchlari hosil bo'ladi.



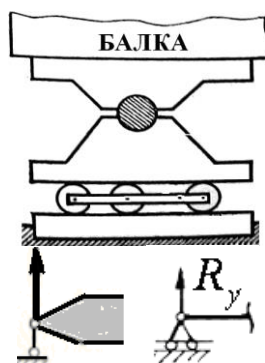
**Egiluvchan yoki elastik jismlar.** Jismlar cho'zilmaydigan ip, tros, zanjir vositasida osilgan bo'lsa, ularda hosil bo'ladigan reaksiya kuchlari mos ravishda egiluvchan jismlar bo'ylab yo'naladi.  $T_1$  va  $T_2$ -taranglik kuchlari (2-rasm)



Balka A nuqtada vertikal devorga, V nuqtada silliq polga va S nuqtada ikki yoqli burchak qirrasiga tayanadi. Pol va vertikal devorning reaksiya kuchlari, A va V nuqtalarda mos ravishda pol va devorga o'tkazilgan perpendikulyar bo'yicha yo'naladi, ikki yoqli burchakdan tashkil topgan qirraning reaksiya kuchi S nuqtada balkaning o'qiga o'tkazilgan perpendikulyar bo'yicha yo'naladi (3-rasm)

**Sharnirli tayanchlar to'g'risida tushuncha**  
Sharnirli tayanchlar ko'priksizlik va qurilish konstruksiyalarida, mashina va mexanizmlarda keng qo'llaniladi. Uch xil sharnirli tayanch turlari mavjud:

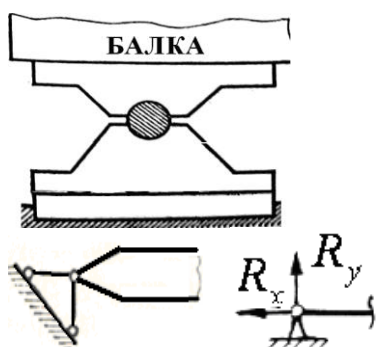
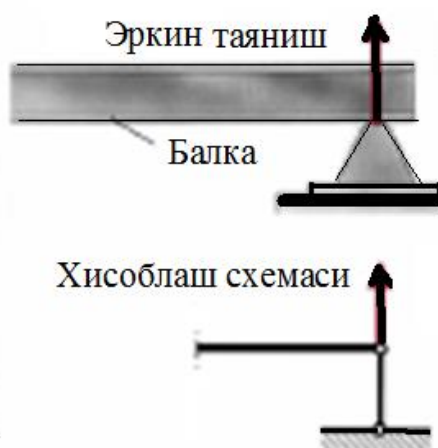
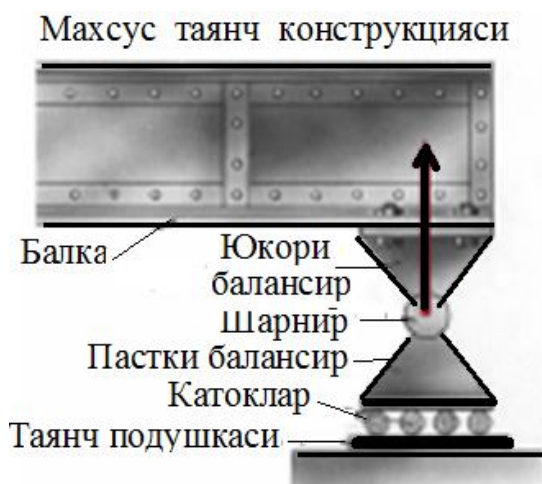
1. Qo'zg'aluvchan sharnirli tayanch.
2. Qo'zg'almas sharnirli tayanch.
3. Biki mahkamlangan tayanch.



4-rasm. Qo'zg'aluvchan sharnirli tayanch

1) **qo'zg'aluvchi sharnirli tayanch**, sterjenning tayanch kesimini sharnir uqi atrofida aylanish burchagini va sterjenning gorizontal tekislikdagi harakatini cheklamaydi. Bir chiziqli bog'lanish yoki qo'zg'aluvchan sharnirli tayanch, bog'lanish tekisligida tayanch nuqtasining harakatini cheklaydi. Tayanch kesim ikkita erkinlik darajaga ega, bitta reaksiya hosil bo'ladi

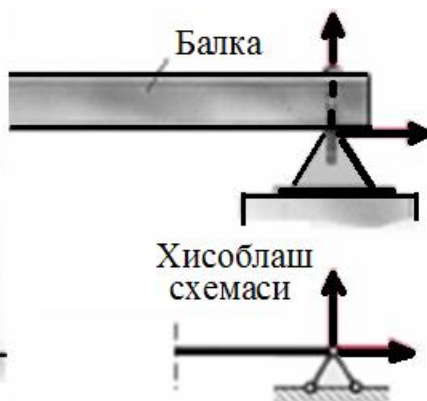
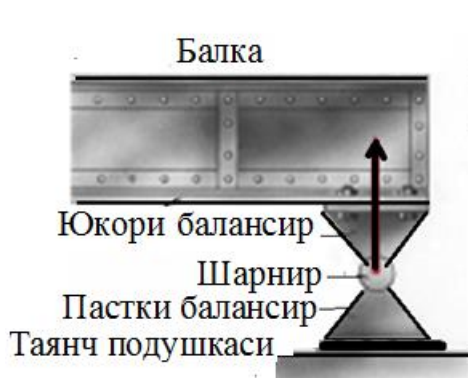
2) (4-rasm )



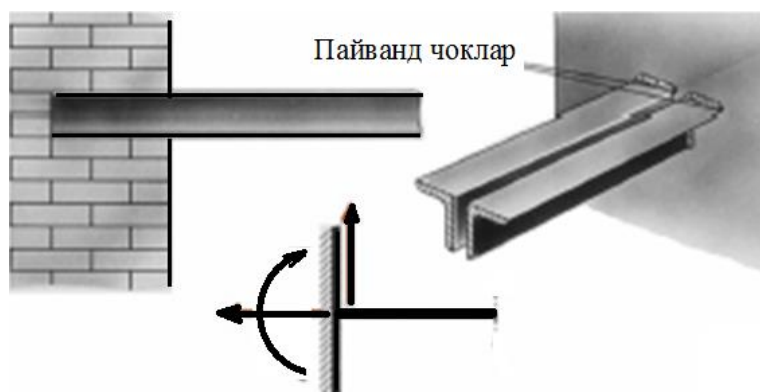
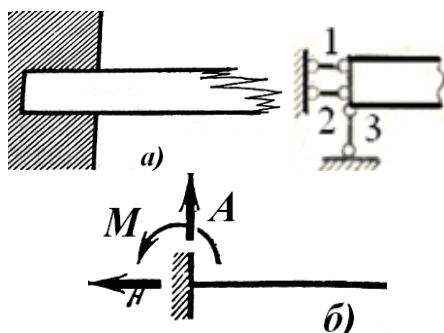
5-rasm. Qo'zg'almas sharnirli tayanch

2) **qo'zg'almas sharnirli tayanch**, Ikki bog'lanishli tayanch yoki qo'zg'almas sharnirli tayanch sterjen tayanch kesimining vertikal va gorizontal tekisliklardagi harakatini chegaralaydi; kesimni aylanish burchagini cheklamaydi. Bu tayanchda vertikal va gorizontal reaksiya kuchlari hosil bo'ladi Tayanch kesim bitta erkinlik darajaga ega va unda ikkita reaksiya kuchi hosil bo'ladi

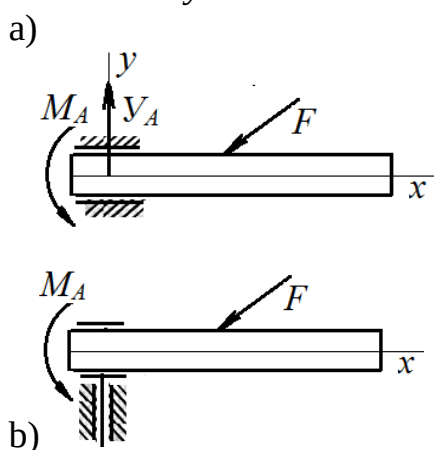




Qo'zg'almas  
sharnirli tayanch  
konstruktsiyasi



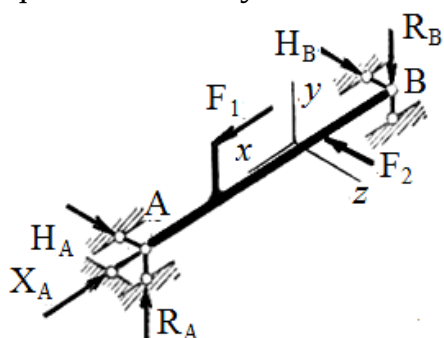
6-rasm. Birk mahkamlangan  
tayanchlar



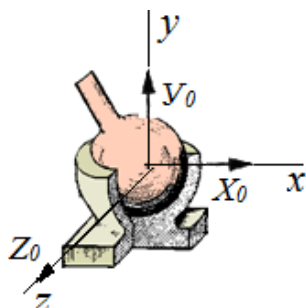
3) **Quzg'almas birk mahkamlangan tayanch.**  
Uch bog'lanishli tayanch, hamma erkinlik darajani cheklaydi. Sterjen 3 vertikal tekislikdagi harakatni, 1 va 2 sterjenlar esa gorizont tekislikdagi harakatni va kesimni aylanishini cheklaydi. Tayanchda uchta reaksiya vertikal, gorizont reaksiya kuchlari va reaktiv moment hosil buladi (6-rasm., a-b). Bir uchi gorizont tekislikda harakatlanishiga yo'l qo'yilgan balka. Reaksiya kuchi harakat yo'nalishi tekisligiga perpendikulyar va balkaning tayanch nuqtasi atrofida aylanishiga to'sqinlik qiluvchi

reaksiya momentidan iborat (6-rasm, b).

Bir uchi ham gorizont ham vertikal tekisliklarida harakatlanishiga yo'l qo'yilgan balka. Reaksiya kuchi tayanch nuqtasi atrofida aylanishiga to'sqinlik qiluvchi reaksiya momentidan iborat (6-rasm, b).

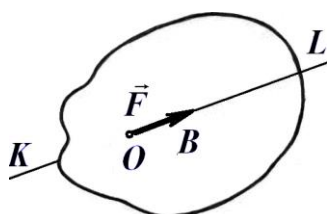


Sharnirli fazoviy tayanch –  $x$  va  $z$  o'qlari yo'nalishida ko'chishni cheklaydi, undan tashqari A tayanch  $y$  o'qi yo'nalishidagi chiziqli ko'chishni ham cheklaydi. Bunday tayanchlarga A va B kesimlarga bir tomoni ochiq va ikkinchi tomoni yopiq vtulkalar o'rnatilgan bo'lishi mumkin.



Sferik sharnir

Jism sferik sharnir vositasi yordamida bog'langan bo'lsa, bu sharnir o'z markazidan o'tadigan har qanday o'q atrofida jismni aylanishiga to'sqinlik qilmaydi. Sferik sharnirning reaksiya kuchi uning markazidan o'tadi, lekin qaysi tomonga yo'nalganligi noma'lum. Masalani echishda reaksiya kuchini tanlab olingan koordinata o'qlari bo'ylab tashkil qiluvchilarga ajratish kerak.



Kuch elementlari

**Kuch haqida umumiy tushunchalar.** Kuch – jismlarning o'zaro mexanik ta'sirlashuvining o'lchovi va uchta elementga ega.

**Elementlari** - kuchning miqdori, yo'nalishi va qo'yilish nuqtasi. Kuch chizmada strelkali to'g'ri chiziq kesmasi shaklida tasvirlanadi. Kuch vektor kattalik bo'lib, uni chizmada uzunligi ma'lum masshtabda kuch miqdorini, strelkaning yo'nalishi kuch yo'nalishini ifodalovchi vektor kesma tarzda tasvirlanadi. Kuch vektori yo'nalgan  $KL$  to'g'ri chiziq kuchning ta'sir chizig'i deyiladi.

**Kuch turlari.** Tashqi - jismga ta'sir qiluvchi kuch yoki undagi temperaturani o'zgarishi tashqi faktordir. Jismga qo'yilgan tashqi faktor yuklanish deyiladi

### To'planma kuch



Kuchlar qo'yilish xarakteriga ko'ra to'planma va taqsimlangan kuchlar bo'ladi. Jismning o'z o'lchamiga nisbatan juda kichik sirtiga ta'sir qilgan kuchlar to'planma kuchlar deyiladi. Hisoblashni osonlashtirish uchun bunday kuchlar bir nuqtaga qo'yilgan deb faraz qilinadi.

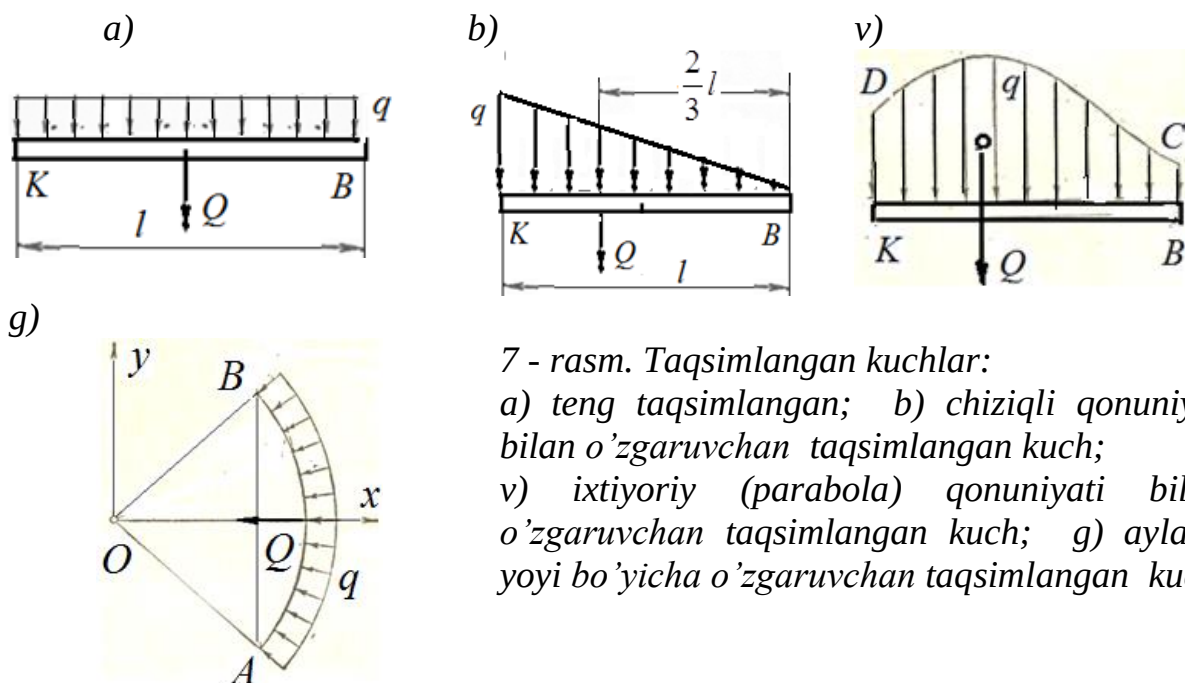
**Taqsimlangan kuch.** Jism sirtidagi yuzaning biror

qismiga yoki undagi chiziqning biror qismiga ta'sir qilgan kuchlar yoyilgan (taqsimlangan) kuchlar deb ataladi. Taqsimlangan kuch - tekis sistemasi, uning intensivligi bilan xarakterlanadi, yuklangan uchastkaning uzunlik birligiga to'g'ri keladigan kuch. Yoyilgan kuchlar yuk intensivligi, ya'ni balkaning yuza yoki uzunlik birligiga to'g'ri keladigan miqdori bilan xarakterlanadi. Agar yuklar intensivligi yuza yoki uzunlik bo'yicha bir xil bo'lsa bunday yuklar tekis taqsimlangan yuklar deyiladi.

Jismlarga, asosan, parallel yoki bir nuqtada kesishuvchi taqsimlangan kuchlar ta'sir etadi. Masalan, jism zarrachalarining og'irlik kuchi hajm bo'yicha, suvning to'g'on sirtiga bosim kuchi sirt bo'yicha taqsimlangan parallel kuchlarni ifodalaydi. Chiziq kesmasi bo'yicha taqsimlangan kuchlar (7-rasm,a).

Bunday kuchlarning intensivligi  $q$  o'zgarmas kattalik bo'ladi. KB kesma bo'yicha tekis taqsimlangan kuchlarni KB ning o'rtasiga qo'yilgan  $Q = lq$  teng ta'sir etuvchi bilan almashtirish mumkin.

2.To'g'ri chiziq kesmasi bo'yicha chiziqli qonuniyat asosida taqsimlangan kuchlar (7-rasm,b). Bunday kuchlarning intensivligi  $q$  o'zgaruvchan bo'lib, noldan to maksimal qiymatgacha o'zgaradi. Ushbu kuchlarning teng ta'sir etuvchisi KBC uchburchakning yuzasiga teng.



7 - rasm. Taqsimlangan kuchlar:

a) teng taqsimlangan; b) chiziqli qonuniyat bilan o'zgaruvchan taqsimlangan kuch; v) ixtiyoriy (parabola) qonuniyati bilan o'zgaruvchan taqsimlangan kuch; g) aylana yoyi bo'yicha o'zgaruvchan taqsimlangan kuch

3. To'g'ri chiziq kesmasi bo'yicha ixtiyoriy qonuniyat (parabola) asosida taqsimlangan kuch. Bunday kuchlarning teng ta'sir etuvchisi miqdor jihatdan mos masshtabda o'lgan KBCD shakl yuzasiga teng hamda berilgan yuzaning og'irlik markaziga qo'yiladi.

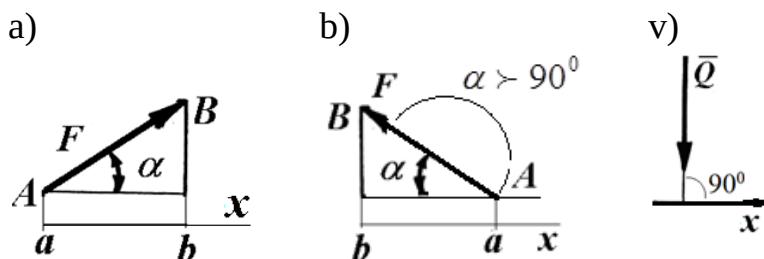
4. Aylana yoyi bo'yicha tekis taqsimlangan (7-rasm, g) radial kuchlar. Bunday kuchlarning teng ta'sir etuvchisi yoyini tortib turuvchi AB vatar uzunligining taqsimlangan kuchlar intensivligiga ko'paytmasiga teng.

Chiziqli taqsimlangan kuchlarning teng ta'sir qiluvchisi

$$Q = \int_0^l q(x) dx \text{ ga teng.}$$

Taqsimlangan kuchning qo'yilish nuqtasi yoki ta'sir chizig'i statika qoidasiga asosan topiladi

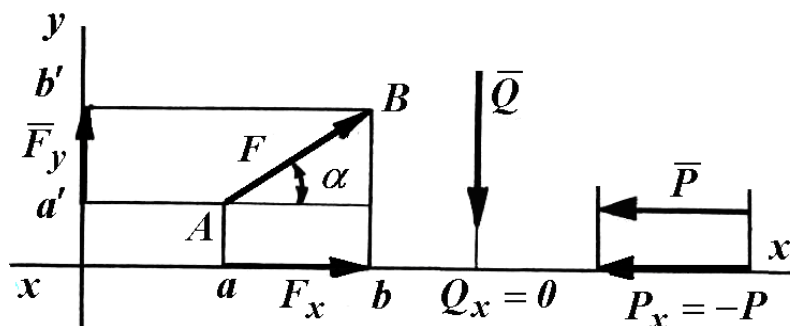
**Kuchning o'qdagi proektsiyasi.** Ma'lum yo'nalish berilgan to'g'ri chiziq o'q deb ataladi. Vektorning o'qdagi proektsiyasi skalyar kattalik bo'lib, u o'qning vektor boshidan va uchidan o'qqa tushirilgan perpendikulyar kesishishidan hosil bo'lgan kesmasi bilan aniqlanadi.



8 - rasm. Kuchni o'qlarga proektsiyasiga oid:

a) proektsiya musbat,  
b) proektsiya manfiy;  
v) proektsiya nolga teng

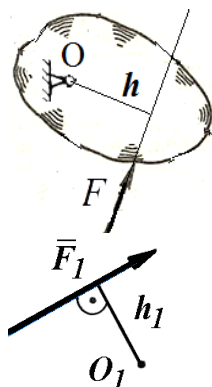
Kuchning o'qdagi proektsiyasi kuch vektorining boshi va oxiridan o'qqa tushirilgan ikkita perpendikulyar orasidagi o'q kesmasi bilan topiladi:



$$F_x = F \cos \alpha; \quad F_y = F \sin \alpha \quad F = \sqrt{F_x^2 + F_y^2}$$

Agar,  $\alpha < 90^\circ$  bulsa kuchning o'qdagi proektsiyasi musbat,  $\alpha > 90^\circ$  bulsa manfiy ishorali

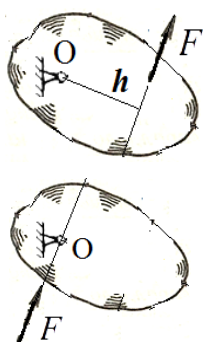
**Kuch momenti.** Kuch ta'sirida jism ilgarilanma harakatda, biror nuqta yoki o'q atrofida aylanma harakatda bo'lishi mumkin.



$$M_1 = -\bar{F}_1 \cdot h_1$$

$$M_2 = F_2 \cdot h_2 \text{ (N.m)}$$

**Kuchni nuqtaga nisbatan momentining xossalari:**



Kuchni nuqtaga nisbatan momenti deb, kuch modulini uning elkasiga ko'paytmasini tegishli ishora bilan olinganiga aytiladi

**Moment markazi** - kuch momenti qaysi nuqtaga nisbatan olinsa, shu nuqta moment markazi.

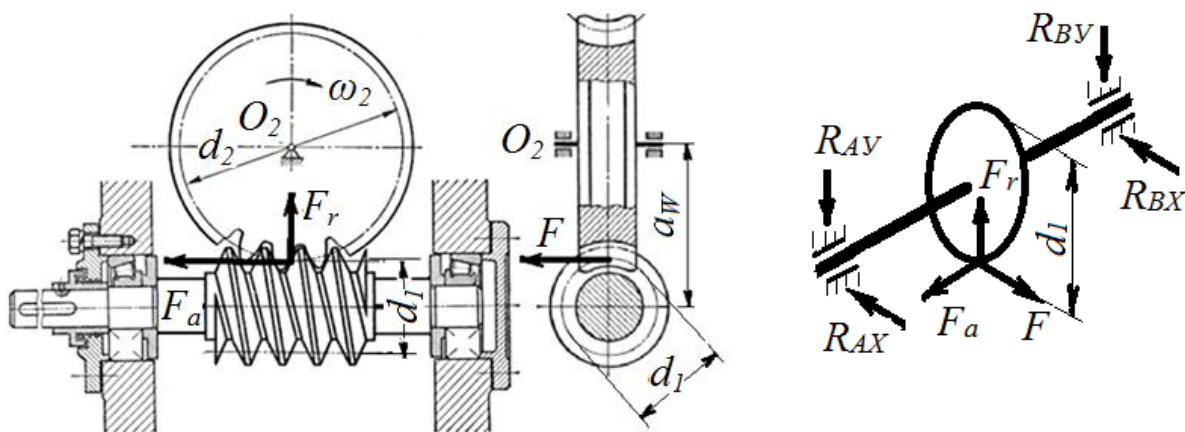
**Kuch elkasi**- moment markazidan kuchning ta'sir chizig'igacha bo'lgan eng qisqa oraliq  $h$ .

**Ishorasi** -kuch moment markazi atrofida jismni soat strelkasining harakat yo'nalishiga teskari tomonga aylantirishga intilganda, kuch momenti musbat ishorali va aksincha kuch moment markazi atrofida jismni soat strelkasining harakat yo'nalishiga mos tomonga aylantirishga intilganda manfiy ishorali.

Kuchning miqdori va yo'nalishini o'zgartirmay ta'sir chizig'i bo'ylab istalgan nuqtaga ko'chirilsa, kuch momenti o'zgarmaydi.

Agar kuchning ta'sir chizig'i moment markazidan o'tsa, uning shu markazga nisbatan momenti nolga teng bo'ladi.

**Fazoda ixtiyoriy joylashgan kuchlar sistemasi.** Fazoviy kuchlar sistemasi mexanik uzatmalarda, masalan, qiyshiq tishli va chervyakli uzatmalarning ilashmasida o'zaro perpendikulyar joylashgan doiraviy  $F$ , bo'yлама  $F_a$  va radial  $F_r$  kuchlar hosil bo'ladi



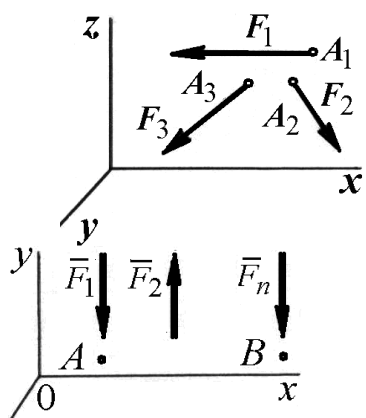
9-rasm. Chervyakli uzatma valining yuklanish sxemasi

**Fazoda ixtiyoriy joylashgan kuchlar sistemasining analitik muvozanat shartlari.** Jismga ta'sir etuvchi fazodagi kuchlar sistemi muvozanatda bo'lishi uchun barcha kuchlarning uchta Dekart koordinata o'qlarining har biridagi proektsiyalarining yig'indilari nolga teng bo'lishi va kuchlarning uchta koordinata o'qlarining har biriga nisbatan momentlarining yig'indilari ham nolga teng bo'lishi zarur va etarli

Yuqoridagi muvozanat tenglamalarini quyidagicha yozish qulaydir:

$$\left. \begin{aligned} \sum X &= 0, & \sum Y &= 0, & \sum Z &= 0, \\ \sum M_x &= 0, & \sum M_y &= 0, & \sum M_z &= 0, \end{aligned} \right\}$$

**Tekislikdagi parallel kuchlarning muvozanat shartlari.**



Bir tekislikda yotgan  $\bar{F}_1, \bar{F}_2, \dots, \bar{F}_n$  kuchlar sistemasining muvozanat shartlari:

$$\sum F_{kx} = 0; \quad \sum F_{ky} = 0;$$

$$\sum Y = 0, \quad \sum m_0(\bar{F}_k) = 0;$$

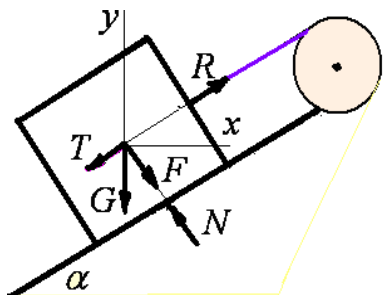
yoki  $\sum m_A(\bar{F}_k) = 0; \quad \sum m_B(\bar{F}_k) = 0;$

Bir tekislikda yotgan va bir-biriga parallel bo'lgan kuchlar muvozanatda bo'lishi uchun barcha kuchlarning  $u$  o'qidagi proektsiyalarining yig'indisi va kuchlarning tekislikdagi ixtiyoriy  $O$  nuqtaga nisbatan olingan momentlarining yig'indisi alohida-alohida nolga teng bo'lishi zarur va etarli.

$$\sum X = 0; \quad \sum Y = 0; \quad \sum m_0(\bar{F}_k) = 0$$



## Kuchlar sistemasining muvozanatiga oid misollar echish.



**misol- 1.** Og'irligi  $G = 50 \text{ kH}$  bo'lgan yuk gorizont bilan  $\alpha = 30^\circ$  burchak hosil qilgan qiyalikda joylashgan. Yukni harakatlanishiga ip to'sqinlik qiladi Ipni taranglik kuchi  $T$  va yukni qiya devorga ta'sir kuchi  $F$  hisoblansin.

**echish.** Yuk muvozanat holatda. Yukni bog'lanishlari, ip va sirtni tashlab yuborib, ularning ta'sirini reaksiyalar bilan almashtiramiz. Reaksiya  $N$  qiyalikka perpendikulyar joylashgan va yukning markazidan o'tadi,  $G$  og'irlik gorizontga tik yo'nalgan va yukning geometrik markaziga qo'yilgan, reaksiya  $R$  ip bo'ylab yo'nalgan va yukning geometrik markazidan o'tadi. Natijada ta'sir chiziqlari bir nuqtada kesishuvchi kuchlar sistemi hosil bo'ladi. Ta'sir chiziqlari bir nuqtada kesishuvchi kuchlar sistemasining analitik muvozanat shartlarini tuzamiz:

$$\sum X = 0; \quad -N \cdot \sin \alpha + R \cdot \cos \alpha = 0 \quad (1)$$

$$\sum Y = 0; \quad -G + N \cdot \cos \alpha + R \cdot \sin \alpha = 0 \quad (2)$$

(1) tenglamadan topilgan  $R = N \cdot \operatorname{tg} \alpha$  ifodani (2) tenglamaga qo'yib

$$N = \frac{G}{\cos \alpha + \operatorname{tg} \alpha \cdot \sin \alpha} \quad \text{hosil qilamiz.}$$

$$\text{Unda, } R = \frac{G \cdot \operatorname{tg} \alpha}{\cos \alpha + \operatorname{tg} \alpha \cdot \sin \alpha} \cdot F \text{ kuch, o'zaro ta'sirlashish aksiomasiga}$$

asosan modul jihatdan  $N$  reaksiyaga teng va qarama-qarshi tomonga yo'nalgan. Unda  $F = N = \frac{50}{\cos 30^\circ + \operatorname{tg} 30^\circ \cdot \sin 30^\circ}.$

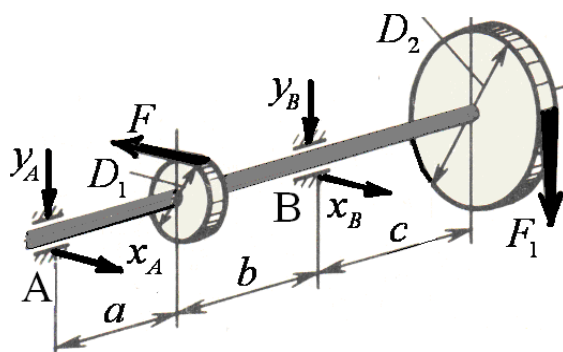
Ipni taranglik kuchi modul jihatdan reaksiyaga teng:

$$T = R = \frac{50 \cdot \operatorname{tg} 30^\circ}{\cos 30^\circ + \operatorname{tg} 30^\circ \cdot \sin 30^\circ}$$

**misol-2.** Valga diametrlari  $D_1 = 100 \text{ mm}$  va  $D_2 = 200 \text{ mm}$  bo'lgan remenli uzatmaning shkiqlari o'rnatilgan. Birinchi shkiqdagi remenning taranglik kuchi  $F = 100 \text{ H}$ . Valning  $A$  va  $B$  tayanch reaksiyalari va ikkinchi remenning taranglik kuchi  $F_2$  hisoblansin.

Masofalar:  $a = 100 \text{ mm}$   $b = 110 \text{ mm}$ ;  $c = 120 \text{ mm}$  (10-rasm)

**echish.** Tayanchlardagi reaksiyalarning yo'nalishlarini belgilaymiz va ularni koordinata o'qlariga proektsiyalab muvozanat tenglamalarini tuzamiz. Kuchlarni o'qlarga nisbatan momentlarini aniqlaganda quyidagilarga amal qilamiz: kuch o'qni kesib o'tsa yoki unga parallel bo'lsa, ushbu kuchni mazkur o'qqa nisbatan momenti nolga teng



10-rasm

Muvozanat tenglamalarni tuzamiz:

$$\sum X = 0; \quad x_A + x_B - F = 0 \quad (3)$$

$$\sum Y = 0; \quad y_A + y_B - F_1 = 0 \quad (4)$$

$$\sum Z = 0; \quad \text{valni o'qi bo'ylab yo'nalgan } Z \text{ o'qiga proektsiya beradigan kuch yo'q}$$

$$\sum M_x = 0; \quad -y_B(a+b) - F_1(a+b+c) = 0 \quad (5)$$

$$\sum M_y = 0; \quad F \cdot a - x_B(a+b) = 0 \quad (6)$$

$$\sum M_z = 0; \quad F \cdot \frac{D_1}{2} - F_1 \cdot \frac{D_2}{2} = 0 \quad (7)$$

$$(7) \text{ tenglamadan } F_1 = F \frac{D_1}{D_2} = 100 \cdot \frac{100}{200} = 50H$$

$$(6) \text{ tenglamadan } x_B = F \cdot \frac{a}{a+b} = 100 \cdot \frac{0,1}{0,21} = 47,62H$$

$$(5) \text{ tenglamadan } y_B = F_1 \cdot \frac{a+b+c}{a+b} = 50 \cdot \frac{0,33}{0,21} = 78,57H$$

$$(4) \text{ tenglamadan } y_A = -78,57 + 50 = -28,57H$$

$$(3) \text{ tenglamadan } x_A = -47,62 + 100 = 52,38H$$

A va B tayanchlardagi reaksiya kuchlarining teng ta'sir qiluvchilarini topamiz:

$$R_A = \sqrt{x_A^2 + y_A^2} = \sqrt{(52,38)^2 + (-28,57)^2} = 59,67H$$

$$R_B = \sqrt{x_B^2 + y_B^2} = \sqrt{(47,62)^2 + (78,57)^2} = 91,87H$$

**misol - 3:** Biki rama A nuqtada qo'zgalmas sharnirli va nuqtada qo'zgaluvchi sharnirli tayanchga birlashtirilgan. Ramaga ta'sir qiluvchi barcha kuchlar va uning o'lchamlari 11 – rasmda ko'rsatilgan.

$$\text{Berilgan: } M = 100Hm; \ell = 0,5m; F = F_1 = F_2 = 20H; F_3 = 30H \quad \alpha_2 = 30^\circ \\ \alpha_3 = 60^\circ$$

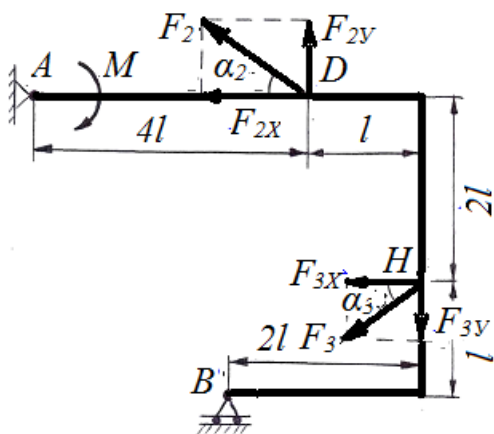
**echish:** D va H nuqtalarga quyilgan  $\vec{F}_2$  va  $\vec{F}_3$  kuchlarni x va y o'qlariga proektsiyalaymiz:

$$F_2' = F_2 \cos \alpha_2 = 20 \cdot 0,85 = 17H$$

$$F_2'' = F_2 \sin 30^\circ = 20 \cdot 0,5 = 10H,$$

$$F_3' = F_3 \cos \alpha_3 = 30 \cos 60^\circ = 30 \cdot 0,5 = 15H$$

Ramani bog'lanishdan ozod qilamiz.



11 - rasm

Bog'lanish ta'sirini  $\overline{X_A}$ ,  $\overline{Y_A}$  va  $\overline{R_B}$  reaksiya kuchlari bilan almashtiramiz. Sharnirli qo'zgalmas A tayanchdagi  $\overline{R_A}$  reaksiya kuchining moduli va yo'nalishi noma'lum, shuning uchun bu kuchni x va y o'qlari buylab yo'nalgan ikkita  $\overline{X_A}$ ,  $\overline{Y_A}$  tashkil etuvchilarga ajratamiz:  $\overline{R_A} = \overline{X_A} + \overline{Y_A}$  Sharnirli qo'zgaluvchan B tayanchdagi reaksiya kuchi  $\overline{R_B}$ . Rama bir momenti

M ga teng bulgan juft kuch ta'sirida muvozanatda.

Rama uchun muvozanat tenglamalarini tuzamiz:

$$\sum X = 0; X_A - F_2' - F_3' = 0 \quad (8)$$

$$\sum Y = 0; Y_A + F_2'' - F_3'' + R_B = 0 \quad (9)$$

$$\sum m_A = 0, M + 4lF_2'' - 2lF_3'' - 5lF_3'' + 3lR_B = 0 \quad (10)$$

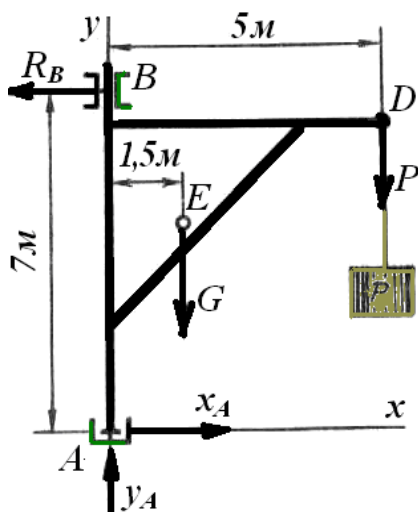
Bu tenglamalarni echib noma'lum reaksiya kuchini topamiz.

$$(8) \text{ tenglamadan } X_A = F_2' + F_3' = 17 + 15 = 32H, X_A = 32H$$

$$(10)\text{-tenglamadan: } 3lR_B = M - 4lF_2'' + 2lF_3'' + 5lF_3''$$

$$\text{bu erdan } 3R_B = 200 - 40 + 30 + 130 = 320; R_B = 107H$$

$$(9) \text{ tenglamadan: } Y_A = -F_2'' + F_3'' - R_B = -10 + 26 - 107 = -91H$$



12-rasm

**misol -4.** Ko'tarish kranining D nuqtasida 50 kN yuk osilgan (12-rasm). Kranni og'irlik kuchi  $G = 30kH$ . A va B tayanch nuqtasidagi reaksiya kuchlari aniqlansin.

**echish.** Kranni muvozanatini o'rganamiz. B podshipnikdagi  $R_B$  reaksiya uning buylama o'qiga perpendikulyar yo'nalgan; A nuqtadagi reaksiyani  $X_A$  va  $Y_A$  tashkil etuvchilarga ajratamiz. Shunday qilib, kranga ixtiyoriy yo'nalgan beshta kuchlar sistemasi quyilgan bo'lib, uchtasi noma'lum.

Analitik muvozanat shartlarni tadbqiq etib uchta tenglama tuzamiz:

$$\sum M_A = 0 \quad R_B \cdot 7 - G \cdot 1,5 - P \cdot 5 = 0$$

$$\sum X = 0 \quad -R_B + X_A = 0$$

$$\text{va } \sum Y = 0 \quad Y_A - P - G = 0$$

$$\text{Birinchi tenglamadan: } R_B = 42,1 \cdot 10^3 H = 42,1kH$$

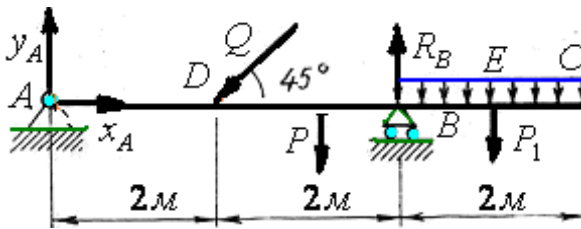


Ikkinchi tenglamadan:

$$X_A = R_B = 42,1kH$$

Uchinchi tenglamadan:

$$Y_A = P + G = 50 + 30 = 80kH$$



13 – rasm

**misol-5.** Og'irligi  $P = 8H$  bo'lgan AC balking D nuqtasiga  $Q = 6H$ , BC qismiga intensivligi  $q = 3Hm$  bo'lgan tekis taqsimlangan kuch qo'yilgan.

Balka B nuqtada erkin

tayanchda yotadi, A nuqtada

tayanch bilan sharnir vositasida biriktirilgan. A va B nuqtalardagi reaksiya (13-rasm) kuchlari aniqlansin

**echish.** Balkaning CB qismiga qo'yilgan tekis taqsimlangan kuchni E nuqtada qo'yilgan  $P_1 = BC \cdot q = 6H$  kuch bilan almashtiramiz. Og'irlik kuchi  $R$  ni va A, B nuqtalarning reaksiya kuchlarini 13-rasmdagidek yo'naltirib, AC balka uchun muvozanat tenglamalarini tuzamiz:

$$\sum M_A(\bar{F}_k) = 0 \quad -2Q \sin 45^\circ - 3P + 4R_B - 5P_1 = 0$$

$$\sum M_B(\bar{F}_k) = 0 \quad -1P + 1P + 2Q \sin 45^\circ - 4Y_A = 0,$$

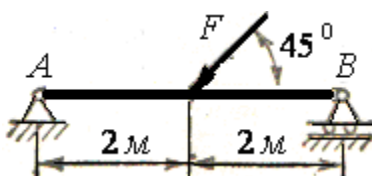
$$\sum X_k = 0 \quad X_A - Q \cos 45^\circ = 0$$

**misol-6.** Og'irliklari e'tiborga olinmaydigan AC va BC sterjenlar bir-biri va vertikal devor bilan sharnirlar vositasida biriktirilgan.



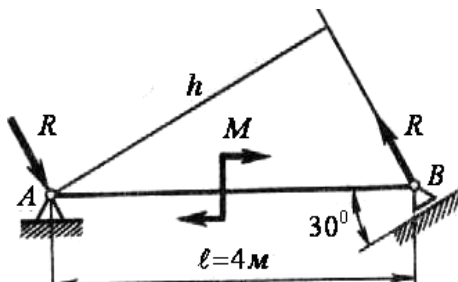
Sharnirli S boltga  $F = 1000H$  vertikal kuch ta'sir qiladi. Agar sterjenlar bilan devor orasidagi burchaklar  $\alpha = 30^\circ$  va  $\alpha = 60^\circ$  bo'lsa, sharnirli C boltga sterjenlarning ko'rsatadigan reaksiyalari aniqlansin.

**javob:** 866 N, 500 N

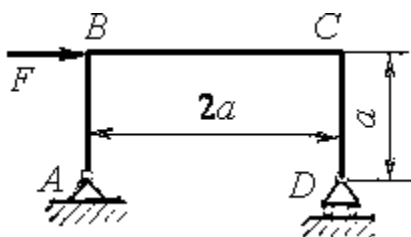


**misol-7.** AB balka A tayanchga sharnir bilan biriktirilgan, uning B uchi katokka qo'yilgan. Balkaning o'rtasiga uning o'qiga  $45^\circ$  burchak ostida  $F = 2kH$  kuch qo'yilgan. O'lchovlar rasmdan olinsin.

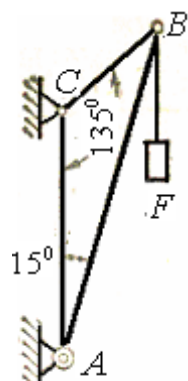
**javob:**  $R_A = 1,58kH$  va  $R_B = 0,71kH$



**misol - 8.** Uzunligi  $\ell = 4$  m bulgan gorizontal balka  $M = 420Hm$  moment bilan yuklangan va rasmda ko'rsatilganidek tayanchlarga tayanadi. A va B reaksiya kuchlari aniqlansin.

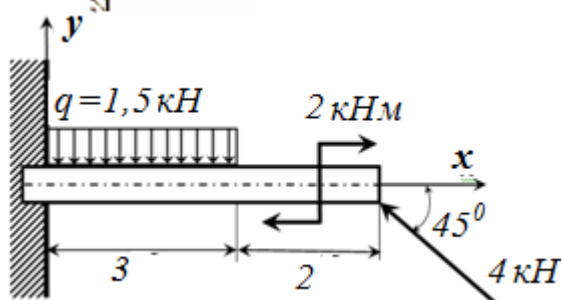


**misol-9.** Ramada  $B$  nuqtaga qo'yilgan  $F$  gorizontal kuch ta'siridan hosil bo'ladigan  $R_A$  va  $R_B$  tayanch reaksiyalari aniqlansin.



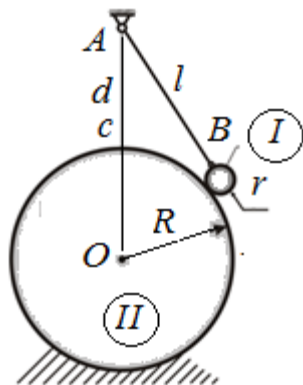
**misol- 10.** Machta krani AB strela va CB zanjirdan iborat: AB strela machtaga A sharnir vositasida biriktirilgan. Strelaning B uchiga  $F = 2\kappa H$  yuk osilgan; burchaklar:  $BAC = 15^\circ$ ,  $ACB = 135^\circ$ . SV zanjirdagi T taranglik kuchi va AB streladagi Q zo'riqish aniqlansin.

**javob:**  $T = 1,04\kappa H$  va  $Q = 2,83\kappa H$

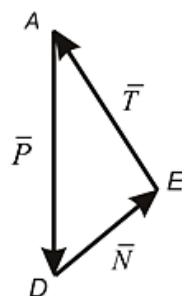
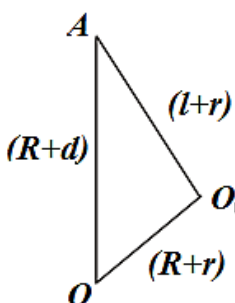
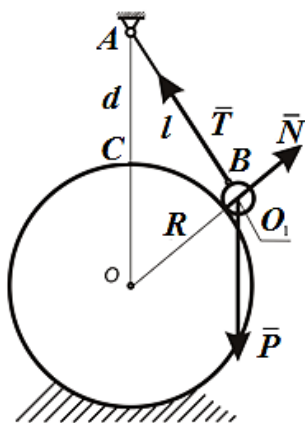


**misol-11.** To'plangan kuch, tekis taqsimlangan yuk va juft kuch ta'siridagi rasmda tasvirlangan konsol balkaning devorga qistirib mahkamlangan uchining reaksiya kuchlari aniqlansin.

**javob**  $X = 2,8 \text{ kN}$ ,  $U = 1,7 \text{ kN}$ ,  
 $M = -5,35 \text{ kNm}$



**misol-12** Og'irligi  $R$ , radiusi  $r$  ga teng bo'lgan sharcha  $A$  nuqtaga  $AB = l$  uzunlikdagi ip yordamida osilgan bo'lib radiusi  $R$  ga teng bo'lgan silliq II- sfera ustida turadi.  $A$  nuqtadan sferagacha bo'lgan masofa  $d$ ,  $OA$  masofa vertikal bo'lsa ipdagi taranglik kuchi va sferaning sharga ko'rsatadigan reaksiyasi aniqlansin. Masala kesishuvchi kuchlarni geometrik qo'shish usulida echilsin.

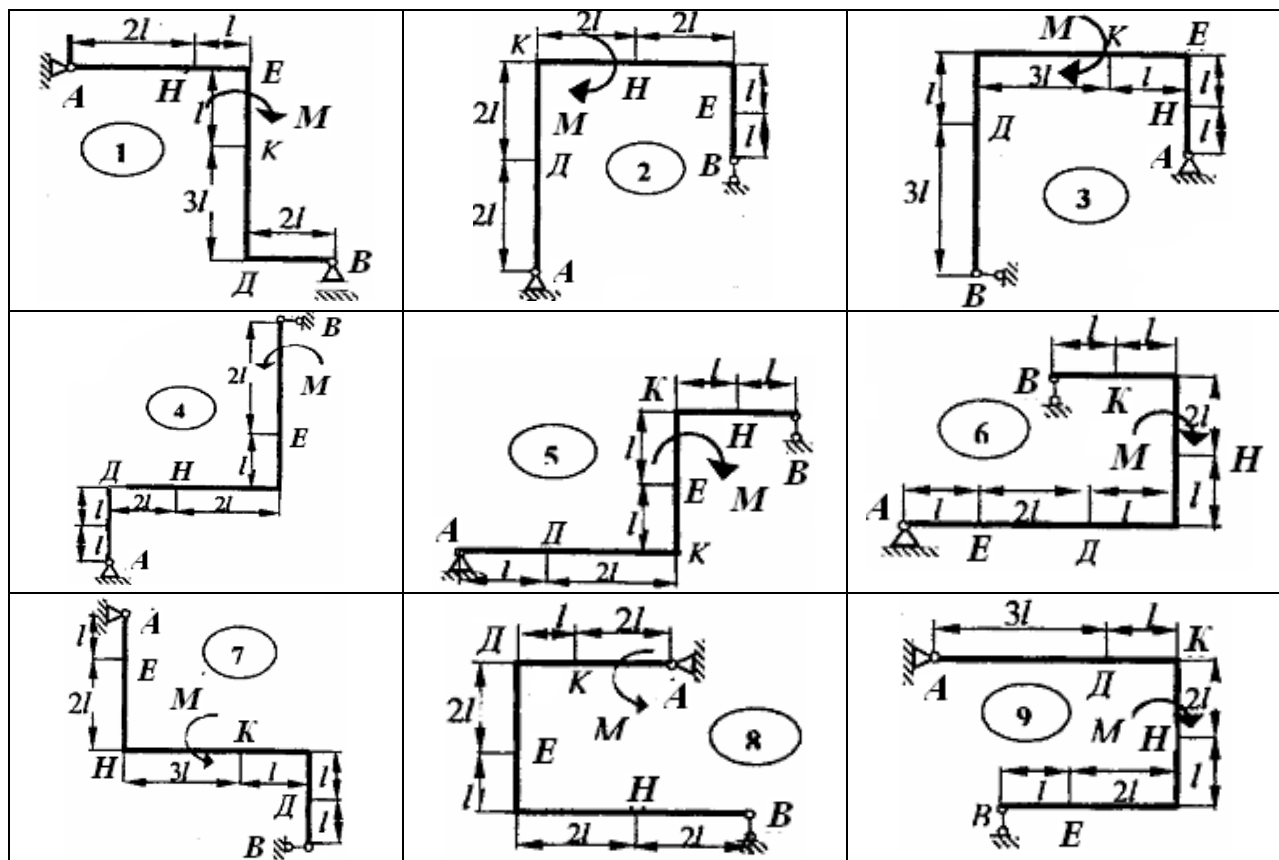


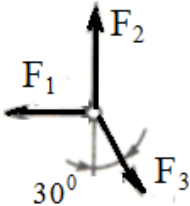
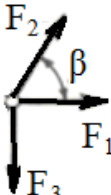
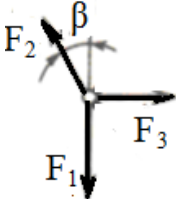
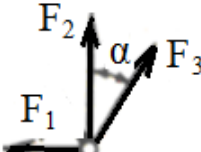
**echish:**  $P$ ,  $N$  va  $T$  kuchlarini o'z ta'sir chiziqlari bo'ylab ko'chirib  $ADE$  kuchlar uchburchagini xosil qilamiz u  $AOO_1$  uchburchakka o'xashash bo'ladi. Unda

$$\frac{T}{P} = \frac{l+r}{d+R}; \quad T = P \frac{l+r}{d+R} \quad \frac{N}{P} = \frac{R+r}{d+R}; \quad N = P \frac{R+r}{d+R}$$

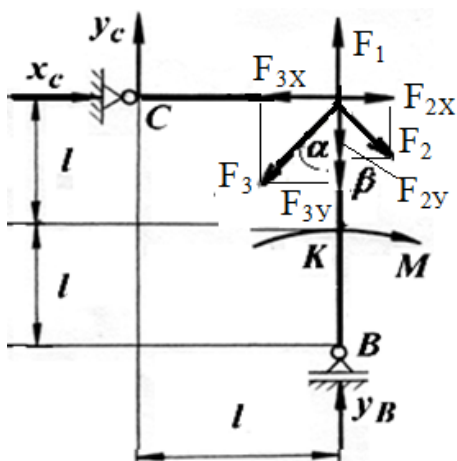
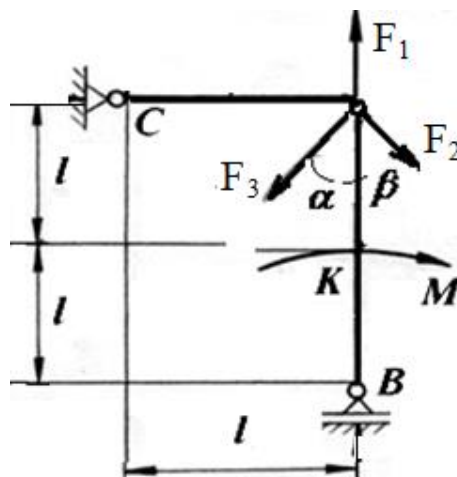
**misol-13.** Biki rama kuchlar bilan yuklangan . Tayanch nuqtalardagi reaksiya kuchlari aniqlansin  $F_1 = 10H$  ;  $F_2 = 20H$  ;  $F_3 = 30H$

$M = 100Hl$  qabul qilinsin. Ramaning ikkita nuqtasiga 6 ta turli yo'nalishdagi kuchlar sistemasi qo'yiladi.



| Kuch |  |  |  |  |   |                 |   |                |
|------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---|-----------------|---|----------------|
|      | D                                                                                   | K                                                                                   | E                                                                                   | N                                                                                     |   |                 |   |                |
|      | Kuchlarni qo'yilish nuqtalari                                                       |                                                                                     |                                                                                     |                                                                                       |   |                 |   |                |
| 0    | -                                                                                   | -                                                                                   | D                                                                                   | $\beta = 60^0$                                                                        | E | $\alpha = 45^0$ | - | -              |
| 1    | K                                                                                   | $\alpha = 30^0$                                                                     | -                                                                                   | -                                                                                     | - | -               | N | $\beta = 60^0$ |
| 2    | -                                                                                   | -                                                                                   | N                                                                                   | $\alpha = 45^0$                                                                       | K | $\beta = 30^0$  | - | -              |
| 3    | D                                                                                   | $\alpha = 60^0$                                                                     | -                                                                                   | -                                                                                     | - | -               | E | $\beta = 30^0$ |
| 4    | -                                                                                   | -                                                                                   | K                                                                                   | $\beta = 30^0$                                                                        | E | $\alpha = 60^0$ | - | -              |
| 5    | N                                                                                   | $\alpha = 60^0$                                                                     | -                                                                                   | -                                                                                     | D | $\beta = 30^0$  | - | -              |
| 6    | -                                                                                   | -                                                                                   | E                                                                                   | $\alpha = 45^0$                                                                       | - | -               | K | $\beta = 45^0$ |
| 7    | D                                                                                   | $\alpha = 45^0$                                                                     | -                                                                                   | -                                                                                     | N | $\beta = 45^0$  | - | -              |
| 8    | -                                                                                   | -                                                                                   | N                                                                                   | $\alpha = 60^0$                                                                       | - | -               | D | $\beta = 30^0$ |

**misol-14.** Bika rama  $C$  nuqtada sharnirli – qo'zgalmas tayanchga,  $V$  nuqtada esa sharnirli qo'zgaluvchan tayanchga mahkamlangan. Ramaga momenti  $M = 100 \text{ Nm}$  ga teng juft kuch va  $K$  nuqtada ta'sir chiziklari bir nuqtada kesishuvchi kuchlar sistemasi ta'sir qiladi.  $C$  va  $V$  nuqtalardagi reaksiya kuchlari aniqlansin.



**echish.** Ramaning tayanch nuqtalaridagi

$x_C, y_C, y_B$  reaksiyalarni ko'rsatamiz

Kuchni o'qlardagi proektsiyalari ta'rifidan foydalanib  $F_1, F_2, F_3$  kuchlarni  $x, y$  o'qlaridagi proektsiyalarini yozamiz:

$$F_{2x} = F_2 \cdot \sin \beta; \quad F_{2y} = F_2 \cdot \cos \beta$$

$$F_{3x} = F_3 \cdot \sin \alpha; \quad F_{3y} = F_3 \cdot \cos \alpha$$

$C$  va  $B$  nuqtalardagi reaksiya kuchlarini aniqlash uchun statikaning muvozanat tenglamalarini tuzamiz

$$\sum x = 0; \quad x_c + F_{2x} - F_{3x} = 0 \quad \text{tenglamadan}$$

$$x_c = -F_{2x} + F_{3x} = -F_2 \cdot \sin \beta + F_3 \cdot \sin \alpha = -10 \cdot \sin 45^\circ + 20 \cdot \sin 45^\circ = 7H$$

$$\sum y = 0; \quad y_c + F_1 - F_{2y} - F_{3y} + y_B = 0$$

tenglamada ikkita noma'lum bor.

$$\sum M_c = 0; \quad y_B \cdot l + F_1 l - M - F_{2y} \cdot l - F_{3y} \cdot l = 0 \quad \text{yoki}$$

$$y_B = \frac{-F_1 \cdot l + M + F_3 \cos \alpha \cdot l + F_2 \cos \beta \cdot l}{l} =$$

$$= -10 + 30 \cdot \cos 45^\circ + 20 \cdot \cos 45^\circ + 100 = 125H$$

Unda

$$y_c = -y_B - F_1 + F_2 \cdot \cos 45^\circ + F_3 \cos 45^\circ = -125 - 10 + 20 \cdot \frac{\sqrt{2}}{2} + 30 \cdot \frac{\sqrt{2}}{2} = -100H$$

$$\text{Tekshirish: } \sum M = 0; \quad -y_c \cdot l - M = 0 \quad 100 \cdot 1 - 100 = 0$$

## Bir necha jismdan tashkil topgan sistemaning muvozanati.

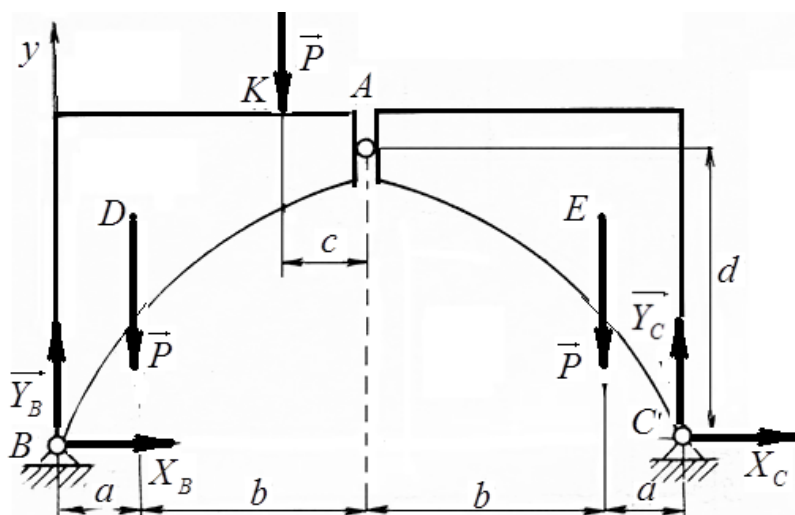
Bir – birlari bilan bog'langan bir necha jismlardan tashkil topgan sistemaning muvozanatini aniqlashga o'tamiz. Buning uchun sistemaga ta'sir etuvchi kuchlarni ikki guruhga : ichki va tashqi kuchlarga ajratamiz. Sistemani tashkil etuvchi jismlarning bir – birlariga ko'rsatadigan ta'sir kuchlari – *ichki kuchlar* deyiladi.

Sistemaga kirmagan jismlarning unga ko'rsatadigan ta'sir kuchlari - *tashqi kuchlar* deyiladi.

Agar sistemani bir butun yaxlit qattiq jism deb qarasak, ta'sir va aks ta'sir haqidagi aksiomaga asosan, ichki kuchlar juft – juft holda miqdorlari teng, yo'nalishlari bir to'g'ri chiziq bo'ylab qarama – qarshi tomonga yo'nalgan kuchlar sistemasini tashkil etadi. Shuning uchun ichki kuchlarning bosh vektor iva biror markazga nisbatan bosh momenti nolga teng bo'ladi. Agar sistema muvozanatda bo'lsa, uning tarkibidagi har bir jism muvozanatda bo'ladi. Sistemaning muvozanatini tekshirish uchun sistemani tashkil etuvchi har bir jismning muvozanati alohida tekshiriladi. Muvozanati tekshirilayotgan sistemada ajratib olingan biror jismning muvozanati teshirilayotganda bu jismga sistemani tashkil etuvchi boshqa jismlarning ta'siri kuchlar bilan almashtiriladi. Bu kuchlar sistema uchun ichki kuchlar bo'ladi, ammo ajratib olingan jism uchun tashqi kuchlar qatoriga kiradi.

Tekslidagi kuchlar ta'sirida  $N$  ta jismdan tashkil topgan sistema muvozanatda bo'lsa, har bir jism uchun uchtdan muvozanat tenglamasi tuzish mumkin. Natijada sistema muvozanat tenglamalarining soni  $3N$  ta bo'ladi.

Ba'zan sistemani yaxlit bitta jism deb qarab, uchta muvozanat tenglamasi tuziladi. Bu tenglamalarda ichki kuchlar qatnashmaydi. So'ngra  $N-1$  ta jismlar uchun uchtdan muvozanat tenglamasi tuziladi. Natijada  $3 + 3(N-1) = 3N$  ta muvozanat tenglamalarini olamiz.



**misol - 15.** Ko'prik A sharnir bilan birga bir – biriga hamda B va C sharnirlar bilan ikki qirg'oqdagi tayanchlarga biriktirilgan ikki qismdan iborat. Ko'prikning K nuqtasiga  $P_1$  yuk qo'yilgan. Ko'prik har bir qismining og'irligi  $R$  bo'lib, D va E nuqtalarga qo'yilgan.

14- rasm. Ko'prikni yuklanishi

O'lchamlari 14– rasmda ko'rsatilgan. B va C nuqtalardagi reaksiya kuchlari hamda ko'prik qismlarining A nuqtadagi o'zaro ta'sir kuchlari aniqlansin.

**echish.** Bu masala  $\vec{P}, \vec{P}_1$  kuchlar hamda B va C sharnirlarning reaksiya kuchlarini tashkil etadi. B va C sharnirlarning reaksiya kuchlari noma'lum bo'lgani uchun ularni  $B_x$  va  $B_y$  o'qlarning musbat yo'nalishlari bo'ylab yo'nalgan tashkil etuvchilariga ajratamiz. Sistema ikkita jismdan tashkil topgan (14-rasm) uchun sistemaning muvozanat tenglamalari 6 ta bo'ladi.

Butun ko'prik uchun muvozanat tenglamalari:

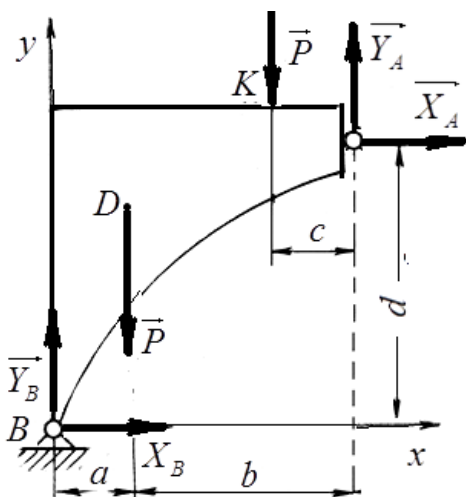
$$\sum X_K = 0 \quad X_B + X_C = 0$$

$$\sum Y_K = 0 \quad Y_B - P - P_1 - P + Y_C = 0$$

$$\sum M_B(F_K) = 0 \quad aP - (a+b-c)P_1 - (a+2b)P + 2(a+b)Y_C = 0$$

Ko'prikning chap qismini olib, o'ng qismining beradigan ta'sirini A nuqtaning reaksiya kuchi bilan almashtiramiz. A nuqtaning reaksiya kuchini  $B_x$  va  $B_y$  o'qlarning musbat yo'nalishi bo'yicha yo'nalgan  $\vec{X}_A$  va  $\vec{Y}_A$  tashkil etuvchilarga ajratamiz (15-rasm)

Ko'prikning chap qismi uchun muvozanat tenglamalarini tuzamiz:



$$\sum X_K = 0 \quad X_B + X_A = 0$$

$$\sum Y_K = 0 \quad Y_B - P - P_1 + Y_A = 0$$

$$\sum M_B(F_K) = 0$$

$$P_1c + bP - Y_B(a+b) + X_Bd = 0$$

Tenglamalar sistemasidan 6 ta noma'lum reaksiya kuchlarini aniqlaymiz.

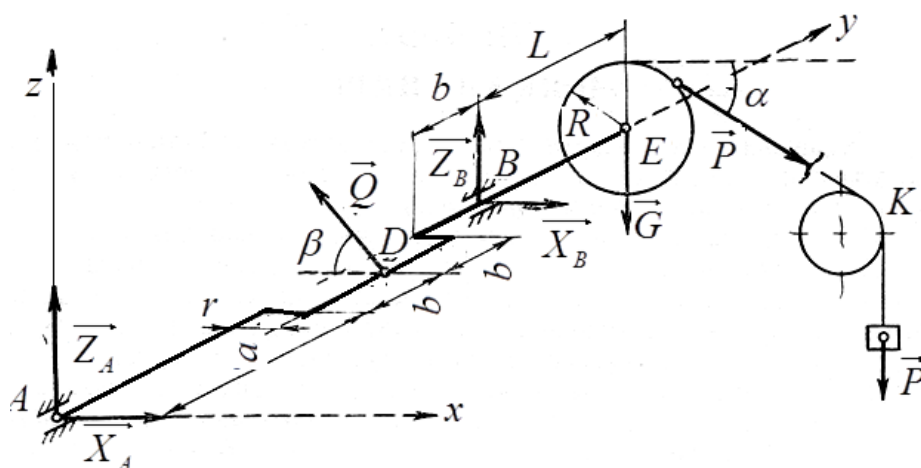
15 - rasm. Ko'prikni chap qismi

**misol -13.** 16 -rasmda tasvirlangan konstruktsiyaning tayanch reaksiya kuchlari aniqlansin.

Quyidagilar berilgan:  $Q=3000 \text{ N}$ ,  $G=2000 \text{ N}$ ,  $a=0,6 \text{ m}$ ;  $b=0,2 \text{ m}$ ;  $s=0,4$ ;  $r=0,5 \text{ m}$ ;  $\alpha=30^\circ$ ;  $\beta=60^\circ$

**echish.** Valga ta'sir etuvchi kuchlarni rasmda tasvirlaymiz. R kuchni arqon bo'ylab yo'naltiramiz. A va B nuqtadagi tsilindrsimon podshipniklarning ta'sirini  $\vec{X}_A, \vec{Z}_A, \vec{X}_B, \vec{Z}_B$  reaksiya kuchlari bilan almashtiramiz. Kuchlarning koordinata o'qlaridagi proektsiyalarini va mazkur o'qlarga nisbatan momentlarini hisoblab, muvozanat tenglamalarini tuzamiz (16-rasm):





16 – rasm. Fazoviy kuchlar sistemasi

$$\sum X_k = 0; \quad X_A - Q \cos 60^\circ + X_B + P \cos 30^\circ = 0 \quad (11)$$

$$\sum Y_k = 0; \quad 0 = 0$$

$$\sum Z_k = 0; \quad Z_A - Q \cos 30^\circ + Z_B + P \cos 60^\circ - G = 0 \quad (12)$$

$$\sum M_k(\overline{F_k}) = 0; \quad (a+b)Q \cos 30^\circ + (a+b)Z_B - (a+3b+c)P \cos 60^\circ - (a+3b+c)G = 0 \quad (13)$$

$$\sum M_y(\overline{F}) = 0; \quad -r \cos 30^\circ + RP = 0 \quad (14)$$

$$\sum M_z(\overline{F}) = 0; \quad (a+b)Q \cos 60^\circ - (a+3b)X_B + (a+3b+c)P \cos 30^\circ = 0 \quad (15)$$

Tenglamalarni birgalikda echib quyidagi qiymatlarni topamiz.

$$(14) \text{ tenglamadan } P = \frac{rQ \cos 30^\circ}{R} = 649,5H$$

(15) tenglamadan:

$$X_B = \frac{1}{a+3b} \left[ (a+b) \cdot Q \cos 60^\circ + (a+3b+c) \cdot P \cos 30^\circ \right] = 1749,96H ;$$

$$(11) \text{ tenglamadan: } X_A = Q \cos 60^\circ - X_B - P \cos 30^\circ = -812,42H$$

(13) tenglamadan:

$$Z_B = \frac{1}{a+3b} \left[ -(a+b) \cdot Q \cos 30^\circ + (a+3b+c) \cdot P \cos 60^\circ + (a+3b+c)G \right] = 1367,67H$$

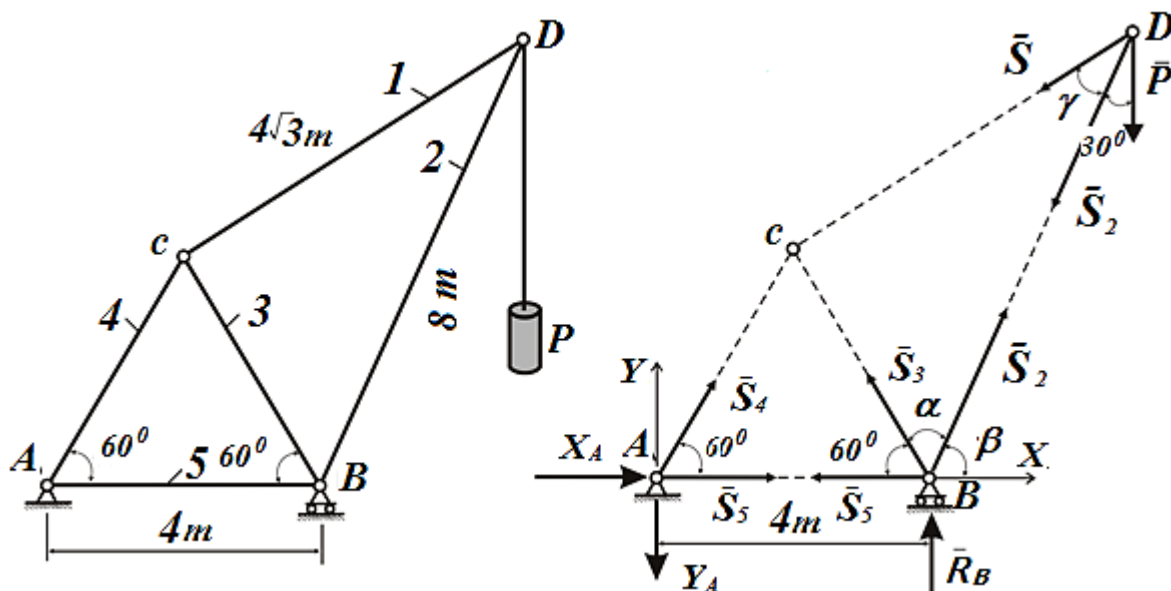
$$\text{tenglamadan: } X_A = -Q \cos 30^\circ - Z_B + P \cos 60^\circ + G = 355,08H$$

**Ferma sterjenlaridagi ichki zo'riqish kuchlarni aniqlash.** Bu misolda cho'zilish va siqilishga ishlaydigan payvandli ajralmas birikma hosil qilgan ferma sterjenlaridagi ichki zo'riqish kuchlarini hisoblash usullaridan birini ko'rib o'tamiz. Buning uchun fermani yuklanish sxemasi va unga qo'yilgan kuchlar



berilgan bo'ladi. Ichki bo'ylama kuchni quyidagi Kesish – Ritter usuli asosida ajratilgan sterjenlar tuguniga ta'sir qiluvchi kuchlarning analitik muvozanat tenglamalarini tuzish usuli bilan topamiz.

**misol-14.** Berilgan fermada  $AB=4\text{ m}$ ,  $CD=4\sqrt{3}\text{ m}$  va  $BD=8\text{ m}$  bo'lib uning D nuqtasiga R yuk osilgan bo'lsa fermaning sterjenlaridagi zo'riqishlar aniqlansin.



**echish:** Tekislikdagi ixtiyoriy kuchlarning muvozanat tenglamalaridan foydalanib fermaning reaksiya kuchlarini aniqlaymiz.

$$\sum F_{kx} = 0; \quad X_A = 0$$

$$\sum F_{ky} = 0; \quad -Q + R_A - D = 0; \quad R_B = 2P$$

$$\sum M_B(F); \quad -Y_A 4 - D(AD) \cos \beta = 0; \quad Y_A = \frac{8P \cos \beta}{4} = 2P \frac{1}{2} = P$$

$\alpha, \beta, \gamma$  burchaklarni aniqlaymiz.

$$\cos \alpha = \frac{(4\sqrt{3})^2 - 4^2 - 8^2}{-2 \cdot 4 \cdot 8} = \frac{32}{64} = \frac{1}{2};$$

$$\alpha = 60^\circ; \quad \cos \alpha = \frac{4^2 - (4\sqrt{3})^2 - 8^2}{-2 \cdot 8 \cdot 4\sqrt{3}} = \frac{96}{64\sqrt{3}} = \frac{\sqrt{3}}{2}; \quad \gamma = 30^\circ$$

D tugunning muvozanatidan.

$$\sum F_{kx} = 0; \quad -S_1 \sin 60^\circ - S_2 \sin 30^\circ = 0; \quad S_1 = P$$

$$\sum F_{ky} = 0; \quad -S_1 \cos 60^\circ - S_2 \cos 30^\circ - P = 0; \quad S_2 = -\sqrt{3}D$$

V tugunning muvozanatidan.

$$\sum F_{kx} = 0; \quad S_2 \cos 60^\circ - S_3 \cos 60^\circ - S_5 = 0; \quad S_5 = \frac{P\sqrt{3}}{3}$$

$$\sum F_{ky} = 0; \quad R_B + S_2 \cos 60^\circ - S_3 \cos 60^\circ = 0; \quad S_3 = \frac{P\sqrt{3}}{3}$$

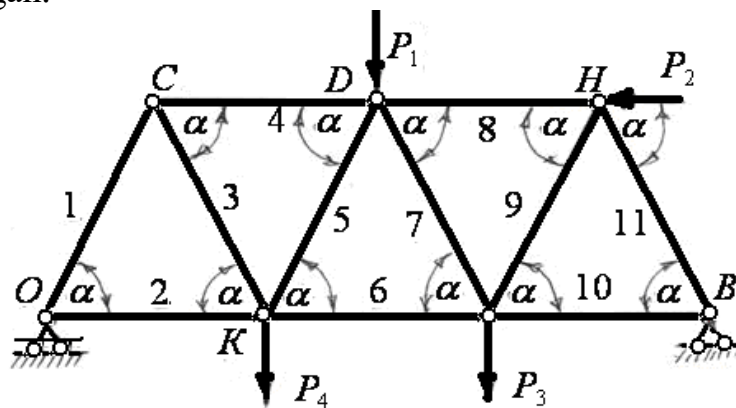
A tugunning muvozanatidan.

$$\sum F_{ky} = 0; \quad Y_A + S_4 \sin 60^\circ = 0; \quad S_4 = \frac{P2\sqrt{3}}{3}$$

javob:

$$X_A = 0; \quad O_A = P; \quad S_1 = P; \quad S_2 = -\sqrt{3}D; \quad S_3 = \frac{P\sqrt{3}}{3}; \quad S_4 = \frac{P2\sqrt{3}}{3}; \quad S_5 = \frac{P\sqrt{3}}{3}$$

**misol-15.** Fermani sxemasi va unga ta'sir qiluvchi kuchlar 17– rasmda ko'rsatilgan.



17–rasm. Fermani yuklanish sxemasi

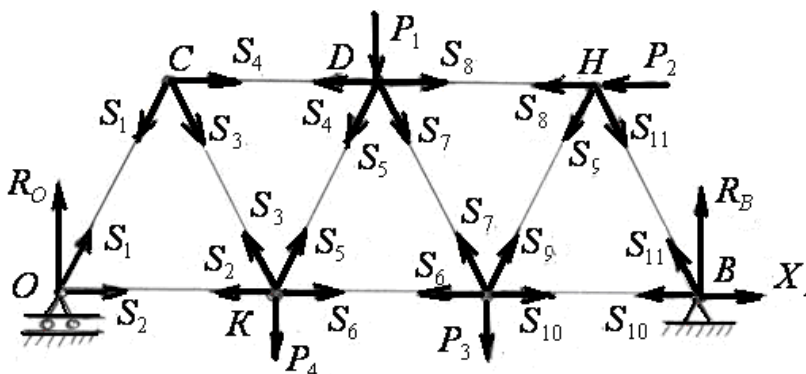
Berilgan:  $P_1 = 10\kappa H$ ;  $P_2 = 20\kappa H$ ;  $P_3 = 30\kappa H$ ;  $P_4 = 40\kappa H$

**echish. 1.** Fermani O va B tayanch nuqtalariga nisbatan moment tenglamalarini tuzib tayanch reaksiyalari aniqlaymiz (17-rasm).

$$\sum x = x_B - P_2 = 0 \quad \text{yoki} \quad x_B = 20\kappa H$$

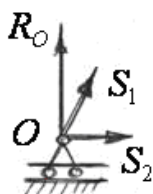
$$\sum M_O = R_B \cdot 3a - P_4 a - P_1 \frac{3}{2} a - P_3 \cdot 2a + P_2 \cdot \frac{\sqrt{3}}{2} a = 0 \quad \text{va}$$

$$\sum y = R_O - P_4 - P_1 - P_3 + R_B = 0 \quad \text{va} \quad R_O = 47,44\kappa H$$



18– rasm. Ferma uzellaridagi kuchlar

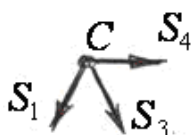
2. Sterjenlardagi zo'riqish kuchlarini kesish usulidan foydalanib topamiz. Eng oldin O yoki B tugunlar atrofidan sterjenlarni kesish mumkin, chunki bu tugunlardagi reaksiya kuchlari aniq va ikkitadan sterjenlardagi zo'riqish kuchlarini aniqlash mumkin (18-rasm).



**I-I qirqim.** O tugundagi 1-2 sterjenlardan kesamiz va muvozanat tenglamalarini tuzamiz:

$$\begin{aligned}\sum x = 0 & \quad S_1 \cdot \cos 60^\circ + S_2 = 0 \\ \sum y = 0 & \quad R_0 + S_1 \cdot \sin 60^\circ = 0\end{aligned}$$

$$S_1 = -\frac{R_0}{\sin 60^\circ} = -\frac{47,44}{\frac{\sqrt{3}}{2}} = -54,78 \text{ kH} \quad \text{va} \quad S_2 = -S_1 \cdot \cos 60^\circ = 27,93 \text{ kH}$$

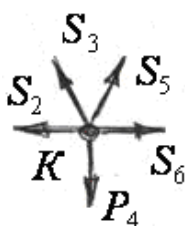


**II-II qirqim.** C tugundagi 1-2-3 sterjenlardan kesamiz va muvozanat tenglamalarini tuzamiz:

$$\sum x = 0 \quad S_1 \cdot \cos 60^\circ + S_4 + S_3 \cdot \cos 60^\circ = 0$$

$$\sum y = 0 \quad S_1 \cdot \sin 60^\circ - S_3 \cdot \sin 60^\circ = 0 \quad \text{va} \quad S_3 = S_1 = 54,78 \text{ kH}$$

$$S_4 = -(S_1 + S_3) \cdot \cos 60^\circ = -(54,78 + 54,78) \cdot 0,5 = -54,78 \text{ kH}$$



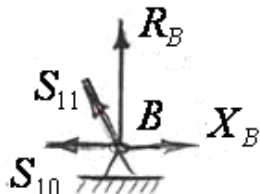
**III-III qirqim.** K tugundagi 2-3-5-6 sterjenlardan kesamiz va muvozanat tenglamalarini tuzamiz

$$\sum x = 0 \quad -S_2 + S_5 \cdot \cos \alpha + S_6 - S_3 \cdot \cos \alpha = 0$$

$$\sum y = 0 \quad S_3 \cdot \sin \alpha + S_5 \cdot \sin \alpha - P_4 = 0 \quad \text{va}$$

$$S_5 = \frac{P_4}{\sin \alpha} - S_3 = \frac{40}{\sin 60^\circ} - 54,78 = -8,54 \text{ kH}$$

$$S_6 = S_2 + S_3 \cdot \cos \alpha - S_5 \cdot \cos \alpha = 27,34 + (54,78 + 8,54) \cdot 0,5 = 59,05 \text{ kH}$$



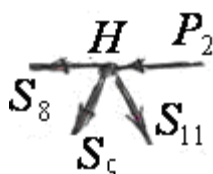
**IV-IV qirqim** B tugundagi 10-11 sterjenlardan kesamiz va muvozanat tenglamalarini tuzamiz

$$\sum x = 0 \quad X_B - S_{11} \cdot \cos 60^\circ - S_{10} = 0$$

$$\sum y = 0 \quad R_B + S_{11} \cdot \sin 60^\circ = 0 \quad \text{va}$$

$$S_{11} = -\frac{R_B}{\sin 60^\circ} = -\frac{32,56}{0,866} = -37,64 \text{ kH}$$

$$S_{11} = X_B - S_{11} \cdot \cos 60^\circ = 20 + 37,64 \cdot 0,5 = 38,82 \text{ kH}$$

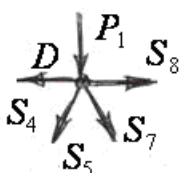


**V-V qirqim** N tugundagi 8-9-11 sterjenlardan kesamiz va muvozanat tenglamalarini tuzamiz:

$$\sum x = 0 \quad -P_2 - S_8 - S_9 \cdot \cos \alpha + S_{11} \cdot \cos \alpha = 0$$

$$\sum y = 0; \quad -S_9 \cdot \sin \alpha - S_{11} \cdot \sin \alpha = 0 \quad S_9 = -S_{11} = 37,64 \text{ kH}$$

$$S_8 = -P_2 - S_9 \cdot \cos \alpha + S_{11} \cdot \cos \alpha = -20 - 2 \cdot 37,64 \cdot 0,5 = 57,64 \text{ kH}$$



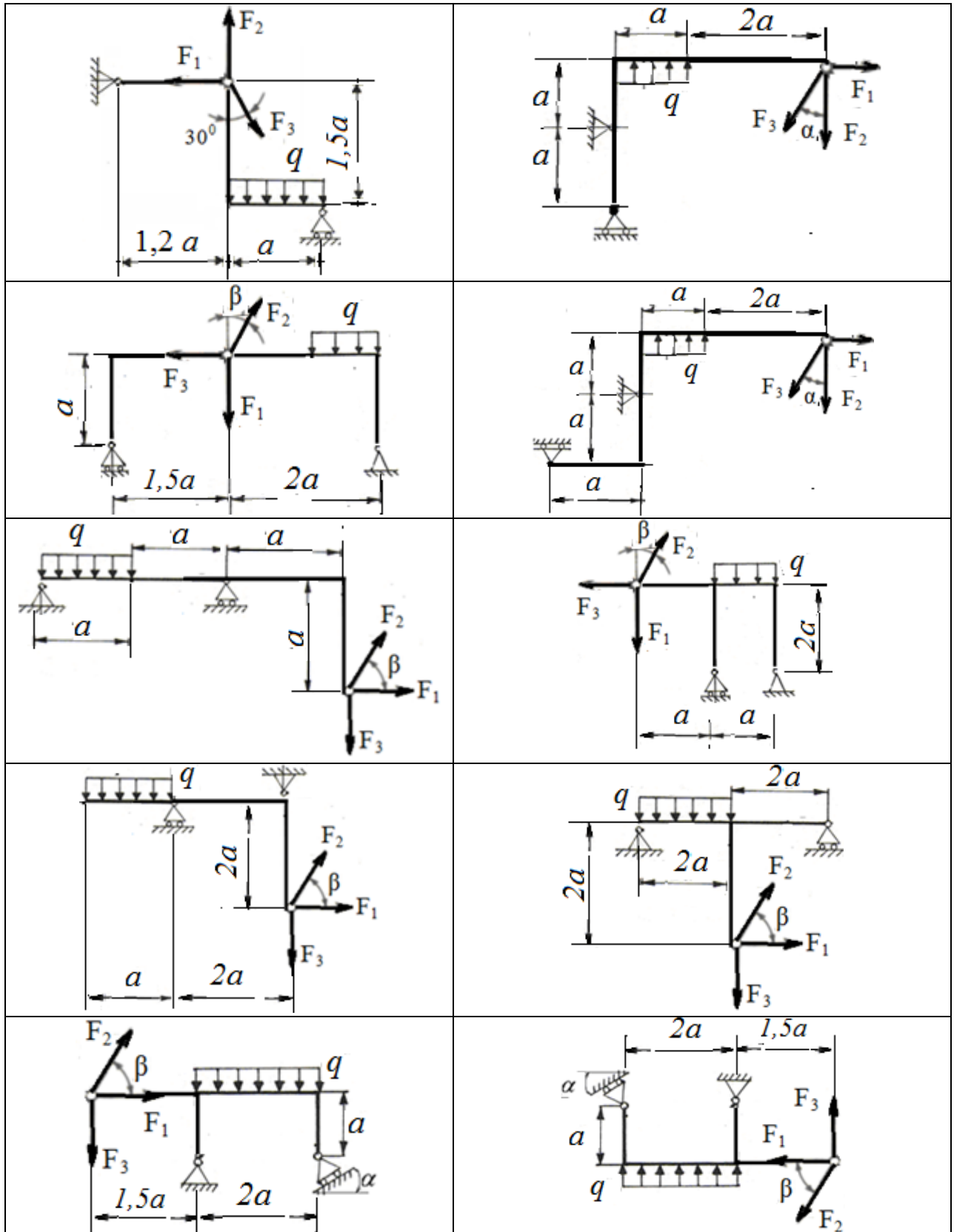
**VI-VI qirqim** D tugundagi 4-5-7-8 sterjenlardan kesamiz va muvozanat tenglamalarini tuzamiz:

$$\sum y = 0 \quad -S_7 \cdot \sin \alpha - S_5 \cdot \sin \alpha - P_1 = 0 \quad \text{va}$$

$$S_7 = -\frac{P_1}{\sin 60^\circ} - S_5 = -\frac{10}{0,866} + 8,54 = -3,02 \text{ kH}$$

## Mustaqil ish uchun misollar

**misol -16.** Biki rama kuchlar bilan yuklangan. Tayanch nuqtalardagi reaksiya kuchlari aniqlansin:  $F_1 = 10H$ ;  $F_2 = 20H$ ;  $F_3 = 30H$   $q = 20 \frac{H}{m}$



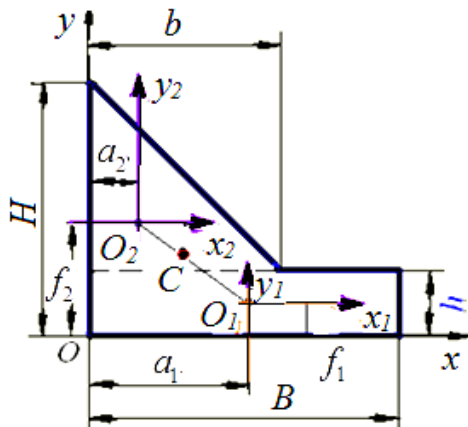
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## Kesim yuzalarning geometrik xarakteristiklari.

Berilgan murakkab shaklli kesim yuzaning og'irlik markazi topilsin.

**echish.** Murakkab shaklli kesim yuza (19-rasm) og'irlik markazining koordinatalari:

$$x_C = \frac{x_1 A_1 + x_2 A_2}{A} = \frac{a_1 A_1 + a_2 A_2}{A} \quad y_C = \frac{y_1 A_1 + y_2 A_2}{A} = \frac{f_1 A_1 + f_2 A_2}{A}$$



19-rasm.

Murakkab shaklli kesim yuzani ikkita to'g'ri to'rtburchak va uchburchak yuzalarga ajratamiz. Murakkab shaklli kesim yuzadan ajratilgan yuzalar og'irlik markazlarining koordinatalarini chizmadan topamiz:

$$a_1 = \frac{B}{2} \quad a_2 = \frac{B}{3} \quad A_1 = B \cdot h$$

$$A_2 = \frac{b}{2}(H-h) \quad f_1 = \frac{h}{2} \quad f_2 = \frac{H+2h}{3}$$

$$\text{Unda } x_C = \frac{B^2 h + \frac{B \cdot b}{3}(H-h)}{2Bh + b(H-h)} \quad \text{va } y_C = \frac{Bh^2 + b(H+2h)(H-h)}{2Bh + b(H-h)}$$

## Murakkab geometrik shakllarning inertsia momentlari.

Mashina, mexanizm va muxandislik inshootlarida murakkab shaklli kesim yuzaga ega bo'lgan detallar uchraydi.

Ushbu detallarni mustahkamlikka, bikrikka va ustuvorlikka hisoblashda, ularning inertsia momentlarini aniqlashga to'g'ri keladi.

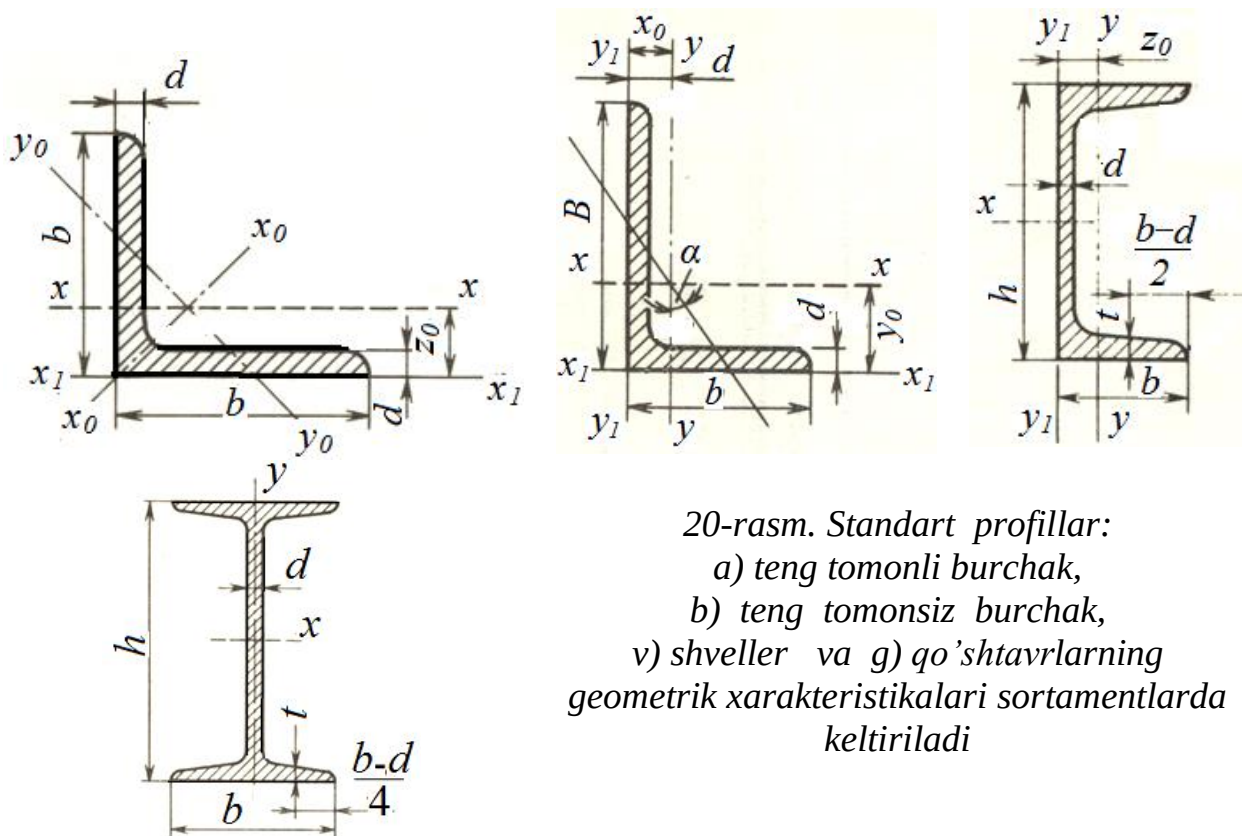
Murakkab geometrik shakllarning inertsia momentlari, undan ajratilgan oddiy geometrik shakllar inertsia momentlarining yig'indisiga teng, ya'ni

$$I_x = I_x^I + I_x^{II} + I_x^{III} + \dots + I_x^n = \sum_{i=1}^n I_x^i$$

buerda:  $I_x^I = I_{x1}^1 + a_1^2 A_1$ ;  $I_x^{II} = I_{x2}^{11} + a_2^2 A_2$  va h.k, murakkab geometrik shakldan ajratilgan oddiy geometrik shakllarni  $x$  o'qiga nisbatan inertsia momenti;

$I_{x1}^1, I_{x2}^{11}$  va h.k - murakkab geometrik shakldan ajratilgan oddiy geometrik shakllarni markaziy o'qiga nisbatan inertsia momentlari;

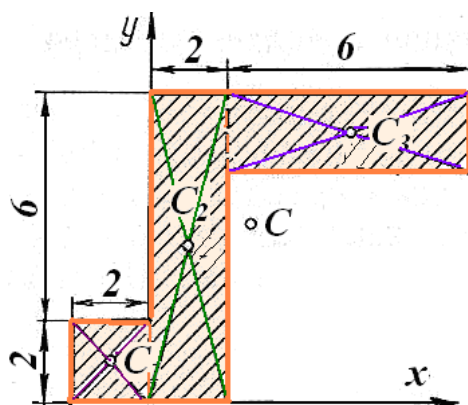
$a_1, a_2$  - va h.k - har bir oddiy shaklning markaziy o'qi bilan murakkab shaklning markaziy o'qigacha bo'lgan masofa



20-rasm. Standart profillar:  
a) teng tomonli burchak,  
b) teng tomonsiz burchak,  
v) shveller va g) qo'shtavrlarning  
geometrik xarakteristikallari sortamentlarda  
keltiriladi

**17-misol.** 21-rasmdagi jism yuzasining og'irlik markazi aniqlansin. Barcha o'lchamlar santimetrda berilgan

**echish.** Koordinata o'qlarini o'tkazib, jism yuzasini uchta to'rtburchakka bo'lamiz (bo'lish chiziqlari shtrix bilan ko'rsatilgan).



Har bir bo'lagi og'irlik markazining koordinatalari va yuzalarini aniqlaymiz:

$$C_1 (-1;1), C_2 (1;4), C_3 (5;7)$$

$$A_1 = 4\text{cm}^2 \quad A_2 = 16\text{cm}^2$$

$$A_3 = 12\text{cm}^2$$

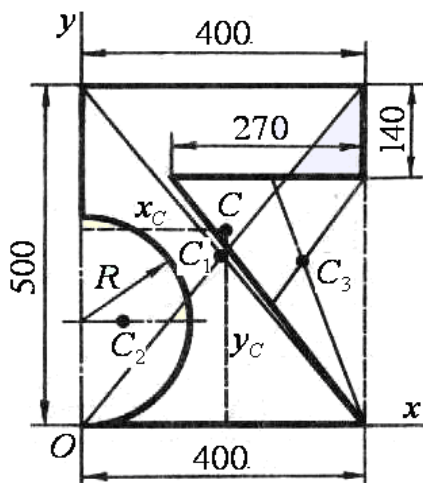
$C$  nuqtani 21 - rasmda ko'rsatamiz. Shakl og'irlik markazining koordinatalarini aniqlaymiz:

21- rasm

$$x_C = \frac{\sum S_y}{\sum A} = \frac{A_1 x_1 + A_2 x_2 + A_3 x_3}{A_1 + A_2 + A_3} = \frac{4(-1) + 16 \cdot 1 + 12 \cdot 5}{4 + 16 + 12} \quad \text{va} \quad x_C = \frac{9}{4} \text{cm}$$

$$y_C = \frac{\sum S_x}{\sum A} = \frac{A_1 y_1 + A_2 y_2 + A_3 y_3}{A_1 + A_2 + A_3} = \frac{4 \cdot 1 + 16 \cdot 4 + 12 \cdot 7}{4 + 16 + 12} \quad \text{va} \quad y_C = \frac{19}{4} \text{cm}$$





22- rasm.

**18-misol.** 22 - rasmda ko'rsatilgan bir jinsli plastinka og'irlik markazining vaziyati aniqlansin.

**echish.** Plastinkani XOY koordinata sistemasiga joylashtiramiz va kesim yuzasini oddiy yuzalarga ajratamiz: to'g'ri burchak – 400 x 500, yarim aylana  $R=150\text{ mm}$  va uchburchak. Unda:

$$x_1 = 20\text{ cm}, \quad A_1 = 40 \times 50 = 2000\text{ cm}^2$$

$$A_2 = -\frac{\pi}{2}(15)^2 = -353\text{ cm}^2;$$

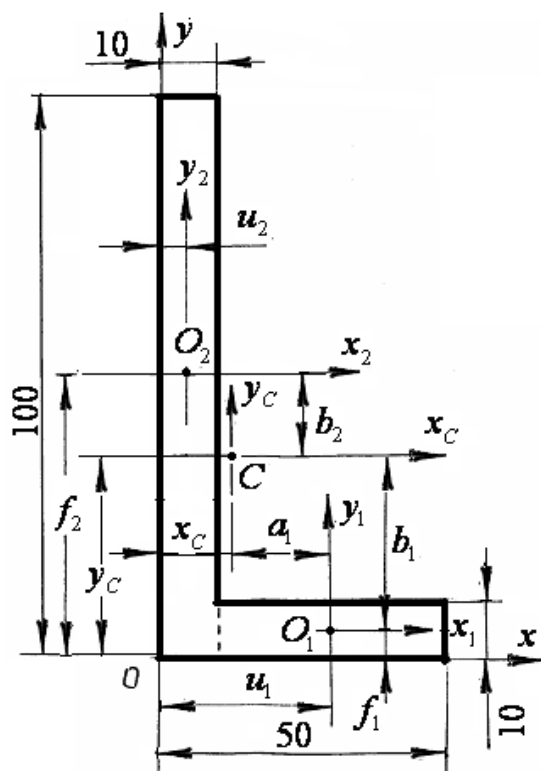
$$x_2 = \frac{4 \cdot 15}{3\pi} = 6,37\text{ cm}$$

$$A_3 = -\frac{1}{2} \cdot 27 \cdot 36 = -486\text{ cm}^2; \quad x_3 = 13 + \frac{2}{3} \cdot 27 = 31\text{ cm};$$

$$y_1 = 25\text{ cm}; \quad y_2 = 15\text{ cm}; \quad y_3 = \frac{2}{3} \cdot 36 = 24\text{ cm}$$

Og'irlik markazining koordinatalari:  $X_C = 19,5\text{ cm}$ ,  $Y_C = 28,4\text{ cm}$

**misol –19.** Rasmda ko'rsatilgan teng yonli bo'lmagan burchakning og'irlik markazi koordinatalarini aniqlang, shakl yuzasining bosh markaziy inertsia o'qlari vaziyatini toping va shu o'qlarga nisbatan inertsia momentlarini hisoblang.



23 -rasm

**echish.** Kesimni M.1:1 masshtabda chizamiz va ikkita to'g'ri to'rtburchakdan tashkil topgan deb, har bir yuzaning og'irlik markazlaridan  $x_1O_1y_1$  va

$x_2O_2y_2$  koordinata o'qlarini o'tkazamiz (23-rasm). Kesim alohida yuzalarining geometrik xarakteristikalarini hisoblaymiz

1. Kesim yuza:

$$A_1 = 10 \cdot (50 - 10) = 400\text{ mm}^2 = 4\text{ cm}^2$$

$$A_2 = 100 \cdot 10 = 1000\text{ mm}^2 = 10\text{ cm}^2$$

2. Xususiy inertsia momentlari:

$$I_{x1} = \frac{40 \cdot (10)^3}{12} = \frac{1}{3}\text{ cm}^4$$

$$I_{y1} = \frac{1 \cdot (4)^3}{12} = \frac{16}{3}\text{ cm}^4$$

$$I_{x2} = \frac{1 \cdot (10)^3}{12} = \frac{250}{3} \text{ cm}^4 \quad I_{y2} = \frac{10 \cdot (1)^3}{12} = \frac{5}{6} \text{ cm}^4$$

3. Yordamchi o'qlar  $X, Y$ -ni tanlab, kesimning statik momentlarini hisoblaymiz:

$$\sum S_x = A_1 \cdot f_1 + A_2 \cdot f_2 \quad \sum S_y = A_1 \cdot u_1 + A_2 \cdot u_2$$

$$\text{buerda } f_1 = \frac{10}{2} = 5 \text{ mm} = 0,5 \text{ cm} \quad \text{va} \quad f_2 = \frac{100}{2} = 50 \text{ mm} = 5 \text{ cm}$$

$$u_1 = 10 + \frac{50 - 10}{2} = 30 \text{ mm} = 3 \text{ cm} \quad \text{va} \quad u_2 = \frac{10}{2} = 5 \text{ mm} = 0,5 \text{ cm}$$

Kesim og'irlik markazining koordinatalarini hisoblaymiz:

$$x_C = \frac{\sum S_y}{A_1 + A_2} = \frac{17}{4 + 10} = 1,2 \text{ cm}; \quad y_C = \frac{\sum S_x}{A_1 + A_2} = \frac{52}{4 + 10} = 3,71 \text{ cm}$$

4. Kesimning topilgan og'irlik markazi  $C$  nuqtadan yangi  $X_C, Y_C$  o'qlarni o'tkazamiz. Kesimni shu o'qlarga nisbatan o'q va markazdan qochma inertsia momentlarini parallel o'qlarga o'tish formulalaridan foydalanib hisoblaymiz:

$$I_{x_C} = I_{x1} + b_1^2 A_1 + I_{x2} + b_2^2 A_2 = \frac{1}{3} + (3,21)^2 \cdot 4 + \frac{250}{3} + (1,29)^2 \cdot 10 = 141,53 \text{ cm}^4$$

$$I_{y_C} = I_{y1} + a_1^2 A_1 + I_{y2} + a_2^2 A_2 = \frac{16}{3} + (1,8)^2 \cdot 4 + \frac{5}{6} + (0,7)^2 \cdot 10 = 23,19 \text{ cm}^4$$

$$I_{x_C y_C} = I_{x_1 y_1} + a_1 b_1 A_1 + I_{x_2 y_2} + a_2 b_2 A_2 = 1,8(-3,21) \cdot 4 + (-0,7)1,29 \cdot 10 = -32,14 \text{ cm}^4$$

$$\text{buerda: } I_{x_1 y_1} = 0 \quad \text{va} \quad I_{x_2 y_2} = 0$$

$$b_1 = -(y_C - f_1) = -(3,71 - 0,5) = -3,21 \text{ cm}; \quad b_2 = f_2 - y_C = 5 - 3,71 = 1,29 \text{ cm}$$

$$a_1 = u_1 - x_C = 3 - 1,2 = 1,8 \text{ cm}; \quad \text{va} \quad a_2 = -(x_C - u_2) = -(1,2 - 0,5) = -0,7 \text{ cm}$$

5.  $x_C$  va  $y_C$  o'qlarga bosh o'qlarning qiyalik burchagini aniqlaymiz

$$\text{tg } 2\alpha_0 = -\frac{2I_{x_C y_C}}{I_{x_C} - I_{y_C}} = -\frac{2(-32,14)}{141,53 - 23,19} = 0,543$$

$$\text{bundan } 2\alpha_0 = 28^0 30^1 \quad \text{va} \quad \alpha_0 = 14^0 15^1,$$

$$\sin \alpha_0 = 0,247; \quad \sin 2\alpha_0 = 0,4772; \quad \cos \alpha_0 = 0,969; \quad \cos 2\alpha_0 = 0,8788$$

6. Og'ishgan o'qlarga o'tish formulalaridan foydalanib bosh markaziy inertsia momentlarini hisoblaymiz:

$$I_{x_0} = I_{x_C} \cdot \cos^2 \alpha_0 + I_{y_C} \cdot \sin^2 \alpha_0 - I_{x_C y_C} \cdot \sin 2\alpha_0 = 149,64 \text{ cm}^4$$

$$I_{y_0} = I_{y_C} \cdot \cos^2 \alpha_0 + I_{x_C} \cdot \sin^2 \alpha_0 + I_{x_C y_C} \cdot \sin 2\alpha_0 = 15,08 \text{ cm}^4$$

$$I_{x_0 y_0} = \frac{I_{x_C} - I_{y_C}}{2} \sin 2\alpha_0 + I_{x_C y_C} \cdot \cos 2\alpha_0 = \frac{141,53 - 23,19}{2} 0,4772 - 32,14 \cdot 0,8788$$

Bosh inertsia momentlarining bittasi maksimal, ikkinchisi esa minimal qiymatga erishadi.

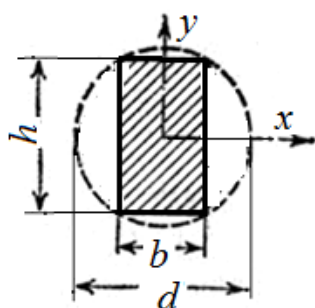
$$I_{\max}^{\min} = \frac{1}{2} \left[ (I_{XC} + I_{YC}) \pm \sqrt{(I_{XC} + I_{YC})^2 + 4 \cdot I_{XCYC}^2} \right] \text{ yoki}$$

$$I_{\max} = \frac{164,72 + 134,67}{2} = 149,69 \text{ cm}^4 \quad \text{va} \quad I_{\min} = \frac{164,72 - 134,67}{2} = 15 \text{ cm}^4$$

Arifmetik amallarni tekshirish:  $I_{XO} + I_{YO} = I_{XC} + I_{YC} = \text{const}$

$$149,64 + 15,08 = 141,53 + 23,19 = 154,72 \text{ cm}^4$$

**misol-20.** Diametri  $d$  bo'lgan yog'ochdan kesimi to'g'ri to'rtburchakli brus qirqib olinishi kerak. Brusni markaziy  $x$  o'qiga nisbatan qarshilik momentining mumkin bo'lgan katta qarshilik momentini e'tiborga olib kesimning  $h$  va  $b$  o'lchamlarini aniqlang.



**echish.** To'g'ri to'rtburchakni  $x$  o'qiga nisbatan

qarshilik momentini topamiz:  $W_x = \frac{bh^2}{6}$

To'g'ri to'rtburchakning diagonali doiraning diametriga teng, unda  $h^2 = d^2 - b^2$  ifodani qarshilik momenti formulasiga keklirib

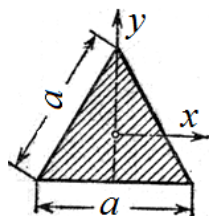
$$\text{qo'yamiz } W_x = \frac{b}{6}(d^2 - b^2)$$

Ushbu tenglikdan  $b$  bo'yicha hosila olib nolga tenglashtiramiz:

$$\frac{dW_x}{db} = d^2 - 3b^2 = 0$$

$$\text{buerdan } b = \frac{d}{\sqrt{3}} \quad \text{va} \quad h = \frac{\sqrt{2}}{\sqrt{3}} d. \quad \text{Nisbat } \frac{h}{b} = \sqrt{2}$$

$$\text{Qarshilik momentni hisoblaymiz } W_x = \frac{bh^2}{6} = \frac{d^3}{9\sqrt{3}}$$

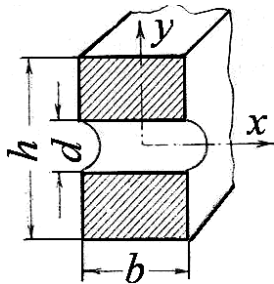


**misol-21.** Teng tomonli uchburchakni o'qlarga nisbatan inertiya momentlari hisoblansin.

$$\text{javob: } I_x = \frac{b h^3}{36} = \frac{a \cdot \left(\frac{a}{2}\sqrt{3}\right)^3}{36} = \frac{a^4}{96}\sqrt{3}$$

$$I_y = \frac{h \cdot b^3}{48} = \frac{\frac{a}{2}\sqrt{3} \cdot a^3}{48} = \frac{a^4}{96}\sqrt{3}$$

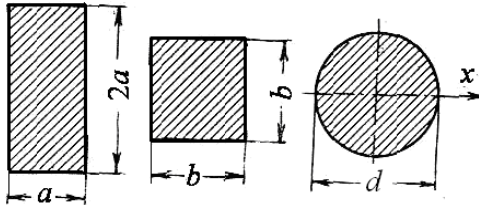
## Mustaqil echish uchun misollar



**misol-22.** Dumaloq teshik bilan zaiflashgan to'g'ri to'rtburchak brus kesimining bosh markaziy inertsia momentlari va qarshilik momentlari kattaligini aniqlang. O'lchamlar quyidagicha:  $\epsilon = 12 \text{ sm}$ ;  $h = 20 \text{ sm}$ ;  $d = 5 \text{ sm}$ .

**javob:**  $J_x = 7875 \text{ sm}^4$ ;  $J_y = 2160 \text{ sm}^4$ ;

$$W_x = 787,5 \text{ sm}^3; W_y = 360 \text{ sm}^3$$



**misol -23.** Agar uchala kesim yuzasi A bir xil bo'lsa to'g'ri to'rtburchak, kvadrat, doiraning kesimlari inertsia momentlari kattaligini markaziy o'q X ga nisbatan taqqoslang.

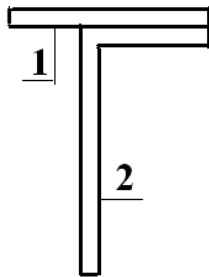
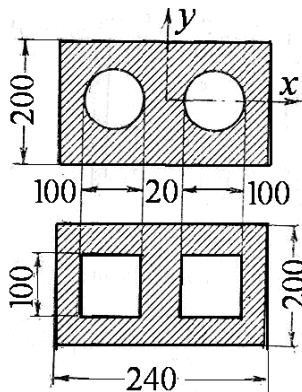
**misol-24.** Quyidagi ikki variantda loyihalangan to'g'ri to'rtburchak shaklli ikki kanalli trubaning bosh markaziy inertsia momentlarini hisoblang:

a) har birining diametri  $d = 10 \text{ sm}$  bo'lgan ikki dumaloq teshikli;

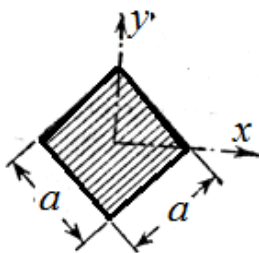
b) har birining o'lchami  $10 \times 10 \text{ sm}$  bo'lgan ikki kvadrat teshikli. Kesimlarining o'lchamlari mm da berilgan.

**javob:** a)  $J_x \approx 15000 \text{ sm}^4$ ,  $J_y \approx 16400 \text{ sm}^4$ ;

$$b) J_x \approx 14300 \text{ sm}^4, \quad J_y \approx 14200 \text{ sm}^4$$

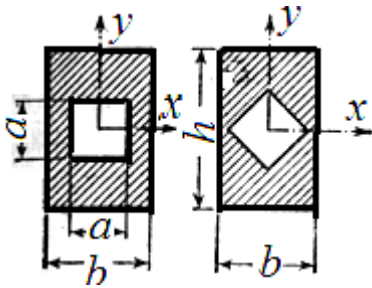


**misol -25.** Berilgan: list  $\epsilon_n \times h_n = 180 \times 25 \text{ (mm)}$  va shveller № 20dan tashkil topgan murakkab shaklli kesim yuzaning og'irlik markazi topilsin, markaziy o'qlarga nisbatan inertsia momentlari hisoblansin.



**misol-26.** Tomonlari  $a$  bo'lgan kvadrat x o'qiga nisbatan  $45^\circ$  ga aylantirganda, kesimning inertsia va qarshilik momentlari qanday o'zgaradi.

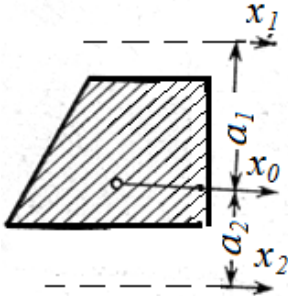
**javob:**  $W = 41\%$  ga o'zgaradi.



**misol-27.** Ichi yuvak to'g'ri to'rtburchakni bosh inertsiya momentlari, bosh inertsiya radiuslari va qarshilik momentlari hisoblansin. O'lchamlar:  $b=12\text{sm}$ ;  $h=20\text{sm}$ ;  $a=60\text{sm}$ . Agar ichki kvadrat  $45^\circ$  ga aylantirilsa xarakteristikalar qanday o'zgaradi,?

**javob:** a)  $I_x = 7892 \text{ cm}^4$ ;  $I_y = 2722 \text{ cm}^4$ ;

$W_x = 789,2 \text{ cm}^3$ ;  $W_y = 462 \text{ cm}^3$ ;  $i_x = 6,16 \text{ cm}$   $i_y = 3,64 \text{ cm}$ .



**misol-28.** Berilgan kesimni  $x_1$  o'qiga nisbatan inertsiya momenti berilgan bo'lsa,  $x_2$  o'qiga nisbatan inertsiya momenti topilsin.

**javob:**  $I_{x_2} = I_{x_1} + (a_2^2 - a_1^2) \cdot A$

### Ишқаланишга оид мисоллар.

**misol -29.** 1-valik klemmali birikmaga qo'zg'almas biriktirilgan.

Klemmali birikmaning tortish kuchi  $F$  topilsin. Valik bilan birikmaning stupitsasi orasidagi ishqalanish koeffitsienti  $f = 0,12$

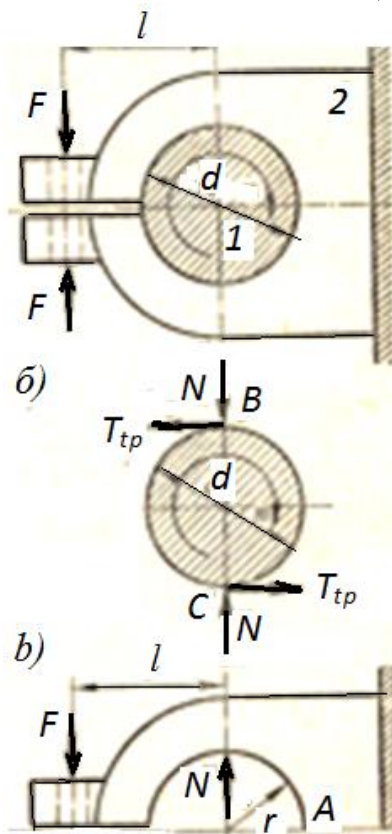
**echish.** Valik muvozanatda bo'lishi uchun ishqalanish kuchining momenti  $m$  tashqi momentga teng yoki undan katta bo'ladi. Ishqalanish kuchi valik bilan stupitsaning tegishli nuqtasiga qo'yiladi. Unda ishqalanish kuchining momenti

$$M_{\text{usuk}} = T \cdot d = f \cdot N \cdot d$$

$N$  -stupitsani tortish kuchi

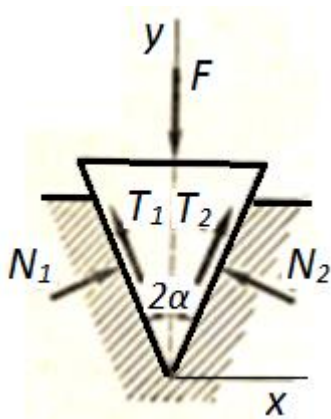
$$N = \frac{M_{\text{usuk}}}{f \cdot d}$$

Barcha kuchlarni  $A$  nuqtaga nisbatan momentini yozamiz



$$\sum M_A = 0 \quad -F\left(\ell + \frac{d}{2}\right) + N \cdot \frac{d}{2} = 0 \quad \text{yoki} \quad -F\left(\ell + \frac{d}{2}\right) + \frac{M_{\text{usuk}}}{f \cdot d} \cdot \frac{d}{2} = 0$$

bu erdan  $F = \frac{M_{\text{usuk}}}{f(2\ell + d)} = \frac{80 \cdot 10^3}{0,12(2 \cdot 30 + 30)} = 7,4 \cdot 10^3 \text{ N}$



**misol -30.**  $F = 10\kappa H$  kuch bilan klinga ta'sir qilinsa yog'och yoriladi. Yog'ochni klinga normal bosim kuchlari  $N_1$  va  $N_2$  topilsin? Metall klin bilan yog'och bo'yicha ishqalanish koeffitsienti  $f = 0,3$ .

**Echish.**  $N_1$  va  $N_2$  kuchlar ta'sirida

$$T_1 = f \cdot N_1 \text{ va } T_2 = f \cdot N_2$$

ishqalanish kuchlari hosil bo'ladi.

Muvozanat tenglamalarini tuzamiz:

$$\sum X = 0 \quad N_1 \cos \alpha - N_2 \cos \alpha - T_1 \sin \alpha + T_2 \sin \alpha = 0 \quad (16)$$

$$\sum y = 0 \quad N_1 \sin \alpha - N_2 \sin \alpha - T_1 \cos \alpha + T_2 \cos \alpha - F = 0 \quad (17)$$

$T_1$  va  $T_2$  kuchlarni e'tiborga olib quyidagilarni hosil qilamiz:

$$N_1(\cos \alpha - f \cdot \sin \alpha) - N_2(\cos \alpha - f \cdot \sin \alpha) = 0 \quad (18)$$

$$N_1(\sin \alpha + f \cdot \cos \alpha) + N_2(\sin \alpha + f \cdot \cos \alpha) = F \quad (19)$$

(18) tenglikdan  $N_1 = N_2$  hosil bo'ladi. Bu tenglikni (19) ga qo'ysak:

$$N_1 = N_2 = \frac{F}{2(\sin \alpha + f \cdot \cos \alpha)}$$

## KINEMATIKA

**Kinematika** deb, moddiy jism massasi va unga ta'sir qiladigan kuchlarni e'tiborga olmasdan, uning harakati geometrik nuqtai nazardan o'rganiladigan nazariy mexanikaning bo'limiga aytiladi.

Kinematikaning asosiy masalasi nuqtaning yoki qattiq jismning harakat qonunlarini o'rganishdan iborat

**Moddiy nuqta-** harakati yoki muvozanatini tekshirishda o'lchamlari va shaklining ahamiyati bo'lmagan, massasi bir nuqtada joylashgan deb tasavvur qilinadigan jism

**Absolyut qattiq jism-** kuch ta'siridagi jismning ixtiyoriy ikkita nuqtasi orasidagi masofa doimo o'zgarmasdan qoladi

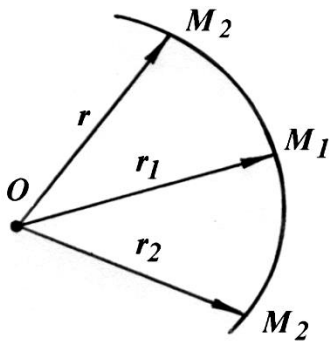
**Tezlik** - harakatni xarakterlovchi vektor kattalik, jismning tez yoki sekin va qaysi tomonga qarab harakat qilayotganligini ko'rsatadi.

**Tezlanish** - tezlikning moduli va yo'nalishi jihatidan o'zgarishini xarakterlovchi vektor kattalik

### Nuqta kinematikasi

Nuqtaning harakati asosan quyidagi uchta:

- 1) vektor;
- 2) koordinatalar;
- 3) tabiiy usulda beriladi.



### Nuqta harakatining vektor usulda berilishi.

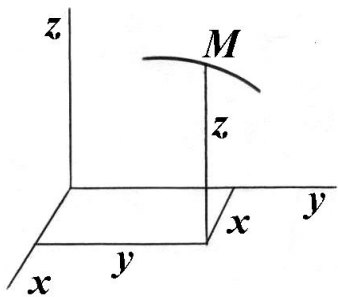
Harakatlanayotgan  $M$  nuqtaning har bir vaqtdagi holatini uning  $\vec{r}$  radius vektori bilan aniqlash mumkin. Harakat vaqtida uning fazoda qoldirgan iziga nuqta traektoriyasi deb aytiladi

Harakat tenglamasi  $\vec{r} = \vec{r}(t)$

Nuqtaning tezligi  $\vec{v} = \frac{d\vec{r}}{dt}$

Nuqtaning tezligini aniqlash uchun uning holatini aniqlovchi  $\vec{r}$  radius-vektordan vaqt bo'yicha birinchi tartibli hosila olish kerak. Tezlik vektori traektoriyaga urinma bo'yicha harakat sodir bo'ladigan tomonga yo'naladi. Tezlanish  $\vec{a} = \frac{d\vec{v}}{dt}$  yoki  $\vec{a} = \frac{d}{dt} \left( \frac{d\vec{r}}{dt} \right) = \frac{d^2\vec{r}}{dt^2}$

Nuqtaning tezlanishi uning tezligidan vaqt bo'yicha olingan birinchi tartibli hosilaga yoki radius-vektoridan vaqt bo'yicha olingan ikkinchi tartibli hosilasiga teng.



### Nuqta harakatining koordinatalar usulida berilishi .

Fazoda harakat qilayotgan  $M$  nuqtaning har bir vaqtdagi holatini uning uchta  $x$ ,  $y$ ,  $z$  dekart koordinatalari bilan aniqlash mumkin.

Harakat tenglamasi  $\left. \begin{aligned} x &= f_1(t) \\ y &= f_2(t) \\ z &= f_3(t) \end{aligned} \right\}$

Tezligi Dekart koordinata o'qlaridagi proektsiyalari bo'yicha aniqlanadi:

$$v_x = \frac{dx}{dt} = \dot{x}; \quad v_y = \frac{dy}{dt} = \dot{y}; \quad v_z = \frac{dz}{dt} = \dot{z};$$

bu erda  $v_x, v_y, v_z$  -  $v$  tezlikning  $x, y, z$  o'qlardagi proektsiyalari.

Nuqta tezligining qo'zgalmas Dekart koordinatalar o'qidagi proektsiyasi uning tegishli koordinatalaridan vaqt bo'yicha birinchi tartibli hosilasiga teng.

Nuqta tezligining miqdori (moduli)  $v = \sqrt{v_x^2 + v_y^2 + v_z^2}$

Tezlanish  $a_x = \frac{d^2x}{dt^2} = \ddot{x}, \quad a_y = \frac{d^2y}{dt^2} = \ddot{y}, \quad a_z = \frac{d^2z}{dt^2} = \ddot{z}$

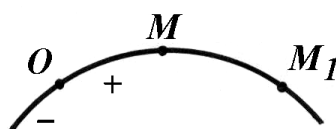
bu erda  $a_x, a_y, a_z$  -  $\vec{a}$  tezlanishining  $x, y, z$  o'qlardagi proektsiyalari.

Nuqta tezlanishining biror qo'zgalmas Dekart koordinatalar o'qidagi proektsiyasi nuqta tezligining mazkur o'qdagi proektsiyasidan vaqt bo'yicha olingan birinchi hosilasiga yoki shu o'qqa uning mos koordinatalaridan vaqt bo'yicha olingan ikkinchi tartibli hosilasiga teng



Nuqta tezlanishining moduli

$$a = \sqrt{a_x^2 + a_y^2 + a_z^2}$$



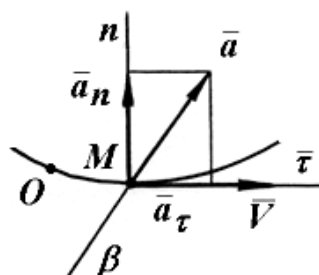
### Nuqta harakatining tabiiy usulda berilishi

$M$  nuqtaning traektoriyadagi har bir vaqtdagi holati sanoq boshi  $O$  nuqtaga nisbatan aniqlanadi

Harakat tenglamasi  $S = s(t)$

Tezligi  $v = \left| \frac{dS}{dt} \right|$

Nuqtaning tezligini aniqlash uchun uning holatini aniqlovchi  $S$  yoy koordinatasidan vaqt bo'yicha birinchi tartibli hosila olish kerak



Tezlanish

$$\bar{a} = \bar{a}_\tau + \bar{a}_n$$

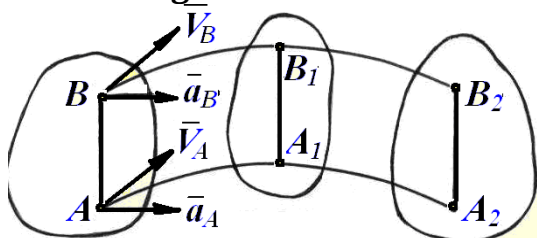
Urinma  $\bar{a}_\tau = \frac{dv}{dt}$  va normal  $\bar{a}_n = \frac{v^2}{\rho}$  tezlanish

To'la tezlanish

$$a = \sqrt{a_\tau^2 + a_n^2}$$

### Qattiq jismning oddiy xarakatlari

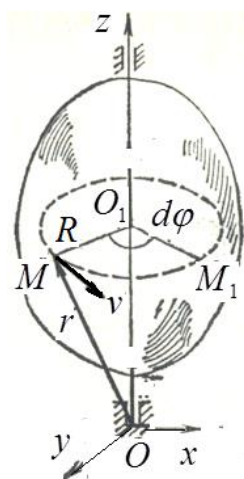
#### Ilgarilanma harakat



Ilgarilanma harakatdagi qattiq jismning hamma nuqtalari bir xil va parallel joylashgan traektoriyalar chizadi va har bir vaqtda ularning tezligi hamda tezlanishi teng bo'ladi.

$$\bar{V}_A = \bar{V}_B, \quad \bar{a}_A = \bar{a}_B$$

### Qo'zg'almas o'q atrofida aylanma harakat



Jism harakatlanganda uning ixtiyoriy ikki nuqtasi hamma vaqt qo'zg'almasdan qoladi. Jismni o'q atrofida harakatlanganda  $\varphi$  burchakka aylanadi

Mazkur burchak vaqtning uzluksiz funktsiyasi sifatida o'zgaradi:  $\varphi = f(t)$

**Aylanma harakatning burchak tezligi** - jismning burchak tezligi uning aylanish burchagidan vakt bo'yicha olingan birinchi tartibli hosilaga teng:  $\omega = \frac{d\varphi}{dt}$

Jism bir minutda  $n$  marotaba tekis aylanma harakatda

bo'lsa, burchak bo'lsa, burchak tezligi quyidagicha topiladi:  $\omega = \frac{\pi n}{30}$

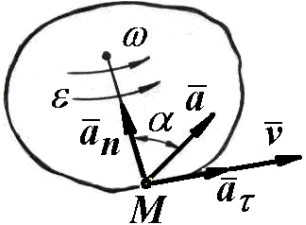
**Burchak tezlanish** - burchak tezlikdan vaqt bo'yicha olingan birinchi tartibli yoki aylanish burchagidan vaqt bo'yicha olingan ikkinchi tartibli hosilaga

teng:  $\varepsilon = \frac{d\omega}{dt} = \frac{d^2\varphi}{dt^2}$

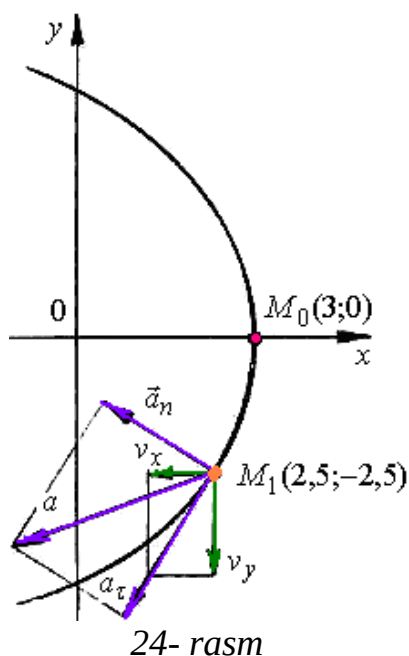
$\frac{d\omega}{dt} > 0$  - burchak tezlik orta boradi va bunday harakat tezlanuvchan aylanma harakat deyiladi

$\frac{d\omega}{dt} < 0$  - burchak tezlik kamaya boradi va bunday harakat sekinlatuvchi aylanma harakat deyiladi

Aylanma harakatdagi jism kinematikasi:

|                                                                                   |                      |                                             |                                                   |
|-----------------------------------------------------------------------------------|----------------------|---------------------------------------------|---------------------------------------------------|
|  | doiraviy tezlik      | normal tezanish                             | urinma tezanish                                   |
|                                                                                   | $V = \omega \cdot h$ | $a_n = \frac{V^2}{\rho} = \omega^2 \cdot h$ | $\dot{a}_t = \frac{dV}{dt} = \varepsilon \cdot h$ |

**misol-31.** Nuqta harakati berilganda uning tezlik va tezlanishi hamda nuqta traektoriyasining egrilik radiusi aniqlansin



Berilgan:  $x = -2t^2 + 3$   $t = \frac{1}{2}$  sek  
 $y = -5t$

**echish:** 1. Nuqta traektoriyasining tenglamasini aniqlaymiz. Buning uchun nuqta harakat tenglamasidan  $t$  -ni yo'qotamiz.

$$t = \frac{y}{-5} \text{ va } x = -2\frac{y^2}{25} + 3$$

Hosil bo'lgan tenglama parabola tenglamasi. Demak nuqtaning harakati davomida qoldirgan izi, ya'ni traektoriyasi parabola ekan.

2. Nuqtaning tezligini aniqlaymiz:  $V_x = -4t$

$$V_y = -5\frac{M}{c}$$

$$V = \sqrt{V_x^2 + V_y^2} = \sqrt{16 \cdot t^2 + 25} \text{ va } V_x = -2\frac{M}{c}, V_y = -5\frac{M}{c}, V = 5,6\frac{M}{c}$$

3. Nuqtaning tezlanishini aniqlaymiz:  $a_x = -4\frac{M}{c^2}; a_y = 0$

$$a = \sqrt{a_x^2 + a_y^2} = -4 \frac{M}{c^2}$$

4. Nuqtaning urinma tezlanishini aniqlaymiz:

$$a_\tau = \left| \frac{dV}{dt} \right| = \frac{V_x a_x + V_y a_y}{V} = \frac{(-2)(-4) + (-5) \cdot 0}{5,6} \approx 1,4 \frac{M}{c^2}$$

5. Nuqtaning normal tezlanishini aniqlaymiz.

$$a_n = \sqrt{a^2 - a_\tau^2} = \sqrt{16 - 1,96} \approx 3,8 \frac{M}{c^2}$$

6. Nuqtaning egrilik radiusini aniqlaymiz.  $\rho = \frac{V^2}{a_n} = \frac{29}{3,8} \approx 7,5 \text{ m}$

7. Nuqtaning  $t=0$  va  $t = \frac{1}{2}$  sekundlar davomidagi traektoriyadagi o'rnini aniqlaymiz:

$$t=0 \text{ bo'lganda } x_0 = 3 \quad y_0 = 0 \quad M_0(x_0 y_0) = M_0(3;0)$$

$$t = \frac{1}{2} \text{ bo'lganda } x_1 = 2,5 \quad y_1 = -2,5 \quad M_1(x_1 y_1) = M_1(2,5; -2,5)$$

**misol-32.** Nuqta harakati Dekart koordinatalarida quyidagi tenglamalar bilan berilgan:

$$X = 8 \sin\left(\frac{\pi \cdot t}{6}\right) - 2; \quad y = -4 - 6 \cos\left(\frac{\pi \cdot t}{3}\right)$$

bu erda  $X, Y$  - santimetr va  $t$  - sekundlar hisobida).

Nuqta traektoriyasining tenglamasi aniqlansin:  $t_1 = 1$  sekund vaqt uchun nuqtaning tezligi va tezlanishi, hamda uning urinma va normal tezlanishlari va traektoriyasining egrilik radiusi topilsin.

**echish.** 1) Nuqta traektoriyasining tenglamasini aniqlash uchun berilgan tenglamalaridan  $t$  vaqtni chiqaramiz. Trigonometrik funktsiya-lardan  $\cos 2\alpha = 1 - 2\sin^2 \alpha$ ,  $\cos\left(\frac{\pi \cdot t}{3}\right) = 1 - 2\sin^2\left(\frac{\pi \cdot t}{6}\right)$  foydalanamiz unda,

birinchi tenglama  $\frac{(X+2)^2}{64} = \sin^2 \frac{\pi \cdot t}{6}$  va ikkinchi tenglama

$\frac{y+10}{12} = \sin^2 \frac{\pi \cdot t}{6}$  ko'rinishga keltiriladi. Tenglamalarni o'ng tomonlarini

tenglashtirsak  $\frac{(X+2)^2}{64} = \frac{y+10}{12}$ ; hosil bo'lgan tenglikdan  $y$  ni topamiz.

$y = \frac{3}{16}(X+2)^2 - 10$  Bu tenglik nuqta traektoriyasining tenglamasidir. Demak, nuqtaning traektoriyasi paraboladan iborat ekan.

1) Tezlikni aniqlash. Nuqtaning tezligini koordinata o'qlaridagi proektsiyalari bo'yicha aniqlaymiz:

$$V_x = \frac{dX}{dt} = 8 \cos\left(\frac{\pi \cdot t}{6}\right) \frac{\pi}{6} = \frac{4}{3} \pi \cos\left(\frac{\pi \cdot t}{6}\right)$$

$$V_y = \frac{dy}{dt} = 6 \sin\left(\frac{\pi \cdot t}{3}\right) \frac{\pi}{3} = 2\pi \sin\left(\frac{\pi \cdot t}{3}\right)$$

$$t=1 \text{ sekundda. } V_x = 3,6 \frac{cM}{c} \quad \text{va} \quad V_y = 5,3 \frac{cM}{c} \quad V = 6,4 \frac{cM}{c}$$

3) Tezlanishni aniqlash. Nuqtaning to'la tezlanishini koordinata o'qlaridagi proektsiyalari bo'yicha aniqlaymiz:

$$a_x = \frac{d^2x}{dt^2} = \left[ \frac{4}{3} \pi \cos \frac{\pi \cdot t}{6} \right]' = -\frac{4}{3} \pi \sin\left(\frac{\pi \cdot t}{6}\right) \frac{\pi}{6} = -\frac{2}{9} \pi^2 \sin \frac{\pi \cdot t}{6}$$

$$a_y = \frac{d^2y}{dt^2} = \left[ 2\pi \sin \frac{\pi \cdot t}{3} \right]' = 2\pi \cos\left(\frac{\pi \cdot t}{3}\right) \frac{\pi}{3} = \frac{2}{3} \pi^2 \cos \frac{\pi \cdot t}{3}$$

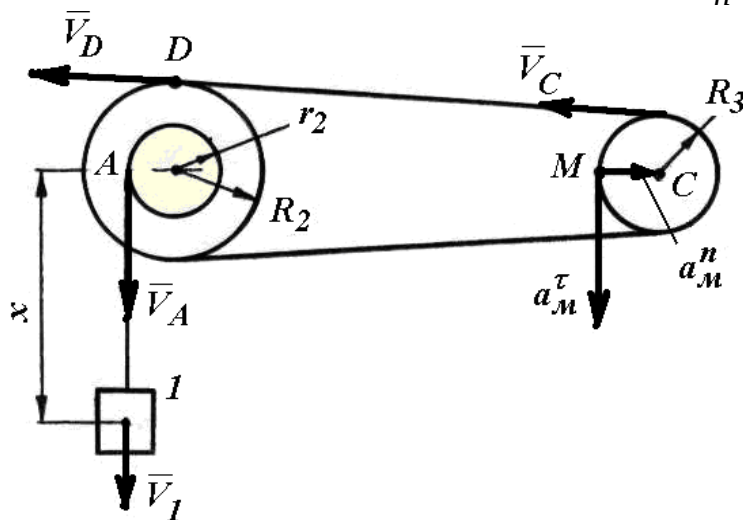
$$t=1 \text{ sekundda } a_x = -1,1 \frac{cM}{c^2} \quad a_y = 3,3 \frac{cM}{c^2} \quad a = 9,5 \frac{cM}{c^2}$$

Nuqtaning urinma tezlanishini quyidagi formula bilan aniqlaymiz:

$$a_r = \frac{V_x a_x + V_y a_y}{V} = \frac{3,6(-1,1) + 5,3 \cdot 3,3}{6,4} = 2,1 \frac{cM}{c^2}$$

Nuqtaning normal tezlanishini to'la va tezlanishlar bo'yicha aniqlaymiz:  $a_n = \sqrt{a^2 + a_r^2} = \sqrt{(12,1) + (2,1)^2} = 2,6 \frac{cM}{c^2}$

$$\text{Nuqta traektoriyasining egrilik radiusi: } \rho = \frac{V^2}{a_n} = \frac{41,05}{2,6} = 16 \text{ sm}$$



25 - rasm

**misol-33.** 1-yuk

$x = 10t^2 + 8t + 9$  qonun bo'yicha ilgarilanma harakat qiladi (25 - rasm).

**Berilgan:**  $R_2 = 40 \text{ cm}$ ,  $r_2 = 25 \text{ sm}$ ,  $R_3 = 20 \text{ sm}$ .

$t=t_1=1$  sekundda 3-shkiv gardishida yotgan  $M$  nuqtaning tezligi va tezlanishi aniqlansin. Bu erda  $x$ -santimetrlarda,  $t$ -sekundlar hisobida.

**echish:** Yukning harakat tenglamasidan vaqt bo'yicha hosila olib, birinchi-yukning tezligini aniqlaymiz.

$$V_1 = \frac{dx}{dt} = 20t + 8 \frac{cM}{c}$$

Birinchi yuk biriktirilgan arqonning osilgan qismi ilgarilanma harakat qilgani uchun  $V_A = V_1$ ; ikkinchi tomondan  $A$  nuqta qo'zg'almas o'q atrofida aylanuvchi 2-shkivga tegishli bo'lgani uchun  $V_A = \omega_2 \cdot r_2$ , bu

$$\text{tenglikdan: } \omega_2 = \frac{V_A}{r_2} = \frac{20t + 8}{r_2} c^{-1};$$

$SD$  tros ilgarilanma harakat qilgani uchun, unda yotgan  $C$  va  $D$  nuqtalarning tezliklari teng bo'ladi:  $V_C = V_D$ .

Ikkinchi tomondan bu nuqtalar, mos ravishda 2 va 3 shkivlarga tegishli bo'lib, ular bilan birga qo'zg'almas o'qlar atrofida aylanganligi uchun

$$V_D = \omega_2 \cdot R_2 \quad V_C = \omega_3 \cdot R_3$$

Demak,  $\omega_2 \cdot R_2 = \omega_3 \cdot R_3$  *ëku*  $\omega_3 = \frac{R_2}{R_3} \cdot \omega_2$  hosil bo'ladi: bunga  $R_2$ ,  $R_3$ ,  $r_2$ ,

qiymat qo'yib 3-shkiv burchak tezligining o'zgarish qonunini aniqlaymiz.

$$\omega_3 = 0,08(20t + 8)c^{-1}$$

uchinchi shkiv burchak tezlanishi:  $\varepsilon_3 = 0,08 \cdot 20 = 1,6c^{-2}$

$M$  nuqta tezligini aniqlaymiz.  $V_M = \omega_3 \cdot R_3 = 1,6 \cdot (20t + 8) \frac{M}{c}$

$t = t_1 = 1$  sekunda  $V_M = 1,6 \cdot 28 = 44,8 \frac{M}{c}$

$\vec{V}_M$  vektori 3-shkiv aylanishi yo'nalishiga mos ravishda  $M$  nuqta traektoriyasiga o'tkazilgan urinma bo'yicha yo'nalgan.

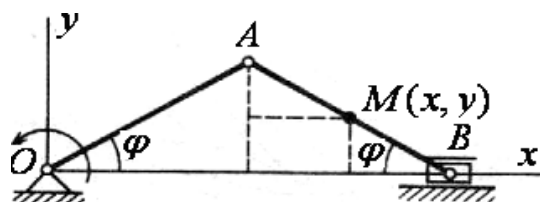
$M$  nuqtaning urinma va normal tezlanishlari topiladi:

$$a_M^{\tau} = \varepsilon_3 \cdot R_3 = 1,6 \cdot 20 = 0,32 \frac{M}{c^2}$$

$$a_M^n = \omega_3^2 \cdot R_3 = (2,24)^2 \cdot 20 = 5,02 \cdot 20 = 1 \frac{M}{c^2}$$

$M$  nuqtaning  $t = t_1 = 1$  sekunddagi to'la tezlanishini aniqlaymiz.

$$a = \sqrt{(a_M^{\tau})^2 + (a_M^n)^2} = \sqrt{(0,32)^2 + 1} = 1,05 \frac{M}{c^2}$$



26- rasm

**misol.- 34.** Krivoship  $OA$  qo'zg'almas o'q atrofida  $\varphi = 10t$  (26-rasm) burchakga aylanadi  $OA = AB = 0,8M$ . Agar boshlang'ich vaziyatda polzun chetki nuqtada bo'lsa shatundagi  $M$  nuqta va polzundagi  $B$  nuqta harakatining va

traektoriyasining tenglamasi tuzilsin.  $M$

**echish:**  $\varphi$  burchakga bog'liq ravishda  $M$  nuqta koordinatalarini topamiz:  $Y_M = MB \sin \varphi = 0,4 \sin \varphi$

$$X_M = OA \cos \varphi + AM \cos \varphi = 0,8 \cos \varphi + 0,4 \cos \varphi = 1,2 \cos \varphi$$

$M$  nuqtaning harakat tenglamasi  $X_M = 1,2 \cos 10t$   $Y_M = 0,4 \sin 10t$

$M$  nuqta traektoriya tenglamasini tuzish uchun harakat tenglamasidan vaqtni chiqaramiz. Harakat tenglamalarini o'zgartirib, kvadratga ko'taramiz:

$$\frac{X_M^2}{(1,2)^2} = \cos^2 10 \cdot t \quad \text{va} \quad \frac{Y_M^2}{(0,4)^2} = \sin^2 10 \cdot t$$

Hosil bo'lgan tengliklarni chap va o'ng qismlarini qo'shsak  $M$  nuqtaning traektoriya tenglamasi hosil bo'ladi.

$$\frac{X_M^2}{(1,2)^2} + \frac{Y_M^2}{(0,4)^2} = 1$$

$M$  nuqta uzunligi 1,2 va 0,4 m bulgan yarim o'qli ellips buylab harakat qiladi. Polzun-B-gorizontal  $X$  o'qi buylab harakat qilganligi uchun,  $Y_B = 0$ . Unda polzunni harakat tenglamasi.

$$X_B = OA \cos \varphi + AB \cos \varphi = 0,8 \cos \varphi + 0,8 \sin \varphi = 1,6 \cos \varphi$$

va  $X_B = 1,6 \cos 10t$  m

**misol-35.**  $R$  radiusli g'ildirak to'g'ri chiziqli rels bo'ylab sirpanmasdan yumaloqda, bunda uning  $O$  markazining tezligi  $v = 2 \frac{M}{c}$  ga teng

G'ildirakning vertikal va gorizontal diametrlari uchlarining tezligi topilsin.

**echish.** Misol shartiga binoan g'ildirak sirpanmasdan yumalaydi, shuning uchun g'ildirakning relsga

tegib turgan  $D$  nuqtasining tezligi nolga teng, binobarin,  $D$  nuqta g'ildirak tezliklarining oniy markazi bo'ladi.  $O$  nuqta tezligidan g'ildirakning burchak

tezligini topamiz:

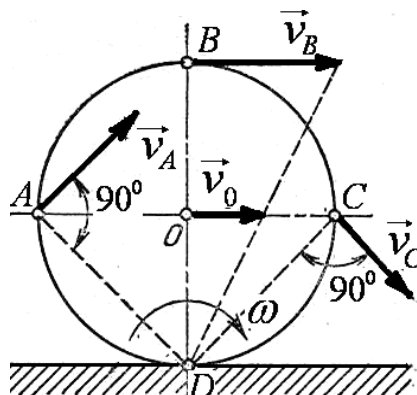
$$\omega = \frac{v_o}{OD} = \frac{v_o}{R}$$

Tezliklar oniy markazining xossalari asosida g'ildirak  $A, B$  va  $C$  nuqtalari tezliklarining modullarini topamiz.  $A, B$  va  $C$  nuqtalar tezliklarining vektorlari bu nuqtalarni tezliklarining oniy markazi bilan tutashtiruvchi to'g'ri chiziqlarga perpendikulyar yo'nalgan.

$$v_A = \omega \cdot AD = \frac{v_o}{R} \cdot R\sqrt{2} = 2\sqrt{2} = 2,83 \frac{M}{c}$$

$$v_B = \omega \cdot BD = \frac{v_o}{R} \cdot 2R = 2 \cdot 2 = 4 \frac{M}{c}$$

$$v_C = \omega \cdot CD = \frac{v_o}{R} \cdot R\sqrt{2} = 2\sqrt{2} = 2,83 \frac{M}{c}$$



**misol-36.** Nuqta  $xu$  tekisligida  $x = f_1(t)$ ,  $y = f_2(t)$  traektoriya bo'ylab harakatlanadi.  $t = 1$  sek. nuqtaning tezlik va tezlanishi hisoblansin. Misolni berilishi 2–jadvaldan olinsin.

jadval – 2

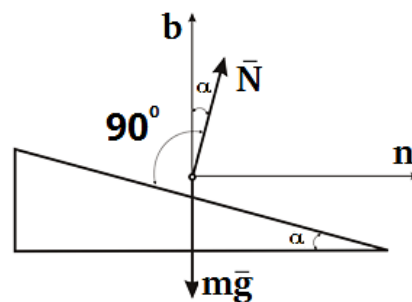
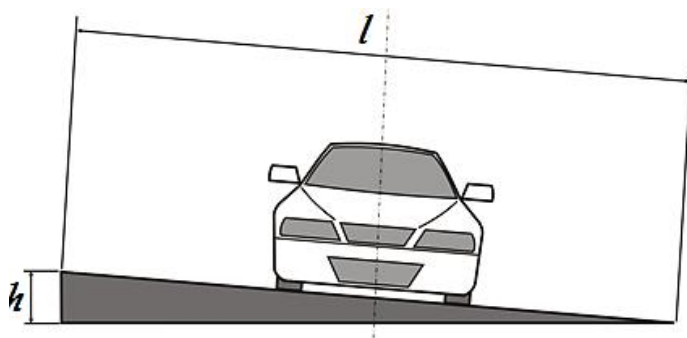
| № | $y = f_2(t)$                             | $x = f_1(t)$                                      | №  | $y = f_2(t)$     | $x = f_1(t)$ |
|---|------------------------------------------|---------------------------------------------------|----|------------------|--------------|
| 0 | $4-9\cos\left(\frac{\pi}{6}t\right)$     | $-4\cos\left(\frac{\pi}{3}t\right)$               | 11 | $t^2 - 2$        | $x = 4 - 2t$ |
| 1 | $2 - 3\cos\left(\frac{\pi}{3}t\right)$   | $10\sin\left(\frac{\pi}{6}t\right)$               | 12 | $t^2 + 2$        | $x = 2t + 4$ |
| 2 | $4 - 6\cos^2\left(\frac{\pi}{6}t\right)$ | $12\sin^2\left(\frac{\pi}{6}t\right)$             | 13 | $4 + 2t^2$       | $x = -2t$    |
| 3 | $12\cos\left(\frac{\pi}{6}t\right)$      | $2 - 4\sin\left(\frac{\pi}{6}t\right)$            | 14 | $2(t+1)^2$       | $x = 6t + 6$ |
| 4 | $9\cos\left(\frac{\pi}{3}t\right) + 5$   | $\frac{12}{\cos\left(\frac{\pi}{3}t\right) + 13}$ | 15 | $2 + 2(t^2 + 2)$ | $x = 2 - 5t$ |
| 5 | $-10\cos\left(\frac{\pi}{6}t\right)$     | $\cos\left(\frac{\pi}{6}t\right)$                 | 16 | $3t^2 + 2$       | $x = 2t + 4$ |
| 6 | $8\cos\left(\frac{\pi}{6}t\right) - 3$   | $3\sin\left(\frac{\pi}{6}t\right)$                | 17 | $3t^2 - 2$       | $x = -2t$    |
| 7 | $-9\cos^2\left(\frac{\pi}{6}t\right)$    | $6\cos\left(\frac{\pi}{3}t\right)$                | 18 | $3 - 4(t^2 + 2)$ | $x = 6t + 6$ |
| 8 | $6\cos\left(\frac{\pi}{3}t\right) - 4$   | $4 - 9\sin\left(\frac{\pi}{6}t\right)$            | 19 | $2t^2$           | $x = 2t + 4$ |
| 9 | $2 - 2\cos\left(\frac{\pi}{6}t\right)$   | $8\cos\left(\frac{\pi}{3}t\right) + 6$            | 20 | $t^2$            | $x = -2t$    |

**misol-37.** Poyga trassasining egri chiziqli uchastkalarida avtomobillar erkin qayrilib olishlari uchun yo'lining tashqi tomoni ichki tomoniga nisbatan balandroq quriladi. Agar yo'lining eni  $l = 12m$ , ko'tarilish balandligi  $h = 1m$ , egrilik radiusi  $\rho = 600m$  bo'lsa, bu uchastkada avtomobil bosimining yo'l polotnosiga tik yo'nalishi uchun u qanday tezlikda harakatlanishi lozim. (Avtomobil yo'lining o'rtasida harakatlanayapti deb qaralsin.)

**echish.** Yo'l qiyaligining trigonometrik kattaliklari

$$\sin \alpha = \frac{h}{\ell} = \frac{1}{12} = 0.0830 \quad \cos \alpha = \sqrt{1 - 0.083^2} = 0.9966$$





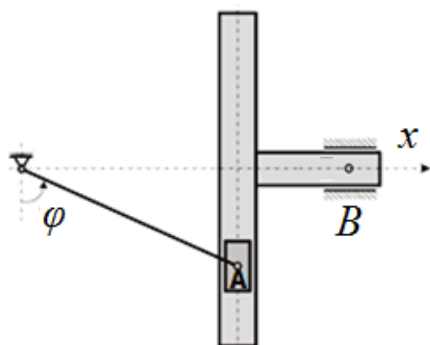
Nuqta xarakatining tabiiy usuldagi differentsial tenglamalaridan foydalanamiz.

$$ma_n = N \sin \alpha$$

$$0 = N \cos \alpha - mg \quad \text{Ikkinchi tenglamadan} \quad N = \frac{mg}{\cos \alpha};$$

Birinchi tenglamada  $a_n = \frac{v^2}{\rho}$ ; va  $m \frac{v^2}{\rho} = \frac{mg}{\cos \alpha} \sin \alpha$

$$v = \sqrt{\rho g \frac{\sin \alpha}{\cos \alpha}} = \sqrt{600 \cdot 9.8 \frac{0.0830}{0.9966}} = \sqrt{489.7} \approx 22.1 = 22.1 \frac{3600}{1000} \approx 80 \frac{\text{km}}{\text{soam}}$$



**misol-38.** Agar masofa  $OA = 0.5 \text{ m}$ , burchak esa  $\varphi = 13.082t$  bo'lsa, B nuqtaning  $t = 1s$  vaqt onidagi tezligi va tezlanishi aniqlansin.

**echish.** A nuqtani qutb usulida berilgan xarakat tenglamasini OB o'qqa proektsiyalab B nuqtaning xarakat tenglamasini xosil qilamiz.

$$x_B = OA \sin \varphi = 0.5 \sin(13.082t)$$

Tenglamadan vaqt bo'yicha xosila olib nuqtaning tezligini aniqlaymiz.

$$v_B = \frac{dx_B}{dt} = 0.5 \cdot 13.082 \cos(13.082t) = 6.54 \cos(13.082 \cdot 1) =$$

$$6.54 \cos(4.166\pi) = 6.54 \cos(750^\circ) = 6.54 \cos(750^\circ - 720^\circ) =$$

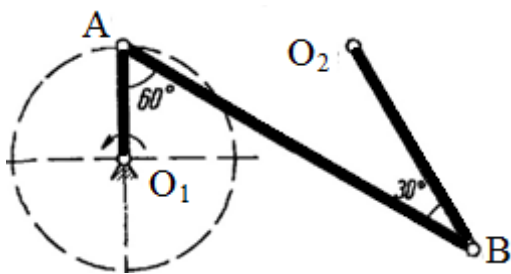
$$6.54 \cos 30^\circ = 6.54 \cdot 0.87 = 5.7 \text{ m/c}$$

Nuqtaning tezlanishi

$$a_B = \frac{dv_B}{dt} = -6.54 \cdot 13.082 \sin(13.082t) = -85.55 \sin(13.082 \cdot 1) =$$

$$-85.55 \sin(4.166\pi) = -85.55 \sin(750^\circ) = -85.55 \sin(750^\circ - 720^\circ) =$$

$$-85.55 \sin 30^\circ = -85.55 \cdot 0.5 = -42.8 \text{ m/c}^2$$



**misol-39.**  $O_1A=20$  krivoship 120 ayl/min bilan harakatlanadi va  $AB =100$  sm zveno yordamida  $O_2$  nuqtaga sharnirli mahkamlangan  $O_2B=60$  sm zvenoni harakat lantiradi. Krivoship  $O_1A$  vertikal holatga kelganda  $AB$  vertikal bilan  $\angle O_1AB=60^\circ$  va  $\angle ABO_2=30^\circ$  burchak tashkil qilisa bu holatdagi  $AB$  va  $O_2B$  sterjenlarning burchakli tezliklari aniqlansin.

## DINAMIKA

Dinamika deb, jismlarning mexanik harakatini ularning massasiga va harakatni vujudga keltiruvchi kuchlarga bog'liq ravishda tekshiradigan nazariy mexanikaning bo'limiga aytiladi.

Dinamikaning masalalari:

**1 - masala (to'g'ri masala).** Nuqtaning massasi va harakatining tenglamalari berilgan. Nuqtaga ta'sir kiluvchi kuchni topish kerak.

**2.-masala (teskari masala).** Nuqtaning massasi va shu nuqtaga ta'sir etuvchi kuch berilgan. Nuqta harakatining tenglamalarini aniqlash kerak.

Ushbu masalalar dinamikaning asosiy qonuni bilan echiladi.

Agar, erkin nuqtaga faqat bita kuch ta'sir qilsa dinamikaning asosiy qonuni

$m \cdot \bar{a} = F$  va bir qancha kuchlar ta'sir qilsa

$$m \cdot \bar{a} = \sum_{K=1}^n F_K$$

Dalamber printsiipi - agar aktiv kuch va bog'lanish reaksiya kuchi  $N$  ta'siridagi nuqtaga har onda  $F^{uh}$  inertsia kuchini qo'ysak, bu kuchlar o'zaro muvozanatlashadi

$$\bar{F} + \bar{N} + \bar{F}^{uh} = 0$$

Egri chiziqli harakatda inertsia kuchi normal va urinma inertsia kuchlaridan tashkil topadi:

normal  $F_{un}^n = m \frac{v^2}{\rho}$  va tangentsial inertsia kuchi  $F_{un}^\tau = m \frac{dv}{dt}$

**Ish va quvvat.**  $F$  kuchning  $s$  yo'ldagi ta'sirini  $F_x$  tashkil etuvchi bilan aniqlaymiz.

$$A = F_x \cdot s = F \cdot s \cdot \cos \alpha$$

Og'irlik kuchining bajargan ishi  $A = \pm mgh$

Aylanayotgan jismga qo'yilgan kuchning ishi  $A_p = M \cdot \varphi$

Quvvat  $N = F \cdot v$

Aylanayotgan jismga qo'yilgan kuch quvvati aylantiruvchi moment bilan burchak tezligining ko'paytmasiga teng:  $N = M \cdot \omega$

Agar quvvat ot kuchida o'lcansa aylantiruvchi moment quyidagicha topiladi:

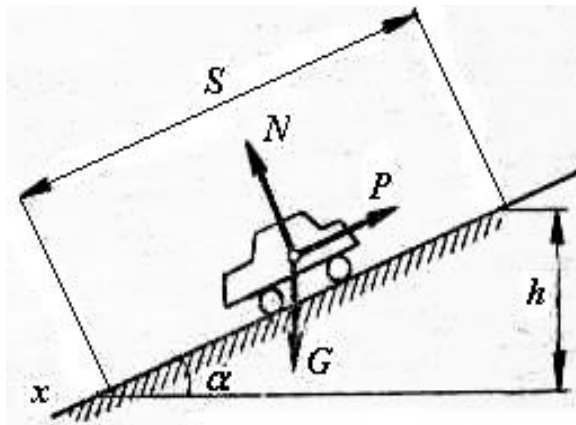
$$M = 7162 \frac{N}{\pi \cdot n} (H_M)$$

Agar bir ot kuchi 0,73562 kVt bo'lsa aylantiruvchi moment quyidagicha topiladi:

$$M = 9736 \frac{N}{n} (H_M)$$

**Foydali ish koeffitsienti.** Mexanik uzatmalarda umumiy FIK, xususi uzatmalar FIK-ning ko'paytmasiga teng:  $\eta = \eta_1 \cdot \eta_2 \cdot \eta_3 \cdot \eta_4 \cdots$

**misol.** -40. Avtomobil qiyaligi  $\alpha = 15^\circ$  bo'lgan tog' yo'lida  $18 \frac{m}{c}$  tezlik bilan harakatlanadi. Avtomobilni harakatiga tormozlanish kuchini og'irlik kuchining 0,3 qismiga teng deb, boshqa qarshilik kuchlarini e'tiborga olmasdan, tormozlanish boshlangandan keyin qancha masofada va vaqtda avtomobil to'xtaydi (27 – rasm).



27- rasm

**echish.** Moddiy nuqta deb qabul qilingan avtomobilga og'irlik kuchi -  $G$ , yo'lni normal reaksiyasi -  $N$ , tormozlashdan qarshilik kuchi -  $P$  ta'sir qiladi. Tormozlanish masofasi -  $S$  ni topish uchun kinetik energiya tenglamasini tadbiq etamiz.

$$A = U = \frac{mv^2}{2} - \frac{mv_0^2}{2}, \text{ lekin } v = 0 \text{ va}$$

$$v_0 = 18 \frac{m}{c}$$

Moddiy nuqtaga qo'yilgan teng ta'sir qiluvchi kuchni bajargan ishi, tashkil etuvchi kuchlarni bajargan ishlarining algebraik yig'indisiga teng.

$$A = A_G + A_p + A_N$$

buerda:  $A_G$  - og'irlik kuchining ishi;

$A_p$  - tormozlash kuchining ishi;

$A_N$  - normal reaksiya ishi,  $A_N = 0$ , chunki  $N$  harakat yo'nalishiga perpendikulyar.

$$A_G = Gh = mgS \sin \alpha \text{ va } A_p = -PS = -0,3GS = -0,3mgS$$

$$\text{Demak, } A = mgS \sin \alpha - 0,3mgS = mgS(\sin \alpha - 0,3).$$

$$\text{Unda kinetik energiya } -\frac{mv_0^2}{2} = mgS(\sin \alpha - 0,3) \text{ va } \frac{v_0^2}{2} = gS(0,3 - \sin \alpha)$$

Tenglamadan 
$$S = \frac{v_0^2}{2g(0,3 - \sin \alpha)} = \frac{18^2}{2 \cdot 9,81(0,3 - 0,258)} = 395 \text{ m}$$

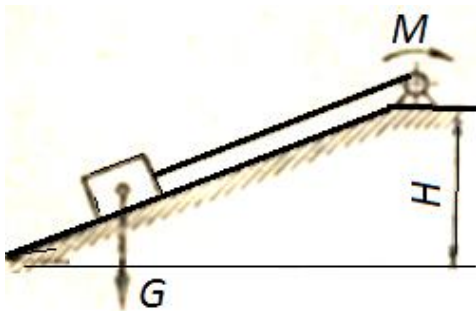
Tormozlash vaqtni aniqlash uchun nuqta harakatining miqdori teoremasidan foydalanamiz.  $mv - mv_0 = \sum Ft$ , lekin  $v = 0$  va

$\sum Ft$  - avtomobilga ta'sir qiluvchi impuls

$$\sum Ft = (G \sin \alpha - P)t = (mg \sin \alpha - 0,3mg)t = mg(\sin \alpha - 0,3)t$$

Unda  $-mv_0^2 = mgt(\sin \alpha - 0,3)$  yoki  $v_0 = gt(0,3 - \sin \alpha)$

Buerda: 
$$t = \frac{v_0}{g(0,3 - \sin \alpha)} = \frac{18}{9,81(0,3 - 0,258)} = 44 \text{ s}$$



**misol -41.** Elektrolebedka yordamida massasi  $m=500 \text{ kG}$ . Bo'lgan yuk qiya tekislikda  $H=10 \text{ m}$  balandlikga  $t=2 \text{ min}$  ko'tariladi. Lebedkaning barabanidagi aylantiruvchi moment  $M=250 \text{ Hm}$ . Barabanning aylanish chastotasi

$$n = 30 \frac{\text{ayl}}{\text{min}}$$

Foydali ish koeffitsient topilsin.

**echish.** Foydali ish koeffitsient 
$$\eta = \frac{A_\phi}{A_\delta}$$

buerda,  $A_\phi$  - foydali ish va  $A_\delta$  - harakatlantiruvchi kuch bajargan ish. Foydali ish og'irlik kuchining ishi bilan topiladi

$$A_\phi = G \cdot H = mgH = 500 \cdot 9,81 \cdot 10 = 4,91 \cdot 10^4 \text{ Дж}$$

Harakatlantiruvchi kuchning ishi lebedka barabanadiga aylantiruvchi moment ishiga teng  $A_\delta = M \cdot \varphi$

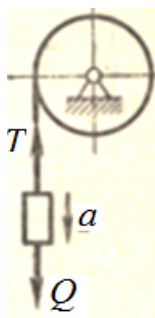
Barabanni aylanish burchagi  $\varphi = \omega \cdot t$

buerda, 
$$\omega = \frac{\pi \cdot n}{30} = \frac{\pi \cdot 30}{30} = \pi, \frac{\text{p}}{\text{c}}; \quad t = 2 \text{ min} = 120 \text{ секунд}$$

unda, 
$$\varphi = \pi \cdot 120 = 377 \text{ рад}$$

$$A_\delta = M \cdot \varphi = 250 \cdot 377 = 94,2 \cdot 10^3 \text{ Hm} = 94,2 \cdot 10^3 \text{ Дж}$$

FIK 
$$\eta = \frac{A_\phi}{A_\delta} = \frac{4,91 \cdot 10^4}{94,2 \cdot 10^3} = 0,521$$



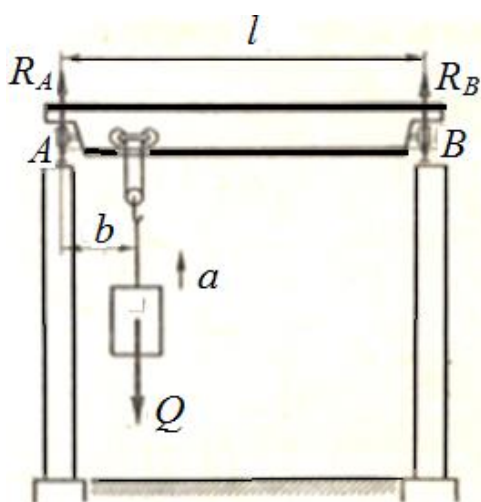
**misol-42.**  $Q=280$  kN og'irlikdagi kareta tekis tezlanishli harakatda tushmoqda. Birinchi 10 s.da u  $s = 3,5$  m masofani bosib o'tadi. Kanatning taranglik kuchi topilsin?

**echish.** Karetaga og'irlik kuchi  $Q$  va kanatning taranglik kuchi  $T$  ta'sir etadi. Unda kanatning taranglik kuchi

$$T = Q - F_{HH} = Q - ma = Q - \frac{Q}{g} \cdot a = Q \left(1 - \frac{a}{g}\right)$$

Tezlanishni  $s = \frac{at^2}{2}$  formuladan topamiz:  $a = \frac{2s}{t^2} = \frac{2 \cdot 3,5}{10^2} = 0,07 \frac{m}{c^2}$

Taranglik kuchi  $T = 280 \cdot \left(1 - \frac{0,07}{9,81}\right) = 278 \text{ kH}$



**misol-43.** Kran balkasida yuk ko'tarish qobiliyati  $m=10^4$  kG. bo'lgan telfer telejkasi harakatlanadi. Telejkani

ko'rsatilgan vaziyatida yukni  $a = 6,5 \frac{m}{c^2}$

tezlanish bilan ko'taradi. Dinamik reaksiya kuchlari topilsin?

**echish.** Qo'shimcha reaksiya kuchlari inertsia kuchi ta'sirida hosil bo'ladi.

$$F_{HH} = ma = 10^4 \cdot 6,5 = 65 \cdot 10^3 \text{ H} = 65 \text{ kH}$$

$F_{HH}$  - inertsia kuchi pastga yo'nalgan, chunki yuk yuqoriga  $a$  tezlanish bilan ko'tariladi.

Balkani bog'lanishlardan ozod etib ularning ta'sirini reaksiyalar bilan almashtiramiz.

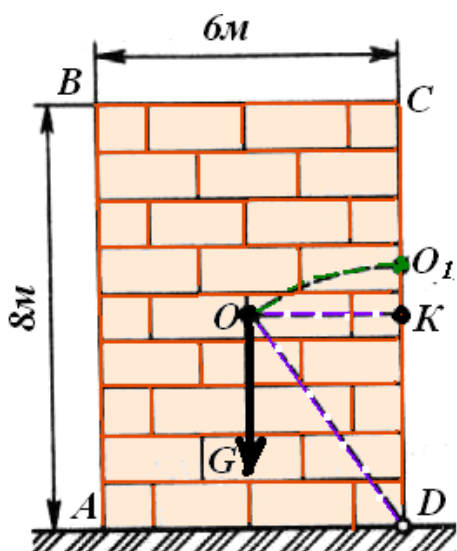
Muvozanat tenglamalarini tuzamiz.

$$\sum M_A = 0 \text{ yoki } -F_{HH} \cdot b + y_B \cdot \ell = 0 \text{ va}$$

$$y_B = F_{HH} \frac{b}{\ell} = 65 \cdot \frac{3}{18} = 10,8 \text{ H}$$

$$\sum M_B = 0 \text{ yoki } F_{HH} \cdot (\ell - b) - y_A \cdot \ell = 0 \text{ va}$$

$$y_A = F_{HH} \frac{\ell - b}{\ell} = 65 \cdot \frac{15}{18} = 54,2 \text{ H}$$



28 - rasm

**misol -44.** Bir jinsli  $ABCD$  massiv  $m = 4080 \text{ kg}$  massaga ega va chizmada ko'rsatilgan o'lchamlarga ega (28-rasm). Massivni  $D$  nuqta atrofida ag'darish uchun bajarilgan ish hisoblansin.

**echish.** Massiv og'irligini aniqlaymiz:

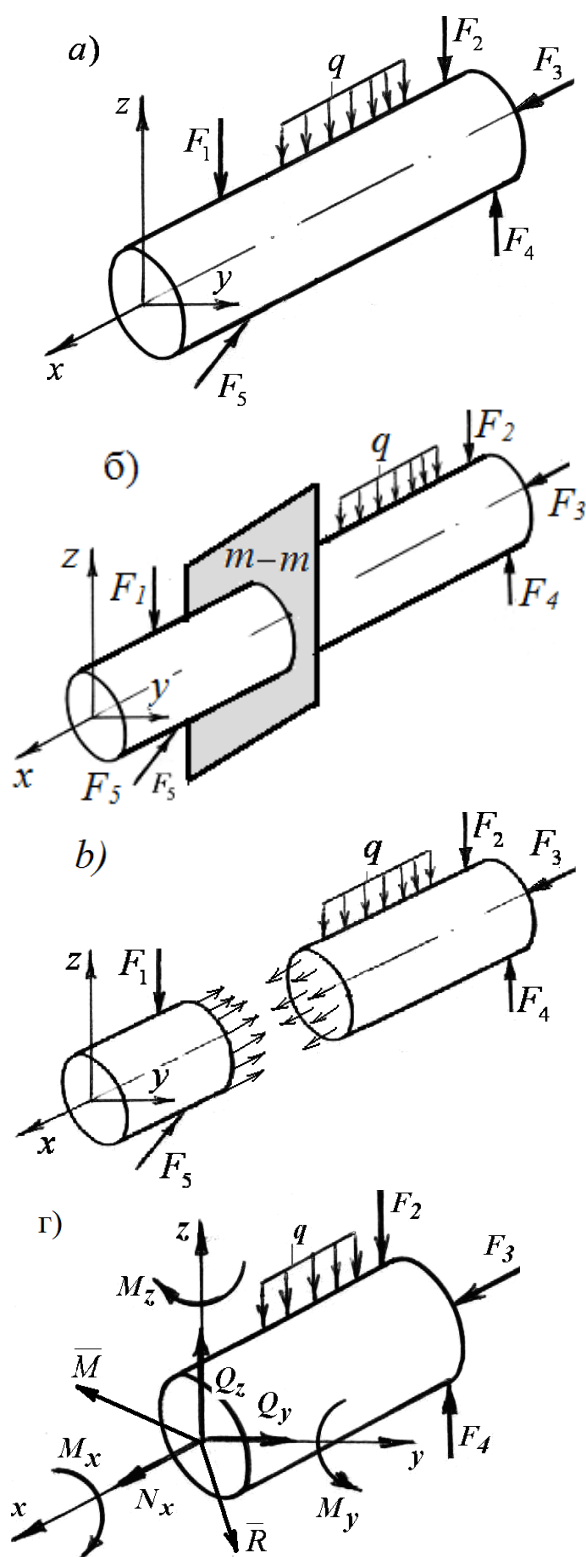
$$G = mg = 4080 \cdot 9,81 = 40 \cdot 10^3 \text{ H} = 40 \text{ kH}$$

Massivni ag'darish uchun sarflangan kuch og'irlik kuchiga teng. Massivni ag'darish uchun uning  $O$  og'irlik markazini  $O_1$  vaziyatga o'tkazish kerak. Shundan keyin massiv og'irlik kuchi ta'sirida ag'dariladi, va og'irlik (qarshilik) kuchi harakatlantiruvchi kuchga aylanadi.

$$W = GKO_1 = G(OD - KD) = G\sqrt{OH^2 + KD^2} - KD =$$

$$40 \cdot 10^3 (\sqrt{3^2 + 4^2} - 4) = 40 \cdot 10^3 \text{ Дж} = 40 \text{ кДж}$$

## II –BOB. MATERIALLAR QARSHILIGI



**Ichki kuch faktorlarini aniqlash.** Ichki kuch - tashqi kuch ta'sirida kelib chiqadi. Qattiq jismning mustahkamligi undagi zarrachalarning o'zaro tortishish kuchlari bilan ifodalanadi.

Zarrachalar muvozanatini saqlovchi reaksiya kuchlari ichki kuchlar deyiladi. Ichki kuch deb, tashqi kuch ta'sirida zarrachalar o'zaro ta'sirining intensivlashuviga aytiladi.

Ichki kuchlar tashqi kuch va materialning fizik - mexanik xossalriga bog'liq bo'ladi. Konstruktsiya qismlarining mustahkamligi va bikrligini ta'minlashda ichki kuch katta rol o'ynaydi

**Kesish usuli.** Ichki kuch faktorlari— bosh vektor va bosh momentni koordinata o'qlaridagi tashkil qiluvchilari bo'lib vektor kattalik.

2.1 – rasm. Kesish usuli:  
 a) brusning umumiy yuklanish sxemasi; b) brusni kesish;  
 b)bruni kesilgan yuzasida ichki kuchlarni ko'rinishi; g) brusning kesilgan yuzasida ichki kuch faktorlarining ko'rinishi

Ichki kuch faktorlari biror jismni kesilgan yuzasiga tasir qilmaydi, balki ushbu yuzada tashqi kuch tasiridan hosil bo'ladi. Ichki kuchni aniqlash uchun kesish usulidan foydalanamiz. Berilgan tashqi kuchlar ta'sirida muvozanatda bo'lgan brusning (2.1– rasm ,a) ixtiyoriy tanlangan kesim yuzasidagi ichki kuchlarni aniqlash uchun, uni shu kesim yuzasidan  $m - m$  tekisligi bilan kesib



ikki qismga ajratamiz. Ajratilgan brus bir qismining ikkinchi qismiga ta'siri o'zaro teng va qarama – qarshi tomonlarga yo'naladi (2.1–rasm, b ). Brusning bir qismini tashlab yuboramiz. Natijada, brusning olib qolingani qismida tashlab yuborilgan qismning ta'siri yo'qotilishi evaziga uning muvozanati buziladi. Bu qismning muvozanatini ta'minlash uchun uning kesilgan yuzasiga tashlab yuborilgan qism ta'sirini bosh kuch vektori  $\bar{R}$  va bosh moment vektori  $\bar{M}$  ko'rinishida keltirilishi lozim (2.1– rasm, g ). Bosh kuch vektori va bosh moment vektori olib qolingani qism uchun ichki kuch hisoblanadi.  $\bar{R}$  va  $\bar{M}$  - ni XYZ o'qlarida tashkil etuvchilar  $N_x, Q_y, Q_z, M_x, M_y, M_z$  -ga ajratamiz:

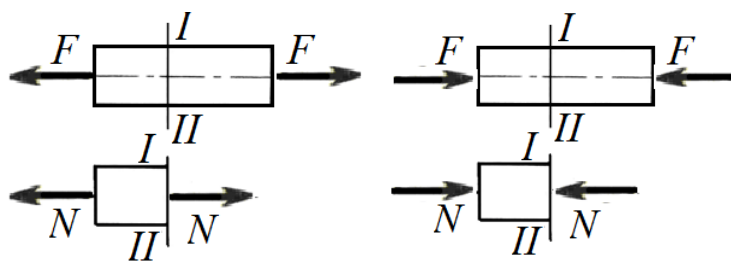
$N_x, Q_y, Q_z, M_x, M_y, M_z$  –ichki kuch faktorlari deyiladi. Ichki kuch faktorlarini topish uchun brusning ajratilgan qismidagi barcha kuchlardan muvozanat shartlari tuziladi.

$$\sum X = 0 \quad \sum U = 0 \quad \sum Z = 0 \quad \sum M_x = 0 \quad \sum M_y = 0 \quad \sum M_z = 0$$

### CHO'ZILISH VA SIQILISH

Markaziy cho'zilish va siqilishda sterjenning ko'ndalang kesimida faqat bir xil ichki kuch – faktori -bo'ylama kuch  $N$  hosil bo'ladi.

Cho'zilish va siqilishda ichki bo'ylama kuch – brusning ko'ndalang kesimidagi barcha normal kuchlarning teng ta'sir etuvchisi. *Bo'ylama kuch – brusning kesilgan ko'ndalang kesimidan bir tomonda olib qolingani tashqi kuchlarni ushbu kesimning bo'ylama o'qiga proektsiyalarining algebraik yig'indisiga teng.* Amaliyotda uchraydigan konstruktsiya qismlarining ko'pchiligi ko'ndalang kesimda hosil bo'ladigan ichki cho'zuvchi yoki siquvchi bo'ylama kuchlarini kesish usulidan foydalanib, sistemaning ajratilgan bo'lagini muvozanat shartidan topiladi.



Ushbu rasmlarda bruslarning cho'zilish yoki siqilishiga oid eng oddiy misollar keltirilgan. Bruslarning ixtiyoriy kesimidagi ichki bo'ylama  $N_x$  kuchlarini kesish usuli bilan

topilgan. Ulardan birinchisi brusni cho'zadi va kesim yuzasidan brusni tashlab yuborilgan tomoniga yo'nalgan. Bunday kuchni musbat ishorali deb qabul qilamiz.

Ikkinchi  $N_x$  kuch kesim yuza tomon yo'nalgan va u brusni olib folingan qismini siqadi. Bunday kuchni manfiy ishorali deb qabul qilamiz. Cho'zuvchi va siquvchi bo'ylama kuchlarning bunday yo'nalishi va ishorasini qoida sifatida qabul qilamiz.

Agar brus o'qi bo'ylab, unga bir qancha kuchlar qo'yilgan bo'lsa, uning ixtiyoriy ko'ndalang kesimidagi ichki bo'ylama kuchlarni topish uchun kesish

usulidan foydalanamiz.

Brusning ixtiyoriy ko'ndalang kesimidagi bo'ylama kuch  $N_X$  brusning qoldirilgan qismiga ta'sir qiluvchi barcha kuchlarning brus o'qiga tushirilgan proektsiyalarining algebraik yig'indisiga teng.

$$N_X = \sum_{\kappa=1}^n F_{KX}$$

bu erda  $\sum_{\kappa=1}^n F_{KX}$  - barcha kuchlarning brus o'qiga tushirilgan proektsiyalarining algebraik yig'indisi  
 $n$  - tashqi kuchlar soni.

**Cho'zilish va siqilishda mustahkamlik shart.** Konstruktsiyada xavfli holatni cheklash uchun elementining qesim yuzasidagi eng katta normal kuchlanish  $\sigma_{\max}$ , shu konstruktsiya materiali uchun ruxsat etilgan kuchlanishdan katta bo'lmasligi kerak, ya'ni  $\sigma_{\max} \leq [\sigma]$  yoki

$$\sigma_{\max} = \frac{N_{\max}}{A} \leq [\sigma] \quad (2.1)$$

(2.1) formula cho'zilish yoki siqilishda mustahkamlik shart

Ruxsat etilgan kuchlanish konstruktsiyani xavfsiz ishlashini ta'minlaydi va uning qiymati konstruktsiyaning materialiga bog'liq.

Cho'zilish va siqilishda loyihaviy hisoblashda sterjennning

kesimi tanlanadi:  $A \geq \frac{F}{[\sigma]} \quad (2.2)$

Ruxsat etilgan yuk hisoblanadi:  $F_{pyx} = [\sigma] \cdot A \quad (2.3)$

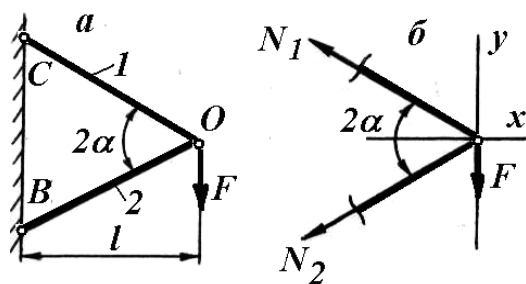
### **Cho'zilish va siqilishda statik aniq va noaniq masalalar**

Inshoot konstruktсийalarini cho'zilish va siqilishga hisoblashda asosan, ularning ichki bo'ylama kuchlari, kesim yuzasidagi normal kuchlanish va bo'ylama uzayishlari aniqlanadi. Masalani qo'yilish vazifasiga ko'ra konstruktsiyaning mustahkamlik shartiga binoan kesim yuzasi tanlanishi, yoki ruxsat etilgan yuk hisoblanishi mumkin. Ushbu masalalarni echishda konstruktsiyadagi noma'lum reaksiya va ichki kuchlar sonini statikaning muvozanat tenglamalari soniga teng yoki ko'pligiga ko'ra, cho'zilish va siqilishda statik aniq va statik noaniq masalalar mavjud.

Amaliyotda uchraydigan konstruktsiya qismlarining ko'pchiligida ko'ndalang kesimda hosil bo'ladigan ichki cho'zuvchi yoki siquvchi o'ylama kuchlarni kesish usulidan foydalanib, sistemaning ajratilgan bo'lagini muvozanat shartini tuzish usuli bilan topish mumkin. Bunday masalalar statik aniq masalalar deyiladi.

## Statik aniq misollarni echish.

**misol–2.1.** C va B nuqtalari tayanchda va O nuqtada  $F$  kuch bilan yuklangan sterjenlar sistemasining ichki bo'ylama kuchlari aniqlansin ( 2.2–rasm )



2.2 – rasm. Sterjenlar sistemasini yuklanishi:

a)  $F$  kuchni qo'yilishi; b) ichki kuchlar va  $F$  kuchni qo'yilishi

**echish.** Sterjenlarni bo'ylama o'qiga tik tekislik bilan ixtiyoriy kesimdan qirqib ikki qismga ajratamiz va tayanch qismini tashlab yuboramiz, olib qoling har bir sterjenga tashlab yuborilgan qism ta'sirini almashtiruvchi  $N_1$  va  $N_2$  kuchlarni qo'yamiz. Sistemaning muvozanat shartini ta'minlovchi ikkita tenglama tuzamiz

$$\sum x = -N_1 \cos \alpha - N_2 \cos \alpha = 0 \quad (a)$$

$$\sum y = N_1 \sin \alpha - N_2 \sin \alpha - F = 0 \quad (b)$$

(a) tenglamadan  $N_1 = -N_2$  tenglikni (b) shartga keltirib qo'ysak,

$$N_2 = \frac{F}{2 \sin \alpha} \quad \text{va} \quad N_1 = \frac{F}{2 \sin \alpha}$$

Ichki bo'ylama kuchlar hisoblangandan keyin berilgan misolning qolgan shartlari echiladi. Ushbu shartlar to'g'risida ma'lumot keyingi mavzularda beriladi.

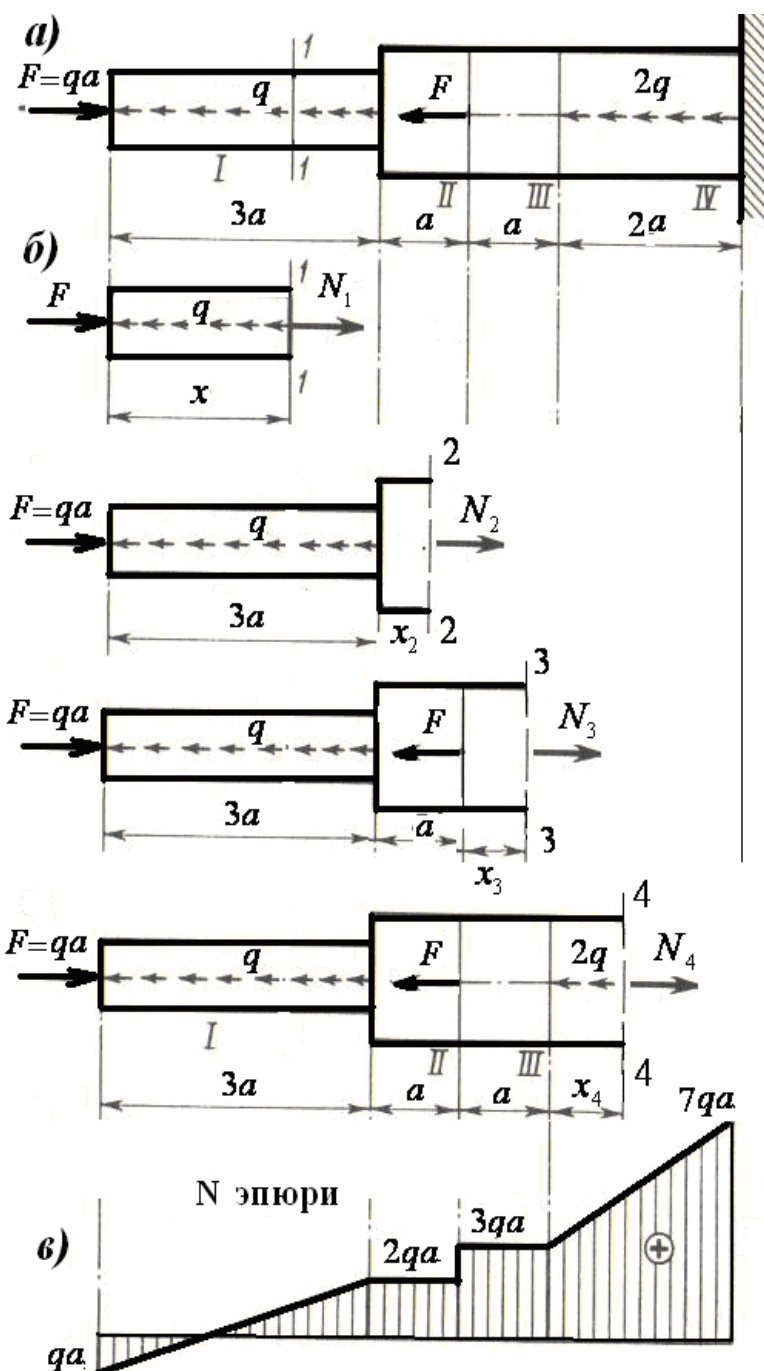
**misol –2.2** To'planma va teng tarqalgan kuchlar bilan yuklangan brus uchun bo'ylama kuch aniqlansin va epyurasi qurilsin (2.3- rasm)

**echish.** Yuklanish oraliqlari 2.3- rasm, a-da ko'rsatilgan.

1 – oraliqning tayanchdan ozod tomonidan -  $x$  masofada tanlangan I– I qirqim bilan ko'rsatilgan ko'ndalang kesimidagi (2.3 - rasm, b ) ichki kuchni aniqlaymiz. Buning uchun brusni olib qolingan qismidagi barcha kuchlarni  $X$  – o'qiga proektsiyalaymiz.

$$\sum X = 0 \quad N_1 + F - qx = 0 \quad \text{yoki} \quad N_1 = -F + qx$$

buerda:  $qx$  - brusni olib qolingan qismidagi taqsimlangan kuchlarning teng ta'sir qiluvchisi bo'lib  $0 \leq x \leq 3a$  oraliqda chiziqli



qonuniyat bilan o'zgaradi.  
 $N_1$  kuchni hisoblaymiz:  
 $x = 0$  bo'lsa  $N_1 = -F = -qa$   
va  $x = 3a$  bo'lsa  $N_1 = 2qa$ .  
Demak, brusning  
boshlang'ich nuqtasida  $N_1$   
kuch manfiy va oxirgi  
nuqtasida musbat ishorali va  
 $x = \frac{F}{q} = a$  masofada nolga

teng

**II – II oraliq.**

$$\sum X = N_2 + F - q \cdot 3a = 0$$

$$\text{va } N_2 = 2qa$$

**III– III oraliq.**

$$\sum X = N_3 + F - q \cdot 3a - F = 0$$

**IV- IV oraliq .**

$$\sum X = 0$$

$$N_4 + F - q \cdot 3a - F - 2q \cdot x = 0$$

2.3 – rasm. Ichki kuchni  
aniqlash texnologik xaritasi

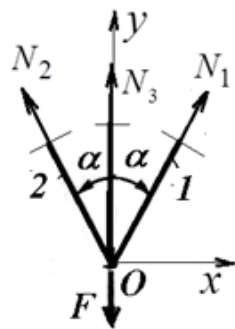
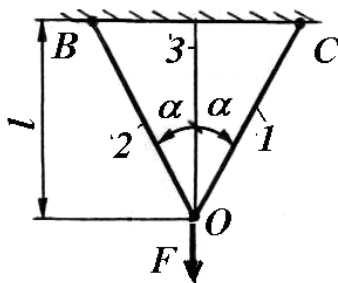
a) pog'onali brusni  
yuklanish sxemasi;

b) pog'onali brusni kesish  
tartibi;

v) pog'onali brus uchun ichki  
bo'ylama kuch epyurasi

$$x = 0 \text{ bo'lsa } N_4 = 3qa \text{ va } x = 2a \text{ bo'lsa } N_4 = 7qa$$

$N_x$  - ichki bo'ylama kuch brus o'qining uzunligi bo'ylab o'zgarishining  
grafiki ichki bo'ylama kuch epyurasi deyiladi.  $N_x$  epyurasini qurish uchun  
hisoblangan ichki bo'ylama kuchning qiymatlari tanlangan masshtabda  
joylashtiriladi.



2.4-rasm. Statik noaniq sterjenlar

**Statik noaniq sterjenlar sistemasi.** Berilgan konstruksiyaning bikrligini oshirish uchun uning tarkibiga 3 sterjenni kiritamiz (2.4-rasm). Natijada konstruksiyadagi 3 ta sterjenda 3 ta noma'lum ichki kuchlar hosil bo'ladi.

Ularni aniqlash uchun

sterjenlar sistemasining muvozanat shartlarini tuzamiz

$$\sum x = -N_1 \sin \alpha + N_2 \sin \alpha = 0$$

$$\sum y = N_1 \cos \alpha + N_2 \cos \alpha - F + N_3 = 0$$

Birinchi tenglamadan  $N_1 = N_2$  e'tiborga olsak ikkinchi tenglamadan hosil bo'ladi

$$2N_1 \cos \alpha - F + N_3 = 0 \quad (a)$$

Bu tenglamada ikkita noma'lum ichki bo'ylama kuchlar bo'lib ularni ushbu tenglamadan topib bo'lmaydi, chunki noma'lum kuchlar soni ularni aniqlash uchun tuzilgan muvozanat tenglamasi sonidan ko'p.

*Statik noaniq sistemalar deb, nomalum kuchlarni (reaktsiya kuchlari, ichki kuchlar) aniqlash uchun kesish usuli yoki statika tenglamalari etisharli bo'lmagan sistemalar*ga aytiladi

Tarkibidagi noma'lum reaksiya va ichki kuchlarining soni statikaning muvozanat tenglamalari sonidan ko'p bo'lgan sistemalar statik noaniq sistemalar deyiladi

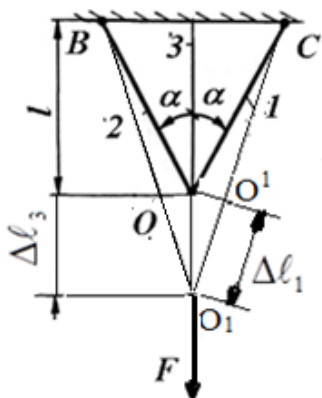
Tashqi va ichki statik noaniq sistemalar mavjud. Masalan, sterjenlar sistemasida ichki bo'ylama kuchlarni aniqlash ichki statik noaniq; ikki tomoni bika mahkamlangan brus tashqi statik noaniq sistema. Har ikkala statik noaniq sistemalarda ham noma'lum kuchlarni aniqlash – statik noaniq masala deyiladi.

Bunday masalalarda noma'lum kuchlarni aniqlash uchun qo'shimcha deformatsiya tenglamalari tuziladi. Qo'shimcha deformatsiya tenglamalari-ning soni sistemani noaniqlik darajasiga teng. Sterjenlar sistemasi-ning statik noaniqlik darajasini quyidagicha topamiz:

$$S = n - m \quad (2.4)$$

buerda,  $n$  – sistemadagi noma'lum kuchlar soni;

$m$  – sistemani muvozanat tenglamalari soni.



2.5-rasm. Deformatsiyalarni bog'lanishi

Qo'shimcha tenglamalar – sistemani deformatsiyasini ifodalaydigan geometrik bog'lanishlar (deformatsiya tenglamalari) muvozanat tenglamalari bilan birgalikda echiladi va noma'lum ichki kuchlar topiladi.

Chizmadagi  $\Delta OO_1O^1$  dan (rasm-2.5)  $\frac{O_1O^1}{OO_1} = \cos \alpha$  (a)

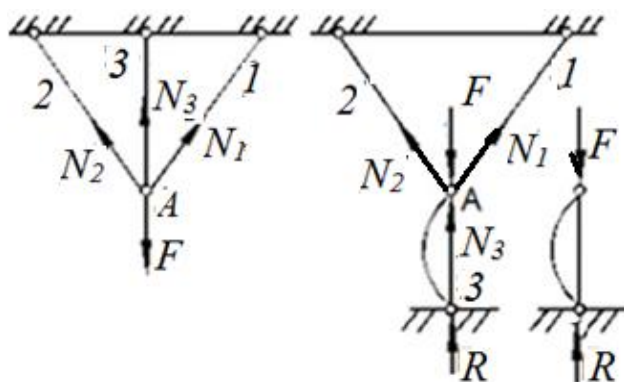
Bu erda  $OO_1$  uchinchi sterjenning uzayishi va  $O_1O^1$  birinchi sterjenning uzayishi. Sterjen materialining elastiklik xossasida  $O_1O^1$  va  $OO_1$  masofalarni Guk qonuni bilan belgilaymiz:

$$O_1O^1 = \Delta l_1 = \frac{N_1 l_1}{EA_1 \cos \alpha} \quad \text{va} \quad OO_1 = \Delta l_3 = \frac{N_3 l_3}{EA_3}$$

Unda (b) tenglikdan  $\frac{N_1 l_1}{EA_1 \cos \alpha} = \frac{N_3 l_3}{EA_3} \cos \alpha$  hosil bo'ladi.

Agar,  $EA_1 = EA_3$  deb qabul qilsak  $N_1 = \frac{N_3}{\cos^2 \alpha}$  (b)

(b) tenglikni (a) tenglamaga keltirib qo'yib  $N_3$  kuchni topamiz



$$N_3 = \frac{F \cos^2 \alpha}{2 + \cos^2 \alpha}$$

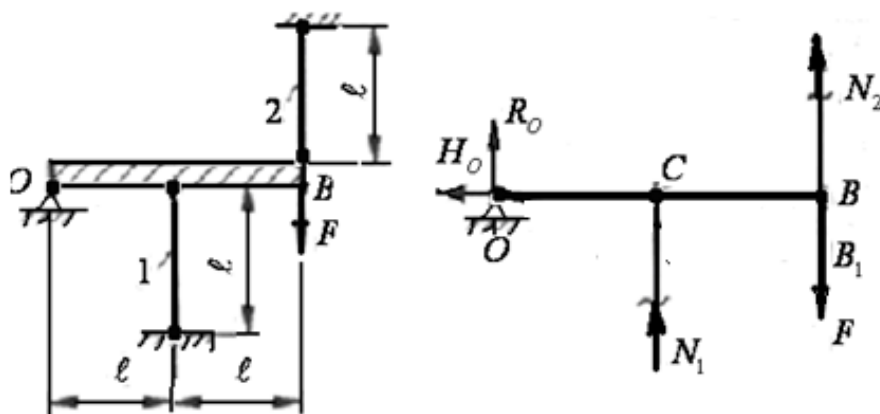
Agar, 3 sterjen A tugunni pastki tomonida o'rnatilsa,  $N_3$  ichki kuchni shunday qiymati topiladiki, ushbu sterjen faqat siqilishga mustahkamligi ta'min-lansin. Aks bu sterjen siqilishda ustuvor holatini yo'qotadi

**misol –2.3.** Po'latdan tayyorlangan 1 va 2 sterjenlar uzunligi  $\ell = 1 \text{ m}$ ., kesim yuzasi  $A_1 = A_2 = A = 2 \cdot 10^{-4} \text{ m}^2$  va qo'zg'aluvchan sharnirli tayanchdagi brusga mahkamlangan (2.6 – rasm).

1) sistemaga qo'yilishi mumkin bo'lgan ruxsat etilgan  $P_{pyx}$  yukning sterjenlardagi eng katta kuchlanishni  $[\sigma] = 160 \text{ mPa}$ . ga tenglashtirib topilsin

2) oquvchanlik chegarasida  $\sigma_{oK} = 240 \text{ mPa}$  dan foydalanib chekli yuk  $F_{u\ell K}$  topilsin.

Tashqi  $F$  kuch ta'sirida  $OB$  brus  $O$  sharnir atrofida aylanadi. Natijada 1 sterjen siqiladi 2 sterjen cho'ziladi. Sterjenlarning siqilishi va cho'zilishi materialining elastik xossasida sodir bo'ladi deb qaraladi.



2.6 – rasm. Statik noaniq sterjenlar sistemasining yuklanish sxemasi

**echish:** Kesish usulidan foydalanib ichki bo'ylama kuchlarni aniqlaymiz (2.6 – rasm).

**Masalani mexanik tomoni.** Sistemani muvozanat holatini ifodalovchi statikaning tenglamalarini tuzamiz:

$$\sum x = H_o = 0$$

$$\sum y = R_o + N_1 + N_2 = 0$$

$$\sum M_o = -N_1 \cdot \ell - N_2 \cdot 2\ell + F \cdot 2\ell = 0$$

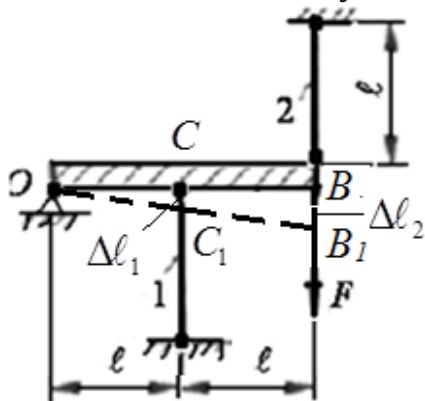
Ushbu tenglamalardan, ko'rinishicha sterjenlardagi noma'lum ( $N_1 : N_2$ ) ichki kuchlari va tayanch kesimidagi reaksiya kuchlari ( $R_o, H_o$ ) statikaning tenglamalaridan ko'p ekan. Demak, berilgan sistema statik aniq emas. Sxemadagi noma'lum  $R_o$  va  $H_o$  reaksiya kuchlarini topish masalaning shartida ko'rsatilmagan va umuman  $R_o$  va  $H_o$  reaksiyalar ichki bo'ylama kuchlar va sterjenlardagi kuchlanishlarga ta'siri yo'q. Shuning uchun reaksiya kuchlarini topmaymiz.

Sistemaning aniqlik darajasi  $S = n - 1 = 2 - 1 = 1$

bu erda:  $n$  – noma'lum ( $N_1$  va  $N_2$ ) kuchlar soni;

1 – statikaning tenglamalar soni

Masalani geometrik tomoni. Noma'lum ichki kuch  $N_1$  va  $N_2$  larni topish uchun sistemani deformatsiyasidan foydalanib qo'shimcha tenglama tuzamiz.



2.7-rasm.

OB brus to'g'riligicha qolib, F kuch ta'sirida O nuqta atrofida kichik burchakka aylanadi. Natijada C va B nuqtalar F kuch yo'nalishida ko'chadi va tegishli,  $C_1$  va  $B_1$  vaziyatlarni egallaydi. Unda 1 sterjenning uzunligi  $\Delta l_1$  miqdorga qisqaradi, 2 sterjen  $\Delta l_2$  miqdorga uzayadi deb kabul kilamiz.

Sxemadan (2.7 – rasm)

$$\frac{BB_1}{BO} = \frac{CC_1}{CO}$$



$$\text{yoki } \frac{\Delta \ell_2}{2\ell} = \frac{\Delta \ell_1}{\ell}; \quad \Delta \ell_2 = 2\Delta \ell_1,$$

Masalani fizik tomoni.  $\Delta \ell_1$  va  $\Delta \ell_2$  deformatsiyalar sterjen materialining proportsionallik chegarasidan ortib ketmaydi deb qaraladi va Guk formulasi bilan ifodalanadi.

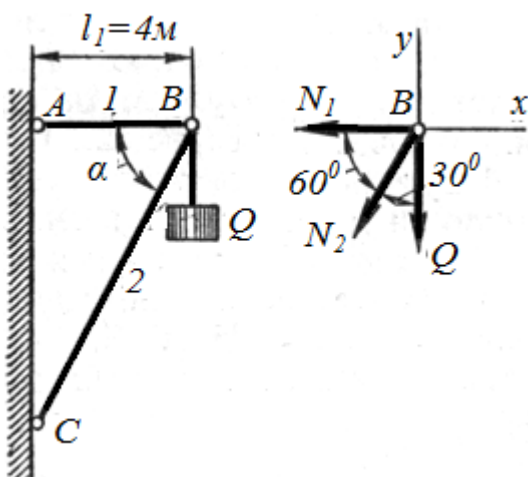
Unda  $\Delta \ell_1 = \frac{N_1 \ell}{EA}$  va  $\Delta \ell_2 = \frac{N_2 \ell}{EA}$  bo'lsa  $\frac{N_2 \ell}{EA} = 2 \frac{N_1 \ell}{EA}$  yoki  $N_2 = 2N_1$  kelib chiqadi.  $N_2 = 2N_1$  tenglamani muvozanat tenglamasi bilan birgalikda echib:  $N_1 = \frac{F}{5}$  va  $N_2 = \frac{2}{5}F$  ni topamiz.  $N_2 > N_1$  bo'lganligi uchun  $\sigma_2 > \sigma_1$ .

Ikkinchi sterjenning mustahkamlik sharti  $\sigma_2 = \frac{N_2}{A} \leq [\sigma]$  yoki

$$\frac{2F}{5A} \leq [\sigma] \text{ dan } F_{\text{pyx}} = \frac{5F[\sigma]}{2} = \frac{5 \cdot 2 \cdot 10^{-4} \cdot 160 \cdot 10^3}{2} = 80 \text{ kH}$$

Demak, 2 sterjenda 1 sterjenga nisbatan kuchlanish katta bo'ladi. Bu esa 1 sterjenda oquvchanlik chegarasini 2 sterjenga nisbatan oldinroq boshlanishiga olib keladi. Bu vaqt oralig'ida, agar kuchni ko'paytirsak ham 1 sterjen kuchlanishi o'smaydi (kattalashmaydi) va sistema  $Q$  va  $N_2 = \sigma_{\text{ok}} A$  kuch bilan yuklangan statik aniq sistemaga aylanib qoladi. Kuchni, yanada orttirsak 2 sterjenda ham oquvchanlik chegarasi boshlanadi  $N_2 = \sigma_{\text{ok}} \cdot A$ . Endi  $N_1$  va  $N_2$  kuch ifodalarini muvozanat tenglamasiga keltirib qo'yamiz  $\sigma_{\text{ok}} \cdot A + 2 \cdot \sigma_{\text{ok}} \cdot A = F$  yoki  $3\sigma_{\text{ok}} A = F$ ,

bu erdan  $F_{\text{чек}} = F = 3 \cdot 240 \cdot 10^3 \cdot 2 \cdot 10^{-4} = 144 \text{ kH}$



rasm-2.8

**misol -2.4.** Kronshteyn AB po'lat tyaga va VC yog'och qiya brusdan tashkil topgan. Tyaganing ko'ndalang kesim yuzasi  $A_1 = 1 \text{ cm}^2$ , brusning kesim yuzasi  $A_2 = 25 \text{ cm}^2$ . B nuqtaga  $Q = 20 \text{ kH}$  yuk osilgan, po'lat uchun elastiklik moduli  $E_{\text{II}} = 2.1 \cdot 10^5 \frac{\text{H}}{\text{mm}^2}$  yog'och  $E_e = 1 \cdot 10^4 \frac{\text{H}}{\text{mm}^2}$ . V nuqtaning gorizontal va vertikal kuchishlari topilsin.

**echish.** AB va BC sterjenlardagi ichki bo'ylama kuchlarni kesish usulidan foydalanib aniqlaymiz.

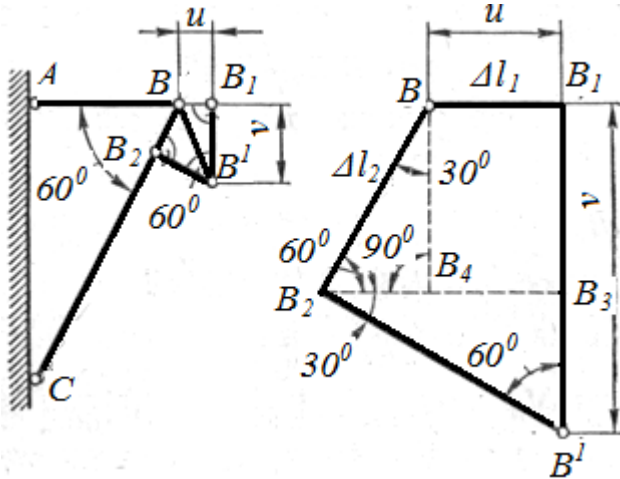
Muvozanat tenglamalarini tuzamiz:

$$\sum x = 0 \quad -N_1 - N_2 \cos 60^\circ = 0 \quad (a)$$

$$\sum y = 0 \quad -Q - N_2 \cos 30^\circ = 0 \quad (b)$$

$$(a) \text{ tenglamadan } N_2 = -\frac{Q}{\cos 30^\circ} = -\frac{20}{0,866} = -23,1 \text{ kH}.$$

$$(b) \text{ tenglamadan } N_1 = 23,1 \cdot \cos 60^\circ = 11,55 \text{ kH}$$



rasm-2.9.

AB tyaga yuk ta'siridan

$$\Delta \ell_1 = \frac{N_1 \ell_1}{E_{II} A_1} = \frac{11,55 \cdot 10^3 \cdot 4 \cdot 10^3}{2,1 \cdot 10^5 \cdot 100} = 2,2 \text{ mm}$$

uzayadi va yog'och brus

$$\Delta \ell_2 = \frac{N_2 \ell_2}{E_e A_2} = -\frac{23,1 \cdot 10^3 \cdot 8 \cdot 10^3}{10^4 \cdot 2500} = -7,4 \text{ mm}$$

qisqaradi. Sterjenlarni mumkin bo'lgan ko'chishlari natijasida hosil bo'lgan  $B_1$  va  $B_2$  nuqtalardan  $BB_1$  va  $BB_2$  kesmalaga tik chiziqlar o'tkazamiz, ularning kesishish nuqtasini

$B^1$  bilan belgilaymiz. Unda gorizontaal

ko'chish  $u = \Delta \ell_1 = 2,2 \text{ mm}$ , vertikal ko'chish  $v = B_1 B_3 + B_3 B^1$  hosil bo'ladi.

Sxemadan (rasm-2.9)  $B_1 B_3 = \Delta \ell_2 \cos 30^\circ$

$$B_3 B^1 = B_2 B_3 \tan 30^\circ = (B_2 B_4 + B_4 B_3) \tan 30^\circ = (\Delta \ell_2 \sin 30^\circ + \Delta \ell_1) \tan 30^\circ$$

Unda

$$v = \Delta \ell_2 \cos 30^\circ + (\Delta \ell_2 \sin 30^\circ + \Delta \ell_1) \tan 30^\circ = 7,4 \cdot 0,866 + (7,4 \cdot 0,5 + 2,2) \cdot 0,577 = 6,4 + 5,9 \cdot 0,577 = 9,8 \text{ mm}$$

**2-usul.** Deformatsiyaning potentsial energiyasini, tashqi kuchni bajargan ishiga tenglashtiramiz:  $U = A_{\text{элac}}$

$$Q \text{ kuchni vertikal ko'chishida bajargan ishi: } A_{\text{элac}} = \frac{Qv}{2}.$$

Deformatsiyaning potentsial energiyasini hisoblaymiz:

$$U = U_1 + U_2 = \frac{N_1^2 \ell_1}{2 E_{II} A_1} + \frac{N_2^2 \ell_2}{2 E_e A_2} = \frac{(11,55 \cdot 10^3)^2 \cdot 4 \cdot 10^3}{2 \cdot 2,1 \cdot 10^5 \cdot 100} + \frac{(23,1 \cdot 10^3)^2 \cdot 8 \cdot 10^3}{2 \cdot 10^4 \cdot 2500} = 9,8 \cdot 10^3 \text{ H} \cdot \text{mm}$$

$$\text{Unda } v = \frac{2 A_{\text{элac}}}{Q} = \frac{2 \cdot 9,8 \cdot 10^3}{2 \cdot 10^3} = 9,8 \text{ mm}.$$

**misol -2.5.** Uzunligi  $\ell = 200 \text{ mm}$  bo'lgan po'lat sterjenning kesim yuzasidagi eng katta yuklanish  $\sigma = 210 \frac{\text{H}}{\text{mm}^2}$ . Sterjenning absolyut uzayishi nimaga teng?

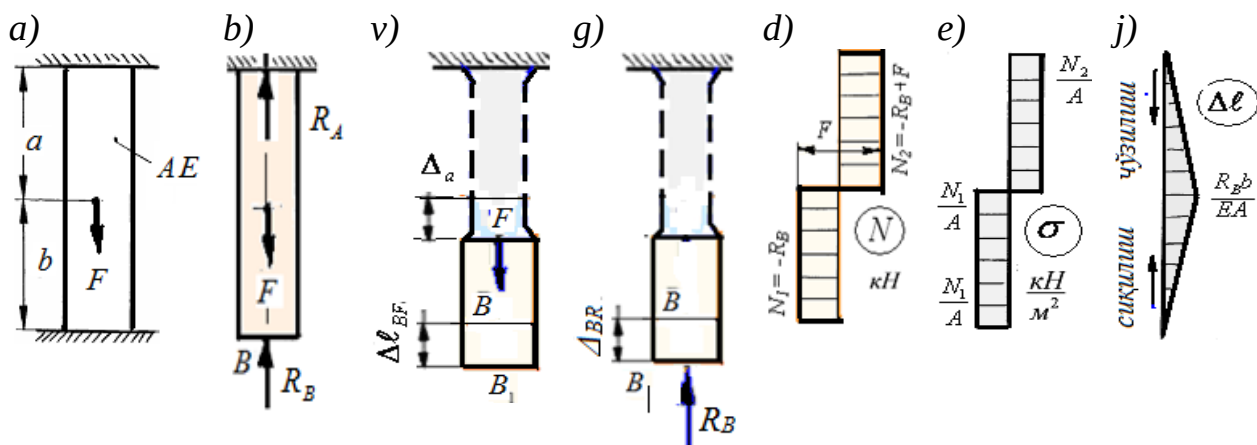
**echish.** Guk qonuni  $\sigma = E \cdot \varepsilon$  dan  $\varepsilon = \frac{\sigma}{E} = \frac{210}{2,1 \cdot 10^5} = 0,01$  va  $\varepsilon = \frac{\Delta \ell}{\ell}$  dan  
 $\Delta \ell = \varepsilon \cdot \ell = 0,001 \cdot 200 = 0,2 \text{ mm}$ .

**Statik noaniq brus.** Ikki tomoni bikr mahkamlangan brus  $F$  kuch bilan yuklangan. Brusni tayanch nuqtalarida  $R_A$  va  $R_B$  reaksiya kuchlari hosil bo'ladi (2.10–rasm, b). Reaksiya kuchlarini aniqlash uchun brusni muvozanat shartini tuzamiz:

$$\sum y = 0; \quad R_A + R_B = F$$

$R_A$  va  $R_B$  tayanch reaksiyalari bitta muvozanat shartidan topilishi mumkin emas, chunki noma'lum kuchlar soni muvozanat tenglamasi sonidan ko'p. Shuning uchun ushbu sistema statik noaniq

Sistemani echish uchun qo'shimcha deformatsiya tenglamasidan (deformatsiyani taqqoslash) foydalanish kerak. Deformatsiyani taqqoslash tenglamasini tuzish tashqi kuchlar ta'sirida tayanchlar oralig'i masofasi o'zgarmasdan (brusni to'liq deformatsiyasi nolga teng bo'ladi), faqat brusni pog'onalar uzunligi o'zgarishi, ya'ni sistemani tashqi kuchlar ta'siridagi to'liq uzayishining absolyut qiymati reaksiya kuchi ta'siridagi to'liq qisqarishni absolyut miqdoriga tengligiga asoslangan.



2.10-rasm. Statik noaniklikni ochish texnologiyasi

Buning uchun berilgan sxemaga ekvivalent bo'lgan asosiy sistemani tanlaymiz (2.10–rasm, b). Asosiy sistema deb, tayanch ta'sirini undagi reaksiya kuchi ta'siri bilan almashtirilgan sistemaga aytiladi. Berilgan sistemada  $B$  tayanch nuqta absolyut qo'zg'almas, shuning uchun bu nuqtaning ko'chishi nolga teng, ya'ni  $\Delta \ell_B = 0$ . Asosiy sistemada ham  $B$  nuqtaning qo'zg'almasligi ta'minlansa, ya'ni (2.10–rasm, b)  $\Delta \ell_B = \Delta \ell_{BF} + \Delta \ell_{BR} = 0$  shart bajarilsa u berilgan sistemaga ekvivalent bo'ladi. Buerda  $\Delta \ell_{BF}, \Delta \ell_{BR}$  - brus  $B$  nuqtasini

tegishlixa, tashqi  $F$  va  $R_B$  reaksiya kuchlari ta'siridan ushbu kuchlar yo'nalishidagi ko'chishi. Ularni quyidagi farazlarda aniqlaymiz:

Birinchi faraz, agar  $B$  tayanch bo'lmaganida brusni bu nuqtasi  $F$  kuch ta'siridan  $B_1$  vaziyatga, ya'ni  $\Delta\ell_{BF}$  miqdorga ko'chadi.  $\Delta\ell_{BF}$  ko'chish brus  $a$  – uzunlikdagi qismining  $F$  kuch ta'siridan absolyut uzayishiga teng bo'ladi

$$(2.44\text{--}rasm, v) \quad \Delta a = \Delta\ell_{BF} = \frac{Fa}{EA}.$$

Ikkinchi faraz, deformatsiyalangan brusning  $B_1$  (2.10–rasm, g) nuqtasiga qo'yilgan  $R_B$  reaksiya kuchi ta'siridan  $B_1$  nuqta boshlangich  $B$  vaziyatga ko'chadi, ya'ni brus uzunligi bo'ylab siqiladi, unda brusning absolyut qisqarishini Guk formulasi bilan

$$\text{quyidagicha ifodalanadi: } \Delta\ell_{BR} = -R_B \frac{a + e}{EA}.$$

$$\text{Unda } B \text{ nuqtaning to'liq ko'chishi } \Delta\ell_B = \frac{F \cdot a}{EA} - \frac{R_B(a + e)}{EA} = 0.$$

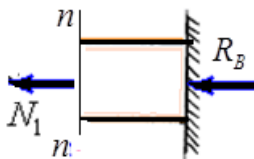
$$\text{Buerdan } R_B = F \frac{a}{a + e} \text{ hosil bo'ladi. va ushbu tenglikni muvozanat}$$

$$\text{tenglamasiga qo'ysak } R_A = F \frac{e}{a + e}.$$

Kesish usulidan foydalanib ichki bo'ylama kuch, normal kuchlanish va bo'ylama deformatsiyani aniqlaymiz (2.10–rasm, d).

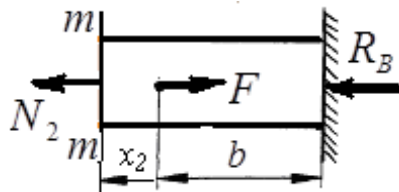
$n-n$  qirqim:  $\sum x = -N_1 - R_B = 0$  muvozanat

shartidan ichki bo'ylama kuch  $N_1 = -R_B$  hosil bo'ladi. (minus ishorasi bu oraliqda siqilish bo'lishini bildiradi).



$$\text{Normal kuchlanish } \sigma_1 = \frac{N_1}{A} \text{ va bo'ylama deformatsiya: } B \text{ tayanch}$$

$$\text{nuqtada nolga teng va tashqi kuch qo'yilish nuqtasida } \Delta\ell_1 = \frac{N_1 \cdot b}{EA} \text{ ga teng}$$



$$m-m \text{ qirqim: } \sum x = -N_2 - R_B + F = 0$$

$$\text{tenglamadan } N_2 = -R_B + F \text{ hosil bo'ladi.}$$

$$\text{Normal kuchlanish } \sigma_2 = \frac{N_2}{A}$$

$$\text{va to'liq bo'ylama deformatsiya } \Delta\ell_2 = \frac{N_2 \cdot x_2}{EA} - \frac{R_B b}{EA}, \text{ buerda } 0 \leq x_2 \leq a$$

oraliqda o'zgaradi.

Agar,  $x_2 = 0$  bo'lsa  $\Delta \ell_2 = -\frac{R_B b}{EA}$  va  $x_2 = a$  bo'lsa

$$\Delta \ell_2 = \frac{(-R_B + F) \cdot a}{EA} - \frac{R_B b}{EA} = \frac{Fa}{EA} - R_B \frac{(a+b)}{EA} = 0 \text{ bo'ladi}$$

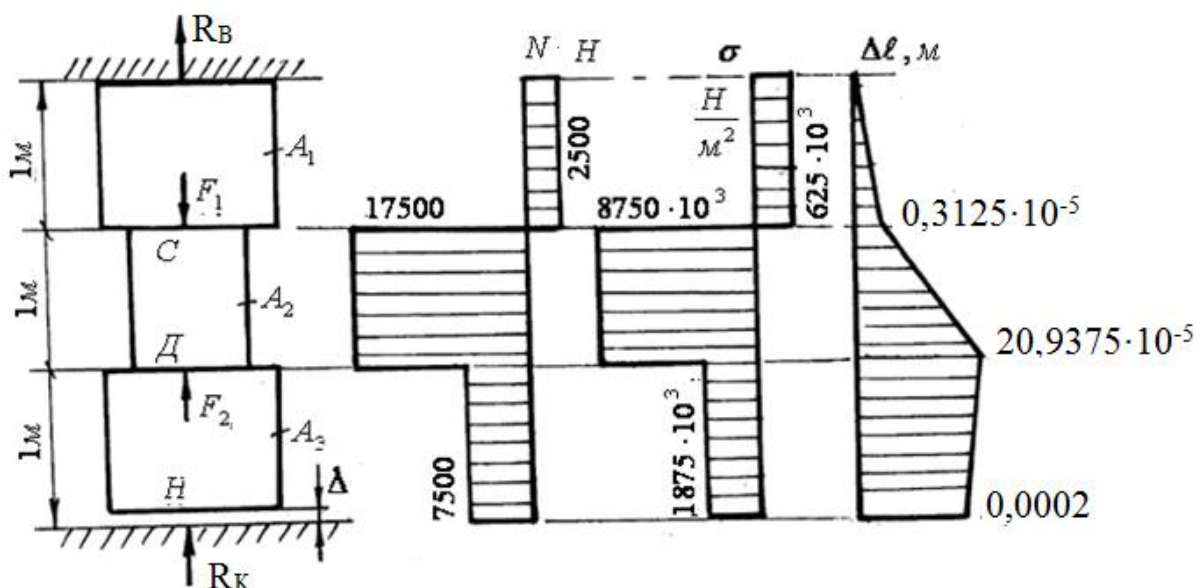
**misol –2.6.** Brus tashqi kuchlar ( $F_1 = 20 \text{ kN}$  va  $F_2 = 10 \text{ kN}$ ) bilan yuklanganligiga qadar pastki kesimi K tayanch nuqtasi bilan  $\Delta = 0,0002 \text{ m}$  masofa hosil qilgan. Brusning DS oraliq uzunligi  $\Delta t = 20^\circ$  ga qizdirilgan ( 2.11–rasm ). Agar brusning tashqi kuchlar va harorat ta'siridagi to'liq uzayishi natijasida  $\Delta$  masofa yopilib brus bilan tayanch orasida o'zaro ta'sir kuchlari hosil bo'lsa sistema statik noaniq bo'ladi;  $\Delta$  masofa yopilmasa yoki yopilib brus bilan tayanch orasida o'zaro ta'sir kuchlari hosil bo'lmasa, sistema statik aniq bo'ladi. Berilgan sistema qaysi holatga to'g'ri kelishini aniqlash uchun «N» kesimning to'liq uzayishini topamiz.

$$\Delta_H = \Delta F_1 - \Delta_{F_2} + \Delta_t = \frac{F_1 \cdot 1}{EA_1} - \frac{F_2 \cdot 1}{EA_2} - \frac{F_2 \cdot 1}{EA_1} + \alpha \cdot \Delta t \cdot 1 =$$

$$\frac{1}{EA_2} \left( \frac{20 \cdot 1}{2} - 10 \cdot 1 - \frac{10 \cdot 1}{2} + 125 \cdot 10^{-7} \cdot 20 \cdot 1 \right) = 0,0002375 \text{ m}$$

Demak,  $\Delta_H > \Delta$  yoki  $0,0002375 > 0,0002 \text{ m}$ , natijada N kesim K tayanch bilan tutashadi va K tayanchda  $R_K$  reaksiya kuchi hosil bo'lib, sistema statik noaniq sistemaga aylanadi. Masalani echish uchun sistemani muvozanat tenglamasini tuzamiz:

$$\sum y = R_K + R_B + F_2 - F_1 = 0$$



2.11 – rasm. Statik noaniq pog'onali brus uchun bo'ylama kuch, normal kuchlanish va absolyut uzayish epyuralari

Sistemani aniqmaslik darajasini ochish uchun qo'shimcha deformatsiya tenglamasini tuzamiz:  $\Delta_H - \Delta = \Delta_K$

Bu erda  $\Delta_K = R_K \left( \frac{1}{EA_1} + \frac{1}{EA_2} + \frac{1}{EA_3} \right)$  brusni  $R_K$  reaksiya kuchi

ta'siridan uzayishi  $0,0002375 - 0,0000375 = R_K \left( \frac{1}{EA_1} + \frac{1}{EA_2} + \frac{1}{EA_3} \right)$  yoki

$$R_K = \frac{(0,0002375 - 0,00002) \cdot 2 \cdot 10^8 \cdot 2 \cdot 10^{-3}}{2} = 7,5 \text{ kH}$$

$$R_B = F_1 - F_2 - R_K = 20 - 10 - 7,5 = 2,5 \text{ kH}$$

Brusni oraliqlarga bo'lib  $N; \sigma$  va  $\Delta \ell$  larni hisoblaymiz.

**1 – 1 qirqim.**  $N_1 = R_B = 2,5 \text{ kH} = 2500 \text{ H}$  va

$$\sigma_1 = \frac{N_1}{A_1} = \frac{2500}{2 \cdot 2 \cdot 10^{-3}} = 625 \cdot 10^3 \frac{\text{H}}{\text{m}^2}$$

$B$  tayanch kesimning ko'chishi nolga teng, ya'ni  $\Delta \ell_B = 0$ .

$C$  kesimning ko'chishi  $BC$  masofani to'liq uzayishiga teng, ya'ni:

$$\Delta \ell_c = \frac{N_1 \cdot 1}{EA_1} = \frac{2500 \cdot 1}{2 \cdot 10^{11} \cdot 2 \cdot 2 \cdot 10^{-3}} = 312,5 \cdot 10^{-8} \text{ m}$$

**II-II – qirqim.**  $N_2 = R_B - F_1 = 2500 - 20000 = -17500 \text{ H}$

$$\text{normal kuchlanish } \sigma_2 = \frac{N_2}{A_2} = -\frac{17500}{2 \cdot 10^3} = -8750 \cdot 10^3 \frac{\text{H}}{\text{m}^2}$$

$BD$  oraliq masofasini to'liq uzayishi quyidagicha topiladi:

$$\Delta \ell_D = 312,5 \cdot 10^{-8} + \frac{N_2 \cdot 1}{EA_2} + \alpha \cdot \Delta t \cdot 1 = 312,5 \cdot 10^{-8} - \frac{17500 \cdot 1}{2 \cdot 10^{11} \cdot 2 \cdot 10^{-3}} +$$

$$125 \cdot 10^{-7} \cdot 20 \cdot 1 = 0,000209375 \text{ m}$$

**III-III qirqim**  $N_3 = R_B - F_1 + F_2 = 2500 - 20000 + 10000 = -7500 \text{ H}$

$$\sigma_3 = \frac{N_3}{A_3} = -\frac{7500}{2 \cdot 2 \cdot 10^{-3}} = -1875 \cdot 10^3 \frac{\text{H}}{\text{m}^2}$$

$N$  kesimning ko'chishi yoki brusning to'liq uzayishi

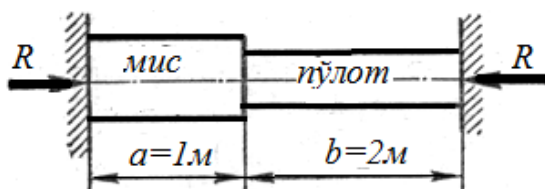
$$\Delta \ell_H = 0,000209375 + \frac{N_3}{EA_3} = 0,000209375 - \frac{7500 \cdot 1}{2 \cdot 10^{11} \cdot 2 \cdot 2 \cdot 10^{-3}} = 0,0002 \text{ m}$$

**misol-2.7.** Pog'onali brus ikki tomonidan bika mahkamlangan. Brusning bir qismi mis, ikkinchi qismi po'latdan tayyorlangan. Harorat  $\Delta t = 40^\circ$  ga ortsa

$$\alpha_m = 16 \cdot 10^{-6}; \alpha_{II} = 12 \cdot 10^{-6}; E_m = 1,0 \cdot 10^5 \frac{\text{H}}{\text{mm}^2}, E_{II} = 2,1 \cdot 10^5 \frac{\text{H}}{\text{mm}^2}, A_m = 2 \text{ A};$$

$A_{II} = A$  bo'lsa mis pog'ona kesimidagi kuchlanish

$\sigma_m$  hisoblansin. Misolni echishda  $\sigma_m = \frac{\sigma_{II}}{2}$  dan foydalanilsin



Brusning uzunligi o'zgarmaydi, demak temperatura o'zgarishidagi uzayish  $\Delta l_t = \Delta l_{II} + \Delta l_M = \Delta t(\alpha_{II} \cdot \epsilon + \alpha_M \cdot a)$

siquvchi kuchlar R ta'siridan qisqarishiga teng

$$\Delta l_R = \Delta l_{II R} + \Delta l_{MR} = \frac{R\epsilon}{E_{II} \cdot A_{II}} + \frac{R \cdot a}{E_M \cdot A_M} = \frac{R}{A} \left( \frac{\epsilon}{E_{II}} + \frac{a}{2E_M} \right)$$

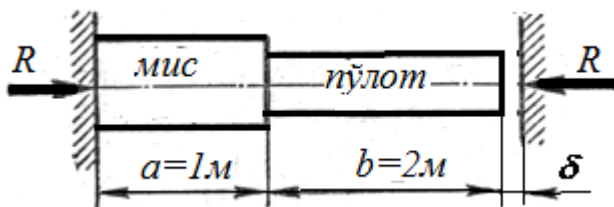
Shunday qilib, ko'chish tenglamalari  $\Delta l_t = \Delta l_R$

$$\text{Unda } \Delta t(\alpha_{II}\epsilon + \alpha_M \cdot a) = \frac{R}{A} \left( \frac{\epsilon}{E_{II}} + \frac{a}{2E_M} \right) \text{ lekin, } \frac{R}{A} = \sigma_{II}$$

$$\text{Shuning uchun } \sigma_{II} \left( \frac{\epsilon}{E_{II}} + \frac{a}{2E_M} \right) = \Delta t(\alpha_{II}\epsilon + \alpha_M \cdot a).$$

$$\text{Bu erdan } \sigma_{II} = \frac{\Delta T(\alpha_{II}\epsilon + \alpha_M \cdot a)}{\frac{\epsilon}{E_{II}} + \frac{a}{2E_M}} = \frac{40(12 \cdot 10^{-6} \cdot 2000 + 16 \cdot 10^{-6} \cdot 1000)}{\frac{2000}{2,1 \cdot 10^5} + \frac{1000}{2 \cdot 10^5}} = 110 \frac{H}{mm^2}$$

$$\text{va } \sigma_M = \frac{\sigma_{II}}{2} = \frac{110}{2} = 55 \frac{H}{mm^2}.$$



**misol-2.8.** Oldingi misol shartla-ridan foydalanamiz. Po'lat brus-ning kesimidagi kuchlanish  $\Delta t = 50^\circ C$  da  $[\sigma] = 100 \frac{H}{mm^2}$  dan ortmasligi kerak.

**echish.** Zazorni e'tiborga olib  $\Delta l_t - \delta = \Delta l_R$

$$\text{tenglamalardan siquvchi kuchni topamiz } R = \frac{\Delta t(\alpha_M \cdot a + \alpha_{II} \cdot \epsilon) - \delta}{\frac{a}{E_M A_M} + \frac{\epsilon}{E_{II} \cdot A_{II}}}$$

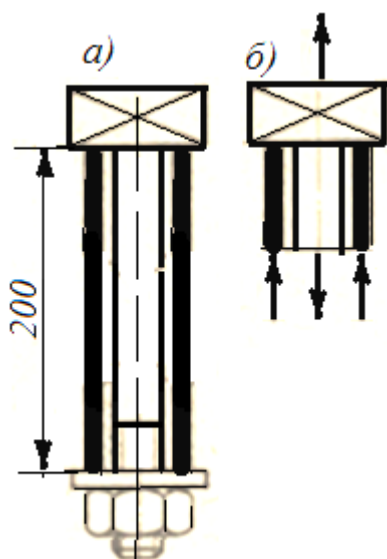
$A_M = 2A$  va  $A_{II} = A$  ni qabul qilamiz,  $\delta$ -ni topamiz

$$\delta = R \left( \frac{a}{E_M \cdot A_M} + \frac{\epsilon}{E_{II} \cdot A_{II}} \right) - \Delta t(\alpha_M \cdot a + \alpha_{II} \cdot \epsilon) \text{ yoki}$$

$$\delta = -\frac{R}{A} \left( \frac{a}{2E_M} + \frac{\epsilon}{E_{II}} \right) + \Delta t(\alpha_M \cdot a + \alpha_{II} \cdot \epsilon) = -\sigma_{II} \left( \frac{a}{2E_M} + \frac{\epsilon}{E_{II}} \right) + \Delta t(\alpha_M \cdot a + \alpha_{II} \cdot \epsilon)$$

$$\sigma_{II} \leq [\sigma] \text{ bo'lsa } \delta = -[\sigma] \left( \frac{a}{2E_M} + \frac{\epsilon}{E_{II}} \right) + \Delta t(\alpha_M \cdot a + \alpha_{II} \cdot \epsilon)$$





rasm-2.12

**misol-2.9.** Boltning gaykasini burab trubada siquvchi kuchlanish hosil qilish mumkin. Agar gayka to'la buralganda uning bolt o'qi bo'yicha ko'chishi  $10^{-3}$  bo'lsa, gayka  $90^\circ$  buralganda trubadagi siquvchi kuchlanish qancha bo'ladi? Bolt bilan truba po'latdandan yasalgan bo'lib, ularning ko'ndalang kesim yuzalari teng.

**echish:** gayka buralganda trubka siqiladi, bolt esa cho'ziladi. Kesish usulidan foydalanib, yuqori qismning muvozanatini tekshiramiz (rasm

$$-2.12, b) \sum x = -N_\delta + 2 \cdot \frac{N_T}{2} = 0 \quad (a)$$

buerda  $N_\delta$  - boltni cho'zuvchi kuch;  $N_T$  - trubani cho'zuvchi kuch.

Tenglamada ikkita noma'lum bor. Bu masala uchun statikaning boshqa tenglamasini tuzib bo'lmaydi. Demak, masala bir marta statik aniqmas.

Qo'shimcha tenglama tuzishda gayka  $90^\circ$  buralganda uning bolt o'qi bo'ylab  $0,25 \cdot 10^{-3}$  m ko'chishini nazarga olish kerak, o'q bo'yicha ko'chish  $\delta$  boltning cho'zilishi bilan trubaning siqilishidan iborat bo'ladi, ya'ni

$$\Delta \ell_\delta + \Delta \ell_m = \delta \quad (b)$$

(a) tenglamadan  $N_\delta = N_T$  bo'lganidan  $\Delta \ell_\delta = \Delta \ell_m$  bo'ladi.

$$(b) \text{ tenglamadan } \Delta \ell_\delta = \Delta \ell_m = \frac{\delta}{2} = \frac{1}{2} \cdot 0,25 = 0,0125 \cdot 10^{-3} \text{ m}$$

kelib chiqadi. Trubadagi siquvchi kuchlanishni aniqlaymiz:

$$\Delta \ell = \frac{N \ell}{EA} = \frac{\sigma \cdot \ell}{E} = -125 \cdot 10^{-6} \text{ m}$$

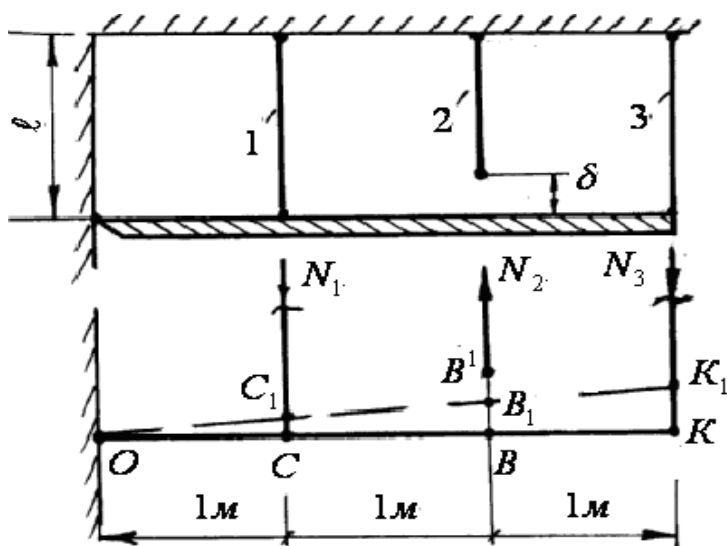
$$\text{buerdan } \sigma = -\frac{0,0125 \cdot E}{\ell} = -\frac{0,0125 \cdot 2 \cdot 10^{11}}{20} = -1250 \cdot 10^5 \frac{H}{M^2}$$

**misol-2.10 .** Biki brus, ko'ndalang kesim yuzalari  $A = 20 \cdot 10^{-4} M^2$  bo'lgan uchta sterjenlarga osilgan. Yrta sterjen loyixa o'lchamidan  $\delta = 0,5 \text{ mm}$ . kalta tayyorlangan. Konstruktsiya yig'ilgandan keyin sterjenlardagi kuchlanish topilsin. Sterjenlarning materiallari bir xil.

**echish:** Konstruktsiyadagi  $\delta$  zazorni yo'qotish uchun 1 va 3 sterjenlarni siqish, 2 sterjenni cho'zish kerak. Natijada uchta sterjenda ham ichki bo'ylama kuchlar hosil bo'ladi.

**Masalani mexanik tomoni.** Ichki kuchlarni topish uchun kesish usulidan foydalanamiz. Konstruktsiya ajratilgan qismining muvozanat holatini qanoatlantiruvchi  $\sum M_0 = 0$  tenglamani tuzamiz:

$$\sum M_0 = N_1 \cdot 1 - N_2 \cdot 2 + N_3 \cdot 3 = 0 \quad (a)$$



2.13 – rasm. Statik noaniq sterjenlar sistemasi va sterjenlar deformatsiyalarining o'zaro bog'lanish sxemasi

Bitta tenglamada uchta  $N_1$ ;  $N_2$  va  $N_3$  ma'lum ichki kuchlar bor. Bu masala statik noaniq. Noma'lum-lar soni muvozanat tenglamasidan ikkitaga ko'p. Shuning uchun, tanlangan masala ikki marotaba noaniq. Masalaning aniqmaslik darajasini ochish uchun ikkita qo'shimcha deformatsiya tenglamalarini tuzish kerak (2.13– rasm)

Masalani geometrik tomoni. Konstruktsiyaning deformatsiyasini o'rganamiz.

1 va 3 sterjenlarning siqilishida, birinchi sterjen

$CC_1$  masofaga, uchinchi sterjen  $KK_1$  masofaga qisqaradi. Natijada B nuqta  $B_1$  ga ko'chadi. 2 sterjenni brus bilan tutashtirish uchun, uni  $BB_1$  masofaga uzaytirish kerak.

Konstruktsiyadagi sterjenlarning deformatsiyasi natijasida uchburchaklar hosil bo'ladi:  $\Delta KK_1O \sim \Delta BB_1O \sim \Delta CC_1O$

$$\text{Unda } \frac{KK_1}{KO} = \frac{CC_1}{CO} \quad \text{va} \quad \frac{BB_1}{BO} = \frac{CC_1}{CO} \quad (b)$$

Masalani fizik tomoni. Sterjenlarni cho'zilish va siqilishida hosil bo'lgan  $KK_1$ ,  $BB_1$ ,  $CC_1$  masofalar sterjenlar materiallarining elastik xossasida Guk qonuni bilan topiladi.

$$CC_1 = \Delta \ell_1 = \frac{N_1 \ell}{EA}, \quad BB_1 = \Delta \ell_2 = \frac{N_2 \ell}{EA} \quad \text{va} \quad KK_1 = \Delta \ell_3 = \frac{N_3 \ell}{EA}$$

$$\text{Unda (b) tenglamadan } \frac{\Delta \ell_3}{3} = \frac{\Delta \ell_1}{1} \quad \text{va} \quad \Delta \ell_3 = 3 \Delta \ell_1$$

$$\text{bu erdan } \frac{N_3 \ell}{EA} = 3 \frac{N_1 \ell}{EA}; \quad \text{va} \quad N_3 = 3N_1 \quad (v)$$

$$\frac{BB_1}{BO} = \frac{CC_1}{CO} \quad \frac{\delta - \Delta \ell_2}{2} = \Delta \ell_1 \quad \text{va} \quad \delta - \Delta \ell_2 = 2 \Delta \ell_1$$

$$\text{bu erdan } \delta - \frac{N_2 \ell}{EA} = 2 \frac{N_1 \ell}{EA} \quad \text{va} \quad N_2 = \frac{\delta \cdot EA - 2N_1 \ell}{\ell} \quad (g)$$

hosil bo'ladi. (v) va (g) tengliklarni (a) tenglamaga keltirib

$$\text{qo'yamiz; } N_1 \cdot 1 - 2 \frac{\delta \cdot EA - 2N_1 \ell}{\ell} + 9N_1 = 0, \quad 10N_1 \ell - 2\delta \cdot EA + 4N_1 \ell = 0$$

$$\text{va } N_1 = \frac{\delta \cdot EA}{7\ell} = \frac{0,5 \cdot 10^{-4} \cdot 2 \cdot 10^8 \cdot 20 \cdot 10^{-4}}{7} = \frac{20}{7} \kappa H$$

Birinchi sterjendagi kuchlanish:

$$\sigma_1 = \frac{N_1}{A} = \frac{20}{7 \cdot 20 \cdot 10^{-4}} = 0,143 \cdot 10^4 \frac{\kappa H}{\text{m}^2}$$

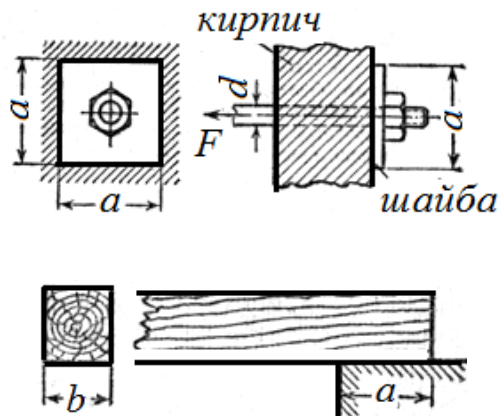
(g) tenglikdan  $N_2$ -ni topamiz:  $N_2 = \frac{100}{7} \kappa H$

Ikkinchi sterjendagi kuchlanish:

$$\sigma_2 = \frac{N_2}{A} = \frac{100}{7 \cdot 20 \cdot 10^{-4}} = 0,715 \cdot 10^4 \frac{\kappa H}{\text{m}^2}$$

(v) tenglikdan  $N_3$ -ni topamiz:  $N_3 = 3 \frac{20}{7} = \frac{60}{7} \kappa H$

va kuchlanish  $\sigma_3 = \frac{N_3}{A} = \frac{60}{7 \cdot 20 \cdot 10^{-4}} = 0,429 \cdot 10^4 \frac{\kappa H}{\text{m}^2}$



**misol-2.11.** Diametri  $d = 30 \text{ мм}$  bo'lgan styajka  $F$  kuch ta'sirida. Kvadrat shayba  $a$ -o'lchamini kirpich kladkasining ruxsat e'tilgan kuchlaish  $10 \kappa\text{z} / \text{cm}^2$  dan foydalanib toping.

**javob:** 24sm.

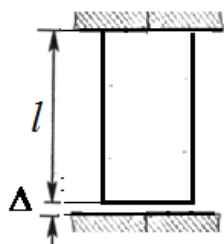
**2.12 misol.** Eni  $b = 15 \text{ см}$  bo'lgan yog'on brus kirpich kladkaga tayanadi. Brusning shu uchidan kladkaga 3 tonna bosim uzatiladi. Yog'on brusni ko'ndalang tomonlari

$12 \kappa\text{z} / \text{cm}^2$ ; kladkaning ezilishga ruxsat e'tilgan kuchlanishi  $10 \kappa\text{z} / \text{cm}^2$  bo'lsa, brusni kladkaga qancha  $a$ -masofaga o'tkazish mumkin. Brusni kladka bilan tegishish yuzasida bosim teng taqsimlangan deb qabul qilinsin.

**javob:** 20sm.

**2.13-misol.** Uzunligi  $40 \text{ m}$  bo'lgan 4 pog'onali ustun  $100 \text{ t}$  kuch bilan siqiladi. Stoyka materialining solishtirma og'irligi  $2 \text{ ga}$  teng, ruxsat etilgan kuchlanishi  $8 \kappa\text{z} / \text{cm}^2$ . Ustun pog'onalarining ko'ndalang kesimlari topilsin.

**javob:**  $1,67 \text{ m}^2$ ;  $2,23 \text{ m}^2$ ;  $2,97 \text{ m}^2$ ;  $3,95 \text{ m}^2$ .



**misol-2.14.** Po'lat brusni tayyorlaganda uzunligi  $\Delta = 1 \cdot 10^{-4} \text{ m}$  miqdorga kalta bo'lgan.  $\Delta$  zazor yopilishi uchun brusning og'irligi qancha bo'lishi kerak?

**2.15 masala.** Kolonnaning balandligi  $3m$ , xalqasimon kesimining tashqi diametri  $25sm$  va ichki diametri  $20sm$ . Kolonna  $50t$  kuch bilan siqiladi. Ko'ndalang kesimdagi kuchlanish, absolyut va nisbiy qisqarishlar topilsin.

**javob:**  $\sigma = -283 \text{ kZ} / \text{cm}^2$ ,  $\Delta l = 0,71 \text{ mm}$ ,  $\varepsilon = 2,36 \cdot 10^{-4}$ .

**2.16 masala.** Diametri  $20 \text{ sm}$  bo'lgan doiraviy kesimli yog'och stoyka uchun siqilishdagi kuchlanish  $40 \text{ kG/sm}^2$  dan katta bo'lmaganda ruxsat etilgan yuk topilsin?

**javob:**  $12,57 \text{ t}$

**2.17 masala.** Doiravi kesimli po'lat sterjen  $10t$  kuch bilan cho'ziladi. Nisbiy uzunlik  $\frac{1}{2000}$  dan, kuchlanish esa  $1200 \frac{\text{kZ}}{\text{cm}^2}$  dan katta bo'lishi kerak. Sterjen kesimining diametri topilsin.

**javob:**  $3,57 \text{ sm}$ .

**2.18 masala.**  $12 \text{ mm}$  diametrli simni bazasi  $10 \text{ sm}$  bo'lgan tenzometrda  $10 \text{ kg}$  yuk bilan sinashda,  $0,08 \text{ mm}$  uzayish o'lchab topilgan. Sim materialining elastiklik moduli nimaga teng?

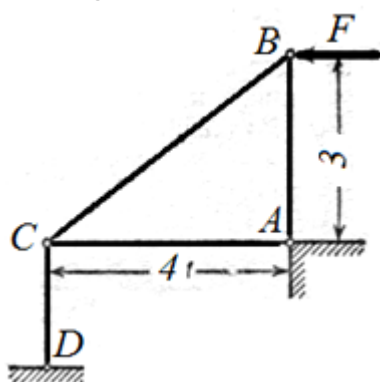
**javob:**  $1,1 \cdot 10^6 \text{ kZ} / \text{cm}^2$ .

**2.19 masala.** Diametri  $1,6 \text{ mm}$  va uzunligi  $3 \text{ m}$  bo'lgan po'lat simga yuk osilganda, uning uzayishi  $1,5 \text{ mm}$ ga tenglashgan. Keyin ushbu yuk uzunligi  $1,8 \text{ m}$  va diametri  $3,2 \text{ mm}$  bo'lgan mis singa osganda uning uzayishi  $0,39 \text{ mm}$  ga tenglashgan. Po'lat simning elastiklik moduli aniq bo'lsa, misning elastiklik moduli nimaga teng?

**javob:**  $1,15 \cdot 10^6 \text{ kZ} / \text{cm}^2$ .

**2.20 masala.** Ko'ndalang kesimining diametri  $30 \text{ mm}$  bo'lgan po'lat sterjen sinov mashinasida  $12,5 \text{ t}$  kuch bilan cho'zganda  $50 \text{ mm}$  uzunlikdagi uzayishi  $0,43 \text{ mm}$ , diametrining o'zgarishi  $0,007 \text{ mm}$  ga teng bo'lgan. Sterjen materialining elastiklik moduli va Puasson koeffitsienti aniqlansin.

**javob:**  $E = 2,06 \cdot 10^6 \text{ kZ} / \text{cm}^2$ ;  $\mu = 0,271$ .

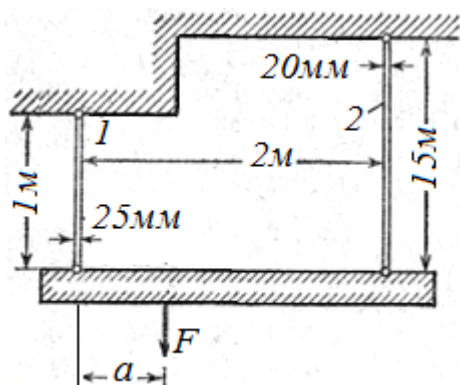


**2.21 masala.**  $F = 10 \text{ m}$  kuch bilan konstruksiyada ko'rsatilgandek yuklangan. Barcha sterjenlarning ko'ndalang kesimi bir hil teng tomonli  $80 \times 80 \times 8$  burchak profildan tashkil topgan. Sterjenlardagi kuchlanishlar aniqlansin.

**javob:**  $\sigma_{AB} = 305 \text{ kZ} / \text{cm}^2$ ;  $\sigma_{AC} = 406 \text{ kZ} / \text{cm}^2$ ;  
 $\sigma_{BC} = -509 \text{ kZ} / \text{cm}^2$ ;  $\sigma_{CD} = -305 \text{ kZ} / \text{cm}^2$

**2.22-masala.** Uzunligi  $5 \text{ m}$  bo'lgan po'lat sterjenni  $25 \text{ t}$  kuch bilan cho'zilishida hajmining kattalashishi topilsin. Jarayon elastiklik chegarada sodir bo'ladi.

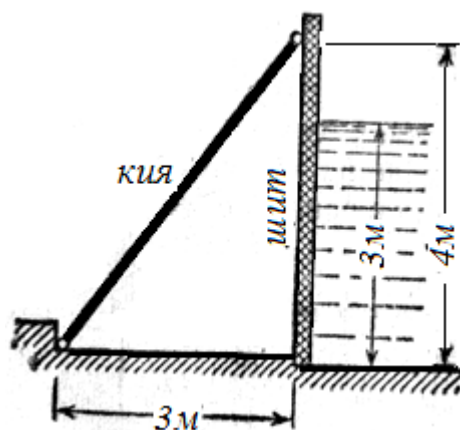
**javob:**  $2,5 \text{ cm}^3$ .



**2.23-masala.** 1 va 2 tyagalarga gorizontal birkir brus osilgan. Deformatsiyadan keyin ham brus gorizontal vaziyatda qolishi uchun  $F$  kuch 1 tyagadan qancha  $a$ -masofada ta'sir etishi kerak? Bu holda tyagalardan kuchlanishlar nimaga teng bo'ladi?

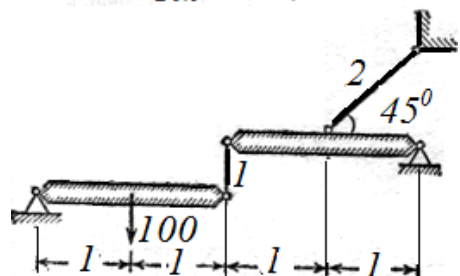
**javob:**  $a=1,08m$ ;

$$\sigma_1 = 440 \text{ kN/cm}^2; \sigma_2 = 330 \text{ kN/cm}^2.$$



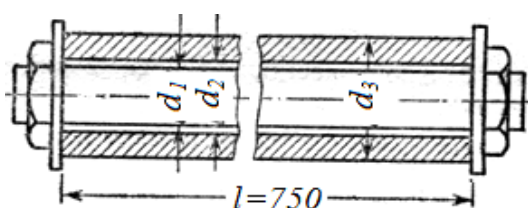
**2.24 masala.** Suv o'tkazmaydigan shitni ag'darilib ketishidan saqlaydigan qiyaliklar orasidagi ruxsat etilgan masofa aniqlansin. Qiyaliklar yog'och, ko'ndalang kesimining diametri 15sm, ruxsat etilgan kuchlanish  $20 \text{ kN/cm}^2$ .

**javob:** 1,88m.



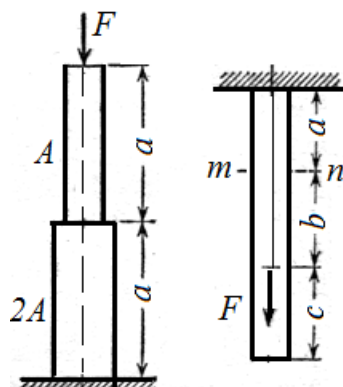
**2.25 masala.** 1 va 2 tyagalar ko'ndalang kesimlarining diametrlari  $1000 \text{ kN/cm}^2$ -ruxsat etilgan kuchlanishdan foydalanib topilsin.

**javob:**  $d_1 = 25,2 \text{ mm}$ ;  $d_2 = 42,4 \text{ mm}$ .



**2.26 masala.** Po'lat bolt mis truba-dan o'tkazilgan. Bolt rezbasining qadami 3mm. Gaykani 1/4 aylanishga bursak bolt va trubadagi kuchlar topilsin.

**javob:**  $\sigma_{II} = 1274 \frac{\text{kN}}{\text{cm}^2}$ ;  $\sigma_M = -364 \frac{\text{kN}}{\text{cm}^2}$ .



**2.27 masala.** Xususiy og'irligi va  $F$  kuch ta'siridagi pog'onali brus uzunligi to'liq qisqarishi topilsin. Materialning solishtirma og'irligi va elastiklik moduli berilgan deb hisoblansin.

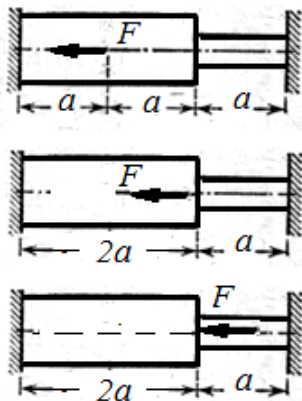
**Javob:**  $\frac{3Fa}{2EA} + \frac{3\gamma a^2}{2E}$ .

**2.28 masala.**  $F$  kuch va xususiy og'irligi ta'siridagi brus  $t$ -p kesimining (oldingi misolning ikkinchi sxemasi) ko'chishi topilsin.  $\gamma$  va  $E$  berilgan.

**javob:**  $\frac{Fa}{EA} + \frac{\gamma(b+c)a}{E} + \frac{\gamma a^2}{2E}$ .

**2.29 masala.** Mustahkamlik chegarasi  $50 \text{ kN/mm}^2$  bo'lgan po'lat sterjenning uzilishi uning qanday uzunligida sodir bo'ladi?

**javob:** 6,41km.



**2.30 masala.** Sterjenlar yuqori qismining kesim yuzasi  $100 \text{ cm}^2$ , pastki kesimi  $200 \text{ cm}^2$ , material ning ruxsat etilgan kuchlanishi  $1200 \frac{\text{N}}{\text{cm}^2}$ . Ruxsat etilgan kuchlar topilsin.

**javob:** a) 360 t, b) 360 t, c) 240 t.

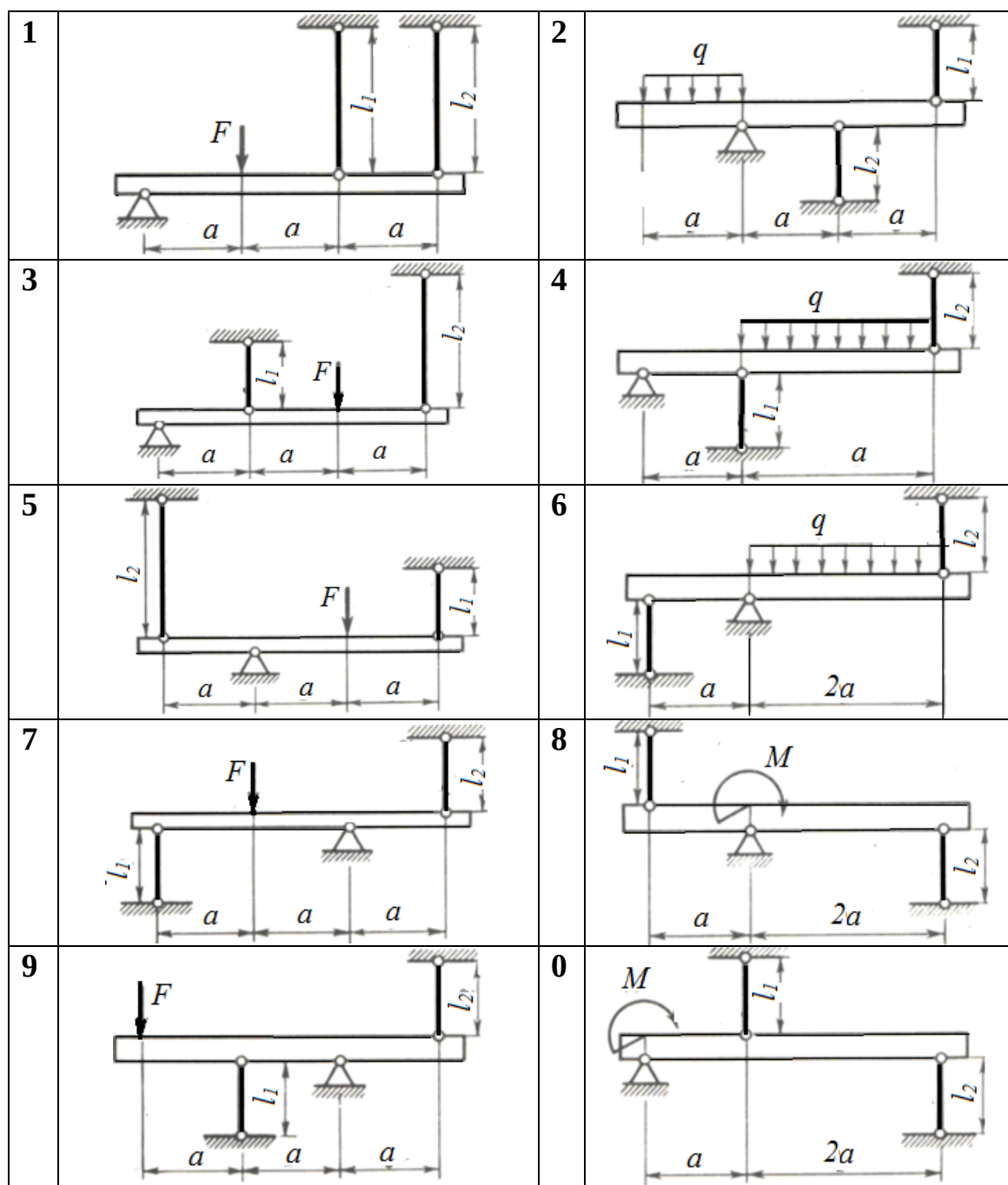
**misol – 2.31** Pog'onali brusni cho'zilish va siqilishga hisoblash.

|   |  |    |  |
|---|--|----|--|
| 1 |  | 2  |  |
| 3 |  | 4  |  |
| 5 |  | 6  |  |
| 7 |  | 8  |  |
| 9 |  | 10 |  |



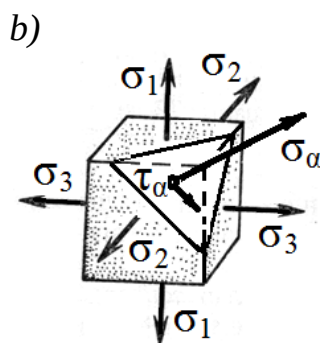
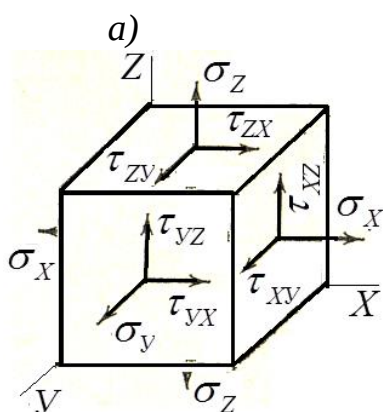
| berilgan  | VARIANT |     |     |     |     |     |     |     |     |     |
|-----------|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|           | 1       | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 0   |
| $a, m$    | 1,0     | 1,2 | 1,4 | 1,6 | 1,8 | 2,0 | 2,2 | 2,4 | 2,6 | 2,8 |
| $b, m$    | 2,8     | 2,6 | 2,4 | 2,2 | 2,0 | 1,8 | 1,6 | 1,4 | 1,2 | 1,0 |
| $s, m$    | 1,0     | 1,2 | 1,4 | 1,6 | 1,8 | 2,0 | 2,2 | 2,4 | 2,6 | 2,8 |
| $A, mm^2$ | 100     | 150 | 200 | 250 | 300 | 300 | 250 | 200 | 150 | 100 |
| $F, kN$   | 10      | 15  | 20  | 25  | 30  | 30  | 25  | 20  | 15  | 10  |
| $F_1, kN$ | 30      | 25  | 20  | 15  | 10  | 10  | 15  | 20  | 25  | 30  |

**misol – 2.32. Sterjenlar sistemasini cho'zilish va siqilishga hisoblash.**





## KUCHLANGANLIK HOLATALARI



rasm-2.14. Kubikning kuchlanganlik holati:

- a) kuchlanishlar komponentlari;  
b) bosh kuchlanishlar va qiya kesimdagi normal va urinma kuchlanishlar

Jism nuqtasining kuchlanganlik holati o'zaro perpendikulyar qiya kesimlardagi

normal  $\sigma_x, \sigma_y, \sigma_z$  va

tangentsial  $\tau_{yz} = \tau_{zy}$ ,

$\tau_{zx} = \tau_{xz}$ ,  $\tau_{yx} = \tau_{xy}$

kuchlanishlar (2.14- rasm, a)

yoki bosh yuzalardagi

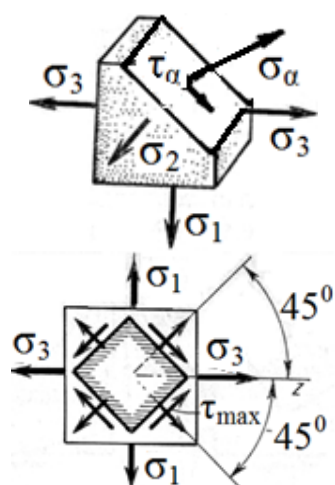
$\sigma_1 \succ \sigma_2 \succ \sigma_3$  (2.14- rasm, b)

berilishi mumkin.

Kuchlanganlik holatlarini

berilishiga ko'ra masala

ikkita variantda echiladi:



- 1) agar, bosh yuzalardagi kuchlanishlar berilgan bo'lsa, masalan  $\sigma_2$  kuchlanish vektoriga parallel qiya kesim yuzadagi normal va urinma kuchlanishlar hisoblanadi

$$\sigma_\alpha = \sigma_1 \cos^2 \alpha + \sigma_3 \sin^2 \alpha \quad \tau_\alpha = \frac{\sigma_1 - \sigma_3}{2} \sin 2\alpha$$

$\alpha = 45^\circ$  burchakda joylashgan qiya kesimda urinma kuchlanish maksimal qiymatga erishadi

$$\tau_\alpha = \tau_{\max} = \frac{\sigma_1 - \sigma_3}{2} \text{ va normal kuchlanish } \sigma_\alpha = \frac{\sigma_1 + \sigma_3}{2}$$

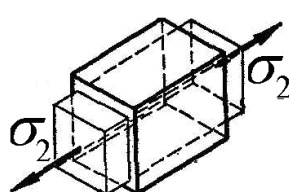
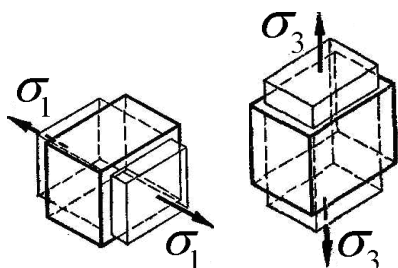
- 2) agar, qiya kesimni vaziyati va undagi normal va

urinma kuchlanishlar berilgan bo'lsa, bosh kuchlanishlar

va ularning yo'nalishi, ya'ni bosh yuzalarni qiya kesimga nisbatan joylashish burchagi hisoblanadi:

$$\sigma_{1,3} = \frac{1}{2} \left[ (\sigma_\alpha + \sigma_\beta)^2 \pm \sqrt{(\sigma_\alpha - \sigma_\beta)^2 + 4\tau_\alpha^2} \right]$$

bosh kuchlanishlarning yo'nalishi  $tg 2\alpha = -\frac{2\tau_\alpha}{\sigma_\alpha - \sigma_\beta}$



$$\varepsilon_1 = \frac{1}{E} [\sigma_1 - \mu(\sigma_2 + \sigma_3)]$$

$$\varepsilon_2 = \frac{1}{E} [\sigma_2 - \mu(\sigma_1 + \sigma_3)]$$

$$\varepsilon_3 = \frac{1}{E} [\sigma_3 - \mu(\sigma_1 + \sigma_2)]$$

**misol-2.33.** Ko'ndalang kesim o'lchamlari  $0,2 \times 0,2 \times 0,2$  m bo'lgan kubikning emirilish vaqtidagi, tashqi siquvchi kuchning ta'sir chizig'iga  $45^\circ$  burchak bilan qiya kesim yuzasidagi normal kuchlanish  $\sigma_\alpha = 40 \text{ MPa}$ . Kubik qancha siquvchi kuch ta'sirida emiriladi.

**echish:** Kubik chiziqli kuchlanganlik holatida bo'lganligi uchun, uning qiya kesimidagi normal kuchlanish formulasi quyidagicha yoziladi.

$$\sigma_\alpha = \sigma \cos^2 \alpha = \frac{F}{A} \cos^2 \alpha = 40 \text{ MPa}$$

Bu erdan 
$$F = \frac{40 A}{\cos^2 \alpha} = \frac{40 \cdot 10^3 \cdot 0,2 \cdot 0,2}{(0,707)^2} = 3,2 \cdot 10^3 \text{ kN}$$

**2.34 -misol.** Po'latdan tayyorlangan kubik tekis kuchlanganlik holatida.

- 1) bosh kuchlanishlar va bosh yuzalar yo'nalishi;
- 2) eng katta urinma bosh kuchlanish;
- 3) nisbiy deformatsiyalar hisoblansin.

Berilgan:  $\sigma_\alpha = 40 \text{ MPa}$ ;  $\sigma_\beta = 10 \text{ MPa}$ ;  $\tau_2 = 10 \text{ MPa}$

Bosh kuchlanishlarni topamiz:

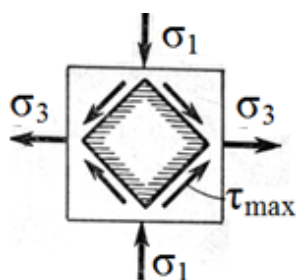
$$\sigma_{1,3} = \frac{1}{2} [(40 + 10) \pm \sqrt{(40 - 10)^2 + 4(10)^2}] = \frac{1}{2} (50 \pm 36,05)$$

Bu erdan:  $\sigma_1 = 43,025 \text{ MPa}$  va  $\sigma_3 = 6,975 \text{ MPa}$

Bosh yuzalarning joylashish burchagini aniqlaymiz:

$$\operatorname{tg} 2\alpha = -\frac{2 \cdot 10}{40 - 10} = -0,667; \quad 2\alpha = -34^\circ; \quad \alpha = -17^\circ$$

$\alpha$  - burchak ishorasi minus bo'lganligi uchun  $\sigma_1$  yo'nalishini



$\sigma_\alpha$  tekisligidan soat strelkasi yo'nalishi bo'yicha joylashtirdik. Eng katta urinma kuchlanish:

$$\tau_{\max} = \frac{\sigma_1 - \sigma_3}{2} = \frac{43,025 - 6,975}{2} = 18,025 \text{ MPa}$$

Kubik tomonlarning nisbiy cho'zilishi:

$$\varepsilon_1 = \frac{1}{2 \cdot 10^8} (43025 - 0,3 \cdot 6975) = 20,466 \cdot 10^{-5}$$

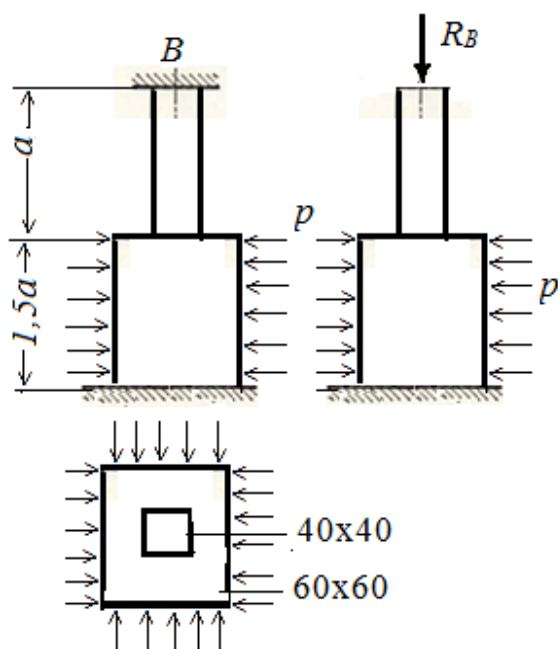
$$\varepsilon_2 = -\frac{0,3}{2 \cdot 10^8} (43025 + 6975) = -7,5 \cdot 10^{-5} \quad (\text{siqilish})$$

$$\varepsilon_3 = \frac{1}{2 \cdot 10^8} (6975 - 0,3 \cdot 43025) = -2,97 \cdot 10^{-5} \quad (\text{siqilish})$$

Hajmning nisbiy o'zgarishi:  $\varepsilon_0 = (20,466 - 7,5 - 2,97) \cdot 10^{-5} = 10 \cdot 10^{-5}$

**misol-2.35.** Pastki pog'onasi  $p = 160 \frac{H}{\text{mm}^2}$  bosim bilan yuklangan pog'onali

po'lat brus ( $E = 2 \cdot 10^5 \frac{H}{\text{mm}^2}$ ,  $\mu = 0,3$ ) ning kesimlaridagi normal kuchlanishlar topilsin.



2.15-rasm. Statik noanik pogonali brus

**echish.** Berilgan brus statik noanik. Tayanch reaksiyalarini aniqlash uchun asosiy sistemani tanlaymiz. Asosiy sistemada bitta tayanch ta'sirini, masalan yuqori  $B$  tayanch ta'sirini undagi noma'lum  $R_B$  reaksiya bilan almashtiramiz. Berilgan sistemadagi kabi, asosiy sistemada ham  $B$  tayanch qo'lg'almas bo'ladi, ya'ni  $\Delta_B = 0$ . Kuchlarni ta'sir qilishdagi halal bermaslik printsiptiga asosan  $B$  nuqtaning qo'yishi bosim  $p$  va reaksiya  $R_B$  ta'siridagi ko'chishlarning algebraik yig'indisiga teng.

$$\Delta_B = \Delta_{BP} + \Delta_{BR} = 0$$

Brusning pastki pog'onasi  $p$  bosim ostida ikki o'qli siqilishda

bo'ladi. Natijada pastki pog'ona  $B$  nuqta yo'nalishi u o'qi bo'ylab deformatsiyalanadi.

$$\text{Gukni umumlashgan qonunidan} \quad \varepsilon_z = \frac{1}{E}[\delta_z - \mu(\delta_x + \delta_y)]$$

$\delta_z = 0$  chunki  $z$  o'qi bo'ylab hech qanday kuch ta'sir qilmaydi.

$$\delta_x = \delta_y = -p, \quad \text{unda} \quad \varepsilon_z = \frac{1}{E}[-\mu(-p - p)] = 2 \frac{\mu \cdot p}{E}$$

Pastki pog'ona  $1,5a \cdot \frac{2\mu p}{E}$  miqdorga uzayadi. Demak,  $B$  nuqta shu

miqdorga yuqoriga ko'tariladi.  $R_B$  reaksiya ta'siridan  $B$  nuqta  $\Delta_{BR}$  miqdorga

$$\text{pastga tushadi:} \quad \Delta_{BR} = -\frac{R_B \cdot a}{EA_1} - \frac{R_B \cdot 1,5a}{EA_2}$$

bu erda  $A_2 = 60 \times 60 = 3600 \text{ mm}^2$  va  $A_1 = 40 \times 40 = 1600 \text{ mm}^2$

$\Delta_{BP}$  va  $\Delta_{BR}$  - ifodalarini umumiy qo'yish tenglamasiga keltirib

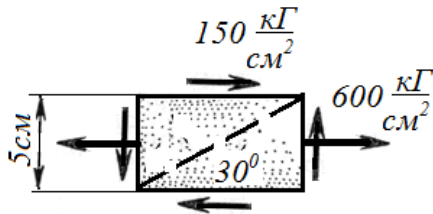
$$\text{qo'yamiz:} \quad \frac{3\mu \cdot p \cdot a}{E} - \frac{R_B \cdot a}{E} \left( \frac{1}{A_1} + \frac{1,5}{A_2} \right) = 0.$$

$$\text{Bu erdan} \quad R_B = \frac{3\mu \cdot p}{\frac{1}{A_1} + \frac{1,5}{A_2}} = \frac{3 \cdot 0,3 \cdot 160}{\frac{1}{1600} + \frac{1,5}{3600}} = 139 \cdot 10^3 \text{ H}.$$

Brusning kesimlaridagi kuchlanishlar:

$$\text{Yuqori pog'ona } \sigma_B = \frac{R_B}{A_1} = \frac{139 \cdot 10^3}{1600} = 87 \frac{H}{\text{mm}^2}$$

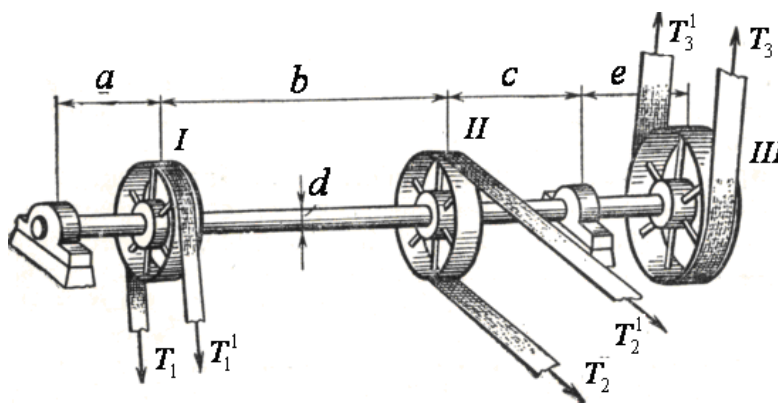
$$\text{Pastki pog'ona } \sigma_H = \frac{R_B}{A_2} = \frac{139 \cdot 10^3}{3600} = 38,6 \frac{H}{\text{mm}^2}$$



**misol.** Po'lat detaldan kesib olingan element tekis kuchlanganlik holatida. Diagonal uzunligining o'zgarishi aniqlansin.

**javob:**  $37 \cdot 10^{-3} \text{ mm}$ .

## BURALISH

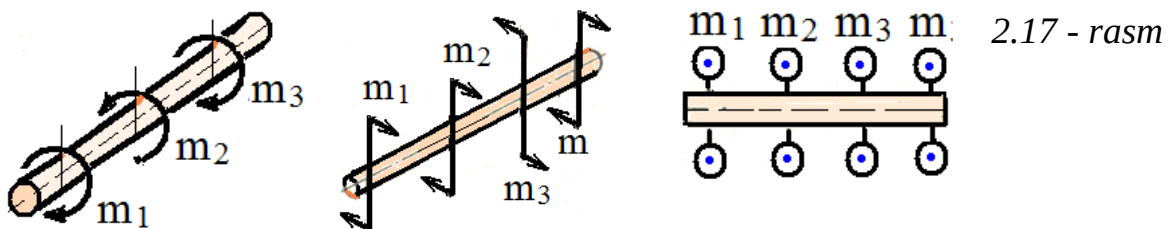


2.16– rasm. Remenli uzatma va remenlarning taranglik kuchlari

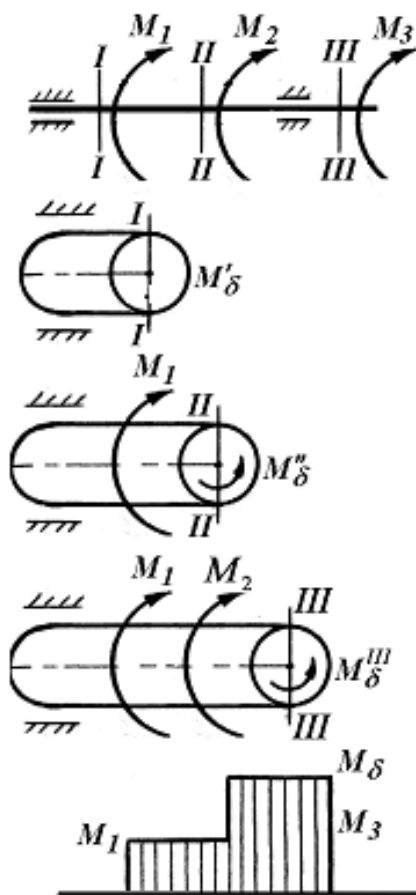
## Burovchi momentni aniqlash

Shkivlar o'rnatilgan doiraviy kesimli sterjenning (2.16–rasm) remenlarida hosil bo'lgan tortishish kuchlari ( $t_1$  va  $T_1$ ;  $t_2$  va  $T_2$ ;  $t_3$  va  $T_3$ ) ning sterjen kesimining markaziga nisbatan momentlari  $M_1 = T_1 R_1 - t_1 R_1 = t_1 R_1$ ;  $M_2 = t_2 R_2$  va  $M_3 = t_3 R_3$

bilan yuklangan sxema, 2.16–rasmda ko'rsatilgan.  $R_1$ ,  $R_2$  va  $R_3$  – tegishli 1,2 va 3 shkivlarning radiuslari.  $M_1$ ,  $M_2$  va  $M_3$  –lar aylantiruvchi momentlar deyiladi va sterjen kesimining sirtiga qo'yiladi.



Brus yuklanishining turli sxemalarini tasvirlashda tashqi aylantiruvchi momentni belgilashda 2.17-rasmdan foydalanish mumkin. Ayrim darsliklarda tashqi aylantiruvchi moment –  $m$  yoki  $M$  harflari bilan belgilanadi. Aylantiruvchi moment ta'siridan sterjenning kesim yuzasida burovchi moment hosil bo'ladi



Ixtiyoriy kesimdagi burovchi momentni topish uchun, sterjenni shu kesimdan tekislik bilan fikran ikki bo'lakka ajratamiz va har bir bo'lakka  $M_x = M_\delta$  burovchi momentlarini qo'yamiz.

**I-I qirqim**dan chap tomonda qolgan sterjenda aylantiruvchi momet ta'siri yo'q, shuning uchun sterjenning olib qoling qismida burovchi moment nolga teng, ya'ni

$$M_\delta^I = 0.$$

**II-II qirqim** uchun chap qismning muvozanat tenglamasidan quyidagi ifodani topamiz:

$$\sum M_x = M_1 - M_\delta^{II} = 0 \quad \text{va} \quad M_\delta^{II} = M_1$$

2.18-rasm. Burovchi momentni aniqlash:

- remani uzatmaning umumiy ko'rinishi va remenlardagi taranglik kuchlari;
- sterjenni kesish tartibi va burovchi moment epyurasi

$$\text{III-III qirqim: } \sum M_x = M_1 + M_2 - M_\delta^{III} = 0 \quad \text{yoki} \quad M_\delta^{III} = M_1 + M_2$$

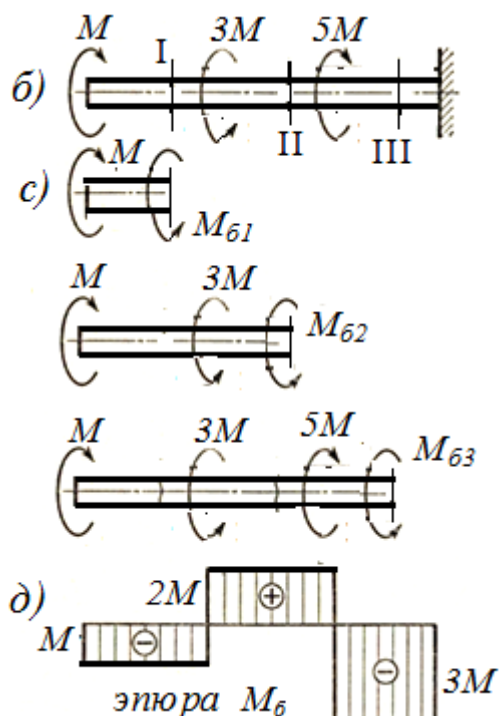
$$\text{IV-IV qirqim} \quad \sum M_x = M_1 + M_2 + M_3 - M_\delta^{IV} = 0 \quad \text{va} \quad M_\delta^{IV} = 0$$

Sterjen kesim yuzasida hosil bo'ladigan burovchi moment  $M_\delta$  kesilgan kesim yuzasiga nisbatan bir tomonda joylashgan tashqi momentlarning algebraik yig'indisiga teng. Sterjenning ajratib olingan bo'lagidagi tashqi moment, kesilgan kesim yuzasining markaziga nisbatan soat strelkasi yo'nalishi bo'yicha harakat qilsa,  $M_\delta$  ishorasi musbat qabul qilinadi.  $M_\delta$  - ni o'zgarish grafikasi, epyurasi (2.18-rasm)

Burovchi momentni hisoblash uchun kesish metodidan foydalanamiz. Buning uchun, valni I-I tekislik bilan fikran kesib ikkita B va C bo'laklarga ajratamiz (2.19-rasm) va bir bo'lagini tashlab yuboramiz. Unda ajratib olingan val bo'lagining muvozanati buziladi. Uni ta'minlash uchun ajratib olingan val bo'lagining kesilgan yuzasiga tashlab yuborilgan qismning ta'sirini M juft momenti ko'rinishida keltiramiz. Val uchta uchastkadan iborat (2.19-rasm,b).

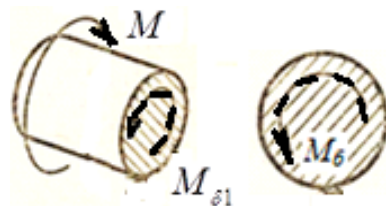
Uchastkalarining chegarasi aylantiruvchi momentlar qo'yilgan kesimlar hisoblanadi.

**1-qirqim.** Valni M va 3M aylantiruvchi momentlari orasidan ixtiyoriy kesimdan I-I tekislik bilan kesib ikkinchi bo'lagini tashlab yuboramiz. Valni olib qoling bo'lagining muvozanatini ta'minlash uchun,

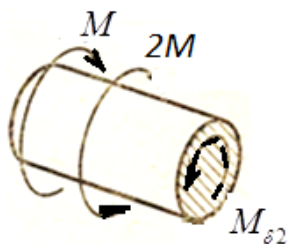


2.99-rasm. Valni yuklanish sxemasi (b), kesish tartibi (c) va burovchi moment yupyurasi (d)

uning kesilgan yuzasiga tashlab yuborilgan tomon ta'sirini  $M_{\delta 1}$  moment ko'rinishida keltirib qo'yamiz.  $M_{\delta 1}$  burovchi moment deyiladi. Burovchi moment tashqi aylantiruvchi moment yo'nalishiga teskari aylanadi. Agar, tashqi aylantiruvchi moment valning olib qolingani qismini uning keilgan yuzasiga nisbatan soat strelkasining aylanish yo'nalishi bo'yicha aylantirishga intilsa burovchi moment manfiy ishorali.



Bunday holatda burovchi momentning yo'nalishi soat strelkasining harakat yo'nalishiga teskari yo'naladi. Valni olib qolingani qismining muvozanat shartidan  $M_{\delta 1} = -M$



Valni keyingi oraliqlari uchun kesish usuli ko'rsatilgan tartibda bajariladi (2.19 – rasm, s).

**2-qirqim**  $M_{\delta 2} = -M + 3M = 2M$

**3-qirqim**  $M_{\delta 3} = -M + 3M - 5M = -3M$

Burovchi moment kesish tekisligidan bir tomonda qolgan aylantiruvchi momentlarnig algebraik yig'indisiga teng. Burovchi momentni valning uzunligi bo'ylab o'zgarish grafikasi uning epyurasi deyiladi (2.19 – rasm, s).

Burovchi moment epyurasini qurish uchun valning o'qiga perpendikulyar tekislikda tanlangan masshtabda ordinata ko'rinishida joylashtiramiz. Val to'planma momentlar bilan yuklanganda burovchi moment epyurasi ko'rilgan masaladagi kabi, bitta uchastka uzunligi bo'ylab valning o'qiga parallel chiziq bo'ladi. Uchastkalarining chegarasida burovchi momentning epyurasida, ushbu kesimga qo'yilgan moment miqdoriga teng sakrash bo'ladi (2.19 – rasm, d).

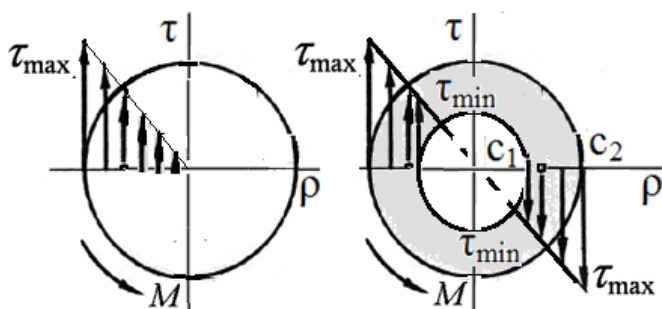
Aylantiruvchi momentni valning uzatayotgan quvvati va burchak tezligi bilan ham ifodalash mumkin:

$$M = 973,8 \cdot \frac{N \cdot \kappa B m}{n, \text{об/мин}} = \kappa \Gamma \cdot M$$

$$M = 71620 \cdot \frac{N}{n, \text{об/мин}} \cdot \frac{\text{л.с}}{\text{об/мин}} = \kappa \Gamma \cdot \text{с.м}$$

$n, \omega$  - tegishli, valni aylanishlar chastotasi va burchak tezligi





2.20-rasm. Valning kesim yuzasida urinma kuchlanishni tarqalish qonuniyati.

**Buralishda mustahkamlik va bikrlilik shartlari.**

$$\tau = \frac{M_{\delta} \cdot \rho}{I_{\rho}} \text{ formulaga urinma}$$

kuchlanish sterjen kesimining diametri bo'ylab to'g'ri chiziqli qonuniyat bilan o'zgaradi (2.20 – rasm).

$$\text{Buerda } I_{\rho} = \frac{\pi d^4}{32} = 0,1 \cdot d^4 \text{ doiraviy kesim}$$

yuzaning qutb inertiya momenti

Halqaning qutb inertiya momenti

$$I_{\rho} = \frac{\pi d^4}{32} (1 - \alpha^4) = 0,1 \cdot d^4 (1 - \alpha^4) \quad \text{buerda } \alpha = \frac{d_0}{d}$$

$$\text{Eng katta kuchlanishni hisoblash} \quad \tau = \frac{M_{\delta}}{W_{\rho}}$$

$$\text{Doira } W_{\rho} = \frac{\pi d^3}{16} = 0,2 \cdot d^3 \quad \text{Halqa } W_{\rho} = \frac{\pi d^3}{16} (1 - \alpha^4) = 0,2 d^3 (1 - \alpha^4)$$

Yuqoridagi formulalardan ma'lumki, sterjen kesimining markazidan eng uzoqda joylashgan nuqtalarida urinma kuchlanish eng katta qiymatga erishadi,

$$\text{ya'ni:} \quad \tau_{\max} = \frac{M_{\delta}}{W_{\rho}}$$

Agar,  $\tau_{\max}$  shu sterjenning materiali uchun ruxsat etilgan kuchlanish- dan katta bo'lmasa, sterjenning buralishdagi mustahkamligi ta'minlangan bo'ladi:

$$\tau_{\max} = \frac{M_{\delta}}{W_{\rho}} \leq [\tau] \quad (2.5)$$

$$\text{bu erda: } [\tau] = (0,5 \dots 0,6) [\sigma]_r$$

Agar, sterjenga kuyilgan burovchi moment va sterjenning materiali ma'lum bulsa, uning diametrini (2.5) formula yordamida tanlash mumkin:

$$d \geq \sqrt[3]{\frac{16 M_{\delta}}{\pi [\tau]}} \quad (2.6)$$

Agar, sterjenning diametri va materiali berilgan bo'lsa, unga qo'yilishi mumkin bo'lgan burovchi moment topilishi mumkin.

$$M_{\delta} = \frac{\pi \cdot d^3}{16} \leq [\tau]$$

Ko'pgina vallar uchun to'liq buralish burchagining qiymatini cheklab qo'yiladi, ya'ni:

$$\varphi_{\max} = \frac{M_{\delta} \cdot \ell}{GI_{\rho}} \leq [\varphi] \quad (2.7)$$



Bu erda  $[\varphi] = 0,15 \dots 0,3^0$  buralish burchagining ruxsat etilgan qiymati. (2.7) formula buralishdagi bikrlilik sharti deyiladi.

$$I_{\rho} = \frac{\pi \cdot d^4}{32} \approx 0,1d^4 \quad \text{qutb inertsia momentini hisobga olib, bikrlilik shartidan}$$

$$\text{sterjenning diametrini topamiz. } d \geq 4 \sqrt{\frac{32M_{\delta} \ell}{\pi \cdot G[\varphi]}} \quad (2.8)$$

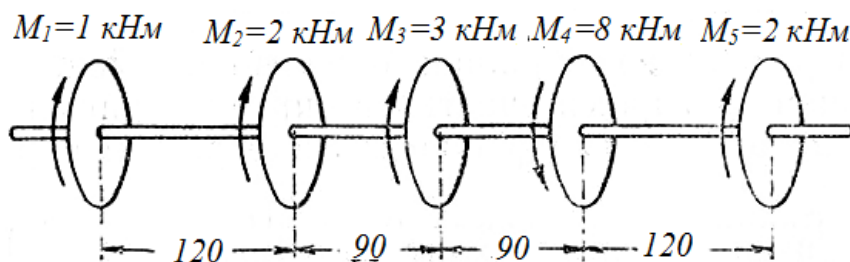
**misol -2.36** Diametri 10 sm va uzunligi 6 m bo'lgan yaxlit po'lat val 4<sup>0</sup> burchakka buralgan. Eng katta urinma kuchlanish nimaga teng?

**javob:** 46,5 MPa

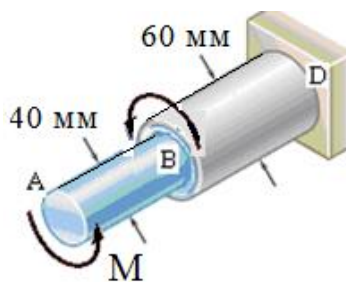
**misol-2.37** Agar ruxsat etiladigan kuchlanish  $[\tau] = 100 \text{ MPa}$  bo'lsa, diametri 20 mm bo'lgan dumaloq kesimli po'lat sterjenning yuk ko'taruvchanligini aniqlang. Sterjenning 100 sm uzunlikdagi uchastkasining buralish burchagi qiymati nimaga teng?

**javob:** 15,7 kNsm; 0,125 rad.

**misol-2.38.** Po'lat valga beshta shkiv orqali (2.21 – rasm) juft kuchlar ta'sir qiladi. Burovchi moment epyurasini quring,  $[\tau] = 9000 \frac{H}{\text{cm}^2}$  bo'lganda val diametrini tanlang va valning o'ngdagi oxirgi kesimining chapdagi kesimiga nisbatan burilish burchagi kattaligini aniqlang. **javob:** 7 sm ; 0,366 rad.



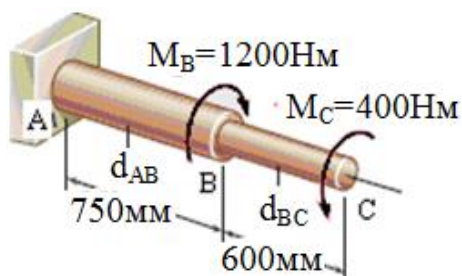
2.21 – rasm.



2.22 – rasm.

**javob:** 13500  $\frac{H}{\text{cm}^2}$

**misol-2.39.** O'ng uchi qisib qo'yilgan doiraviy kesimli sterjenga ikkita bir xil burovchi juft kuchlar  $M$  qo'yilgan (2.22 – rasm ). Sterjen chap uchastkasining diametri 40 mm, o'ng uchastkasining diametri 60 mm, qeng uchastkadagi eng katta urinma kuchlanish  $8000 \frac{H}{\text{cm}^2}$ , sterjenning chap uchastkasidagi eng katta urinma kuchlanish nimaga teng?



**misol-2.40.** Aylantiruvchi momentlar bilan yuklangan brus uchun burovchi moment epyurasi qurilsin. Brus pog'onalarining diametrlari topilsin?

**misol-2.41.** Uzunligi 1,8 m bo'lgan ichi bo'sh po'lat val uchlariga  $M = 6 \text{ kNm}$  momentli ikki juft kuchlar yuklangan. Agar buralish burchagi  $2^\circ$  dan oshishi mumkin bo'lmasa, urinma kuchlanish  $7000 \frac{\text{H}}{\text{cm}^2}$

bo'lsa, valning tashqi va ichki diametrlarini aniqlang.

**javob:** 90,4 mm, 72,4 mm

**misol-2.42.** Agar valdagi urinma kuchlanish  $6000 \frac{\text{H}}{\text{cm}^2}$ , uning ichki diametri

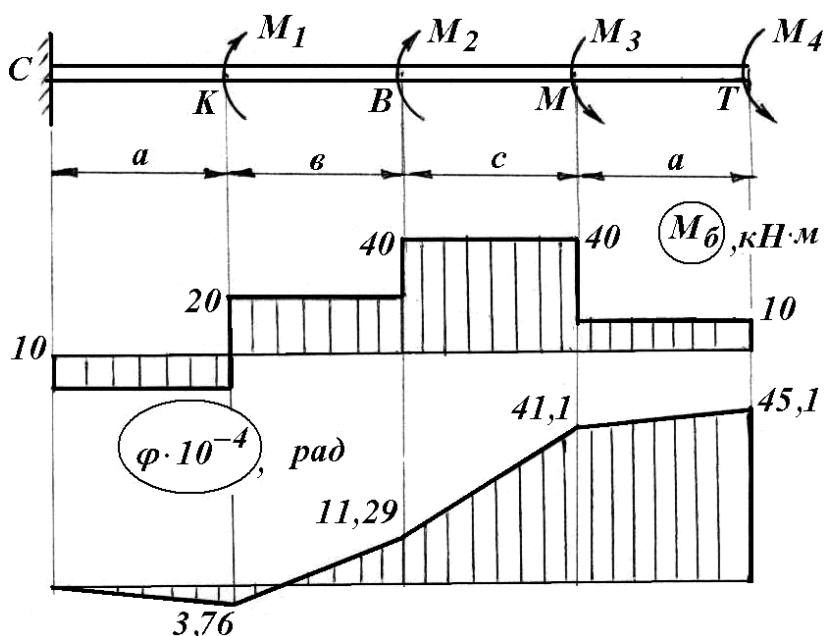
tashqi diametrining 0,6 ulushicha bo'lsa, 100 ayl/min tezlikda 7000 kVt quvvat uzatadigan ichi bo'sh po'lat valning diametrini aniqlang.

**javob:** 40,5 sm va 24,8 sm

**misol -2.43**

$M_1 = 30 \text{ kHm}$ ;  $M_2 = 20 \text{ kHm}$ ;  $M_3 = 30 \text{ kHm}$ ;  $M_4 = 10 \text{ kHm}$ ;

momentlar bilan yuklangan doiraviy kesimli sterjenni, buralishdagi mustaxkamlik sharti asosida  $[\tau] = 90 \text{ MPa}$ , diametrini aniklang (2.23-rasm).



$a = 1 \text{ m}$ ;

$b = 2 \text{ m}$ ;

$c = 2 \text{ m}$ ;

$G = 8 \cdot 10^7 \frac{\text{kH}}{\text{m}^2}$

2.23 – rasm.

Sterjenni yuklanish sxemasi va burovchi moment va buralish burchagining epyuralari.

**echish:** 1) Sterjenni tayanch kesimidagi  $M_s$  reaktiv momentini topamiz  
 $\sum M_c = -M_c + M_1 + M_2 - M_3 - M_4 = 30 + 20 - 30 - 10 = 10 \text{ kHm}$

Sterjenni uzunligi bo'ylab burovchi momentini o'zgarishini topamiz

I – I **oraliq**  $M_{\sigma 1} = -M_c = -10 \text{ kHm}$

II – II **oraliq**  $M_{\sigma 1} = -M_c + M_1 = -10 + 30 = 20 \text{ kHm}$

III – III **oraliq**  $M_{\delta 3} = -M_c + M_1 + M_2 = -10 + 30 + 20 = 40 \text{ kNm}$

IV – IV **oraliq**  $M_{\delta 4} = -M_c + M_1 + M_2 - M_3 = -10 + 30 + 20 - 30 = 10 \text{ kNm}$

2) Buralishdagi mustahkamlik shartiga ko'ra sterjenning diametrini aniqlaymiz

$$d = \sqrt[3]{\frac{16 \cdot M_{\delta \max}}{\pi [\tau]}} = \sqrt[3]{\frac{16 \cdot 40}{3,14 \cdot 90 \cdot 10^3}} = 0,131 \text{ m};$$

$d = 135 \text{ mm}$  qabul qilamiz.

3) Sterjenning buralish burchagini aniqlaymiz  $\varphi_c = 0;$

$$\varphi_K = \frac{M_{\delta 1} \cdot a}{GI_P} = -\frac{10 \cdot 1}{8 \cdot 10^7 \cdot 0,1d^4} = \frac{-10}{8 \cdot 10^6 \cdot (0,135)^4} = -3,763 \cdot 10^{-3} \text{ rad}$$

$$\varphi_B = -3,76 \cdot 10^{-3} + \frac{20 \cdot 2}{2657 \cdot 10^3} = 11,29 \cdot 10^{-3} \text{ rad}$$

$$\varphi_M = 11,29 \cdot 10^{-3} + \frac{40 \cdot 2}{2657 \cdot 10^3} = 41,16 \cdot 10^{-3} \text{ rad}$$

$$\varphi_T = 41,16 \cdot 10^{-3} + \frac{10 \cdot 1}{2657 \cdot 10^3} = 45,16 \cdot 10^{-3} \text{ rad}$$

Buralish burchagining ( $\varphi$ ) epyurasi 2.23-rasmda ko'rsatilgan.

**misol-2.44.** Diametri 25mm po'lat sterjen 6t cho'zuvchi kuch ta'siridan 20sm uzunligi 0,122mm ga uzayadi. Ushbu sterjen 2 tsm burovchi moment ta'siridan 20sm uzunlikda 0,75° buraladi.  $E, G, \mu$  -aniqlansin.

**javob:**  $E = 2 \cdot 10^6 \frac{\text{kg}}{\text{cm}^2}, G = 8 \cdot 10^5 \frac{\text{kg}}{\text{cm}^2}, \mu = 0,25.$

**misol-2.45.** 90mm diametrli val 90 ot kuchini uzatadi. Ruxsat etilgan urinma kuchlanish  $600 \frac{\text{kg}}{\text{cm}^2}$  bo'lsa, valni chegaraviy aylanishlar soni topilsin.

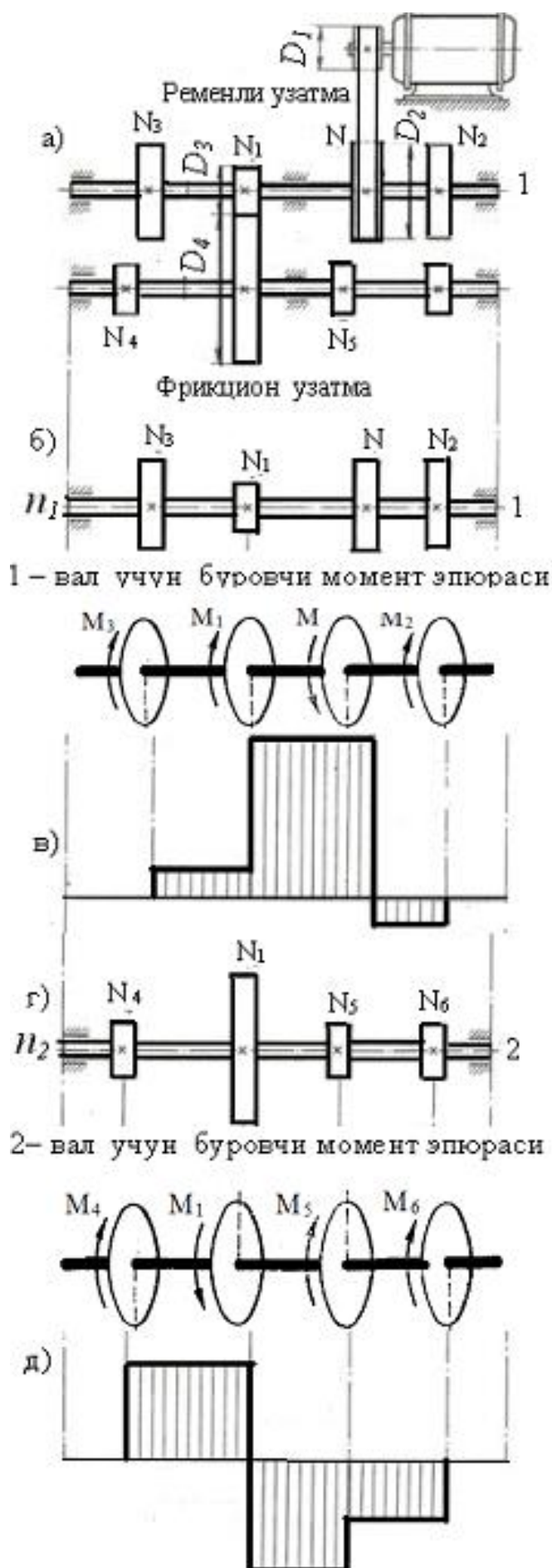
**javob:**  $75 \frac{\text{ayl}}{\text{min}}.$

**misol-2.46.** 90mm diametrli val 150ayl/min aylanish chastotasida 50ot kuchini uzatadi. Shkivlar orasidagi val uzunligi 4m eng katta urinma kuchlanish va bir shkivni ikkinchisiga nisbatan aylanish burchagi aniqlansin.

**javob:**  $\tau = 167 \frac{\text{kg}}{\text{cm}^2}, \varphi = 1^{\circ} 4'.$

**misol-2.47.** O'rtacha diametri 12,5sm ingichka devori po'lat trubaning chetki kesimlariga 62,5t\*sm burovchi moment qo'yilgan. Urinma kuchlanish  $800 \frac{\text{kg}}{\text{cm}^2}$  dan foydalanib truba devorining qalinligi va 1m uzunlikdagi buralish burchagi aniqlansin.

**javob:** 0,32sm 0,016rad.



**misol -2.48.** Remen yordamida elektrodvigateldan 1 valga  $N = 20\text{кВт}$  quvvat uzatiladi. 1 valdan 2-valga  $N_1 = 15\text{кВт}$  va ishchi mashinalarga  $N_2 = 2\text{кВт}$  va  $N_3 = 3\text{кВт}$ , 2-valdan ishchi mashinalarga  $N_4 = 7\text{кВт}$ ,  $N_5 = 4\text{кВт}$ ,  $N_6 = 4\text{кВт}$  quvvat uzatiladi. (2.24 -rasm). 1 va 2 vallarning uzunligi bo'ylab kesim o'zgarmas. Elektrodvigatel valining aylanish chastotasi  $n = 970 \frac{\text{айл}}{\text{мин}}$  shkivlarning

diametrlari  $D_1 = 200\text{мм}$ ;  $D_2 = 400\text{мм}$ ;  $D_4 = 600\text{мм}$ . Rementlarning sirpanishi e'tiborga olinma-sin

**echish.** 1-valga  $N$  quvvat etkaziladi va undan  $N_1$ ,  $N_2$ ,  $N_3$  quvvatlar uzatiladi. 1-valning burchak tezligi va  $m$ ,  $m_1$ ,  $m_2$ ,  $m_3$  - tashqi aylantiruvchi momentlarni topamiz.

- 2.24-rasm. a) uzatmaning umumiy sxemasi;  
 b) birinchi valning yuklanish sxemasi;  
 v) birinchi val uchun burovchi moment epyurasi;  
 g) ikkinchi valning yuklanish sxemasi;  
 d) ikkinchi val uchun burovchi moment epyurasi

$$n_1 = n \frac{D_1}{D_2} = 970 \cdot \frac{200}{400} = 485 \frac{\text{aйл}}{\text{мин}} \quad \omega_1 = \frac{\pi n_1}{30} = \frac{3,14 \cdot 485}{30} = 50,8 \frac{P}{c}$$

$$m = \frac{N}{\omega_1} = \frac{20 \cdot 10^3}{50,8} = 394 H \cdot m \quad \text{va} \quad m_1 = \frac{N_1}{\omega_1} = \frac{15 \cdot 10^3}{50,8} = 295 H \cdot m$$

$$m_2 = \frac{N_2}{\omega_1} = \frac{2 \cdot 10^3}{50,8} = 59,1 H \cdot m$$

1-val uchun (2.24-rasm, v). Valni chap uchidan o'ng tomonga qarab harakat qilamiz va burovchi moment epyuralarini quramiz.

Bunda  $N_1$ , va  $N_3$  ga tegishli momentlarni musbat ishorali va  $N$  ga tegishli momentni manfiy ishorali qabul qilamiz.

$$\text{Eng katta burovchi moment } M_{\max}^1 = 354,5 H \cdot m$$

2-valning aylanish chastotasi

$$n_2 = n_1 \frac{D_3}{D_4} = 485 \cdot \frac{200}{600} = 162 \frac{\text{aйл}}{\text{мин}} \quad \text{va} \quad \omega_2 = \frac{\pi n_2}{30} = \frac{3,14 \cdot 162}{30} = 17 \frac{P}{c}$$

2-valga  $N_1$  quvvat keladi va undan  $N_4$ ,  $N_5$ ,  $N_6$  quvvatlar uzatiladi.

Tashqi aylantiruvchi momentlarni hisoblaymiz.

$$m_1 = \frac{N_1}{\omega_2} = \frac{15 \cdot 10^3}{17} = 882 H \cdot m \quad m_4 = \frac{N_4}{\omega_2} = \frac{7 \cdot 10^3}{17} = 412 H \cdot m$$

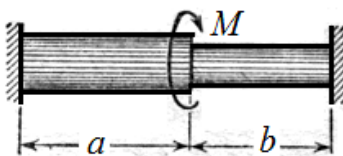
$$m_5 = m_6 = \frac{4 \cdot 10^3}{17} = 235 H \cdot m$$

**misol- 2.49.** Devorning qalinligi kesim o'rtacha diametrining 2% ini tashkil etadi. 3m uzunlikda buralish burchagi  $1^\circ$  shartidan kesimning diametri topilsin. Urinma kuchlanish nimaga teng?

$$\textbf{javob: } 17,8 \text{ sm}, \quad 413 \frac{\text{KЭ}}{\text{cm}^2}.$$

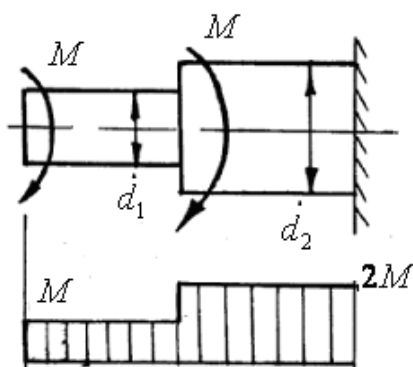
**misol-2.50.** Uzunligi 1,8m, o'rtacha diametri 30sm, devorining qalinligi 3mm bo'lgan trubasimon po'lat val 100aйл/min tezlik bilan aylanadi. Urinma kuchlanish  $630 \frac{\text{KЭ}}{\text{cm}^2}$  bo'lsa, qancha quvvat uzatiladi, buralish burchagi nimaga teng?

$$\textbf{javob: } 275 \text{ kVt}, \quad 0,542^\circ.$$



$$\textbf{javob: } a=1,8m \quad b=1,5m.$$

**misol-2.51.** Sterjen chap qismining diametri 6sm, o'ng qismining diametri 5sm, umumiy uzunligi  $a+b=3,3m$ . Sterjenning kesimlarida bir xi kuchlanish hosil qiladigan burovchi momentdan foydalanib  $a, b$ -o'lchamlar aniqlansin.



**misol – 2.52.** Bir tomoni qistirib mahkamlangan o'zgaruvchan kesimli sterjenga bir xil juft kuch momenti qo'yilgan. Sterjenning kichik diametri  $d_1 = 40 \text{ mm}$  va katta diametri  $d_2 = 60 \text{ mm}$ . Sterjenning o'ng pog'onasidagi eng katta urinma kuchlanish  $80 \text{ MPa}$ . Sterjenning chap pog'onasidagi urinma kuchlanishni toping.

**echish.** Sterjenning o'ng pog'onasidagi eng katta urinma kuchlanish formulasini yozamiz:  $\tau_2 = \frac{M_{\phi}^{II}}{W_{\rho}^{II}} = 80 \text{ MPa}$

Burovchi momentni topamiz:

$$M_{\phi}^{II} = 800 \cdot W_{\rho} = 800 \frac{\pi \cdot d_2^3}{16} = 800 \frac{3,14(6)^3}{16} = 33912 \text{ kГсм}$$

Sterjenning uzunligi bo'ylab burovchi moment epyurasini quramiz. Sterjenning II–II qirqim bilan ajratib olingan qismida burovchi moment tashqi momentlarning yig'indisiga teng, ya'ni  $M_b^{II} = 2M$ . Unda, 1–1 qiqimdagi ya'ni sterjenning chap pog'onasidagi burovchi moment miqdor jihatdan tashqi momentga teng  $M_b^I = M$ .

Chap pog'onadagi eng katta urinma kuchlanishni topamiz:

$$\tau_1 = \frac{M_{\phi}^I}{W_{\rho}^I} = \frac{33912}{2 \cdot 12,56} = 1350 \frac{\text{кГ}}{\text{см}^2}$$

$$\text{bu erda } W_{\rho}^I = \frac{\pi \cdot d_1^3}{16} = \frac{3,14(4)^3}{16} = 12,56 \text{ см}^3$$

**misol – 2.53.** Diametri  $d = 90 \text{ mm}$  bo'lgan val 90 ot kuch quvvatini uzatadi. Val materialining ruxsat etilgan kuchlanishi  $[\tau] = 60 \frac{\text{кГ}}{\text{см}^2}$  bo'lsa, valning bir minutdagi aylanishlari soni topilsin.

**echish:** burovchi moment, uzatilayotgan quvvat  $N$  va valning aylanishlari soni o'zaro bog'lanishda:  $M_{\phi} = 71620 \frac{N}{n}, \text{ kГсм}$

Burovchi momentni valning mustahkamlik shartidan aniq laymiz:

$$M_{\phi} = W_{\rho} [\tau] = \frac{\pi \cdot d^3}{16} [\tau] = \frac{3,14(9)^3}{16} \cdot 600 = 85839,7 \text{ kГсм}$$

Unda valning bir minutdagi aylanishlari soni

$$n = 71620 \frac{N}{M_{\phi}} = 75 \frac{\text{айл}}{\text{мин}}$$

**misol – 2.53.** Avtomobilning kardanli vali ikki xil rejimda bir xil quvvatni uzatadi ( $N = 23$  ot kuchi). Valni bir minutdagi aylanishlari soni, bir holatda

$n_1 = 108 \text{ ayl/min}$ ; ikkinchi holatda  $n = 60 \text{ ayl/min}$ . Val materialining ruxsat etilgan kuchlanishi  $[\tau] = 400 \frac{\kappa\Gamma}{\text{cm}^2}$  bo'lsa, valning tashqi va ichki diametrlarini ( $d_0 = 0,9 d$ ) toping.

**echish.** Kardanli valning ikki rejimiga to'g'ri keluvchi burovchi momentni topamiz:

$$M_{\delta}^1 = 71620 \frac{23}{108} = 15252,4 \kappa\Gamma\text{cm}, \quad M_{\delta}^{11} = 71620 \frac{23}{60} = 27454,3 \kappa\Gamma\text{cm}$$

Valning diametri o'zgarmas bo'lsa, eng katta kuchlanish  $M_{\delta}^{11}$  momenti ta'sirida hosil bo'ladi. Val kesimining qutb inertsia momentini topamiz:

$$I_{\rho} = \frac{\pi \cdot d^4}{32} - \frac{\pi \cdot d_0^4}{32} = \frac{\pi \cdot d^4}{32} (1 - 0,656) = 0,033755 d^4$$

Urinma kuchlanish va kesimining chetki nuqtasida, ya'ni kesim markazidan  $0,5 d$  masofada joylashgan nuqtasida hosil bo'ladi.

$$\tau_{\max} = \frac{M_{\delta}^{11} \cdot 0,5d}{I_{\rho}} = \frac{M_{\delta}^{11} d}{2 \cdot 0,033755 d} \leq [\tau] \quad \text{yoki} \quad d = \sqrt[3]{\frac{M_{\delta}^{11}}{0,06751 [\tau]}} = 10 \text{ cm}$$

Unda valning ichki diametri  $d_0 = 9 \text{ cm}$

**misol – 2.54.** Po'latdan tayyorlangan halqasimon kesimli val  $100 \text{ ob/min}$  tezlik bilan aylanib  $N = 75 \text{ kVt}$  quvvatni uzatadi. Val kesimi devorining qalinligi o'rtacha diametrining  $1/50$  qismini tashkil etadi. Valning  $3m$  uzunligiga to'g'ri keluvchi buralish burchagi  $\varphi = 1^\circ$  dan oshmaslik sharti bilan, uning o'rtacha diametrini toping. Urinma kuchlanish nimaga teng?

**echish:** Valning tashqi va ichki diametrlarini uning devorini qalinligi bilan bog'liq:

$$d = d_y + t = d_y + \frac{d_y}{50} = \frac{51d_y}{50}; \quad d_0 = d_y - t = d_y - \frac{d_y}{50} = \frac{49d_y}{50};$$

Val kesimining qutb inertsia momentini aniqlaymiz:

$$I_{\rho} = \frac{\pi}{32} [d^4 - d_0^4] = \frac{\pi}{32} \left[ \left( \frac{51d_y}{50} \right)^4 - \left( \frac{49d_y}{50} \right)^4 \right] = 0,0157 d_y^4$$

Valning buralishdagi birklik shartini yozamiz:  $\frac{M_{\delta} \cdot \ell}{G \cdot 0,015 d_y^4} = 1^\circ$

$$\text{bu erda: } G = 8 \cdot 10^5 \frac{\kappa\mathcal{Z}}{\text{cm}^2} \quad \text{va} \quad M_{\delta} = 97360 \frac{N}{n} = 97360 \frac{75}{100} = 73020 \kappa\Gamma\text{cm}$$

Yrtacha diametrni topamiz:

$$d_y = \sqrt[4]{\frac{M_{\delta} \ell}{G \cdot 0,0157 \cdot 1^\circ}} = \sqrt[4]{\frac{73020 \cdot 300}{8 \cdot 10^5 \cdot 0,0157 \cdot \frac{314}{180}}} = 17,8 \text{ cm}$$

$$\text{Unda} \quad d = \frac{51 \cdot 17,8}{50} = 18,156 \text{ cm}; \quad d_0 = \frac{49 \cdot 17,8}{50} = 17,45 \text{ cm}$$



Kesimning qutb inertsia momenti:

$$I_{\rho} = 0,0157d_y^4 = 0,0157(17,8)^4 = 1576 \text{ cm}^4$$

Eng katta urinma kuchlanishni topamiz:

$$\tau_{\max} = \frac{M_{\bar{\sigma}} \cdot 0,5d}{I_{\rho}} = \frac{73020 \cdot 9}{1576} = 417 \frac{\text{kg}}{\text{cm}^2}$$

**misol –2.55.** Umumiy uzunligi  $a + b = 3,3 \text{ m}$ , chap qismining diametri  $d_1 = 6 \text{ sm}$ ’ng qismining diametri  $d_2 = 5 \text{ sm}$  bo’lgan sterjen uchi bilan qistirib – bikr mahkamlangan. Sterjenning ikki qismida ham bir xil kuchlanish hosil bo’lsa  $A$  va  $B$  uzunliklar topilsin (2.25 – rasm)

echish. Sterjenning  $C$  va  $B$  tayanchlaridagi reaktiv  $M_c$  va  $M_B$  momentlarni topish uchun, uni muvozanat tenglamasini tuzamiz:

$$\sum M_x = -M_c + M - M_B = 0$$

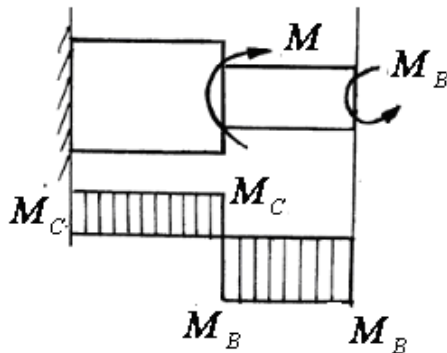
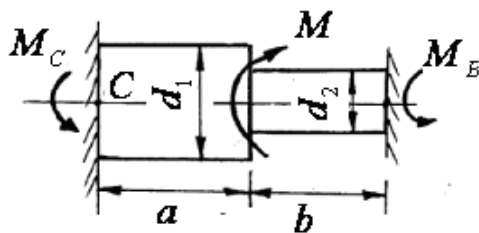
Muvozanat tenglamasidan ko’rinishicha, sterjen statik noaniq sistema ekan. Shuning uchun, asosiy sistemani tanlaymiz va qo’shimcha tenglama tuzamiz:

$$\varphi_B = \varphi_{BM} + \varphi_{BM_B} = 0,$$

ya’ni  $V$  tayanch kesimini buralish burchagi nolga teng.

Bu erda  $\varphi_{BM} = \frac{M \cdot a}{G \cdot I_{\rho_1}}$  va  $\varphi_{BM_B} = -M_B \left( \frac{a}{G \cdot I_{\rho_1}} + \frac{b}{G \cdot I_{\rho_2}} \right) V$

kesimning tegishli  $M_c$  va  $M_B$  momentlari ta’siridan buralish burchaklarini qo’shimcha tenglamaga keltirib qo’yamiz,



2.25 – rasm. Statik noaniq pog’onalı brus va burovchi moment epyurası

unda  $\frac{M \cdot a}{G \cdot I_{\rho_1}} = M_B \left( \frac{a}{G \cdot I_{\rho_1}} + \frac{b}{G \cdot I_{\rho_2}} \right)$

va  $M_B = \frac{Ma}{a + b \frac{I_{\rho_1}}{I_{\rho_2}}}$  momentni

sterjenning muvozanat tenglamasiga keltirib qo’ysak,  $M_s$  tayanch momentini topamiz:

$$M_c = M - M_B = \frac{M \cdot b \cdot \frac{I_{\rho_1}}{I_{\rho_2}}}{a + b \cdot \frac{I_{\rho_1}}{I_{\rho_2}}}$$

Sterjenning uzunligi bo’ylab burovchi moment epyurasini quramiz (2.25 – rasm) ko’ndalang kesimidagi urinma kuchlanishlarni topamiz.

$$\tau_1 = \frac{M_c}{W_{\mu_1}} = \frac{M \cdot b \cdot \frac{I_{\rho_1}}{I_{\rho_2}}}{\left(a + b \cdot \frac{I_{\rho_1}}{I_{\rho_2}}\right) \frac{\pi \cdot d_1^3}{16}} \quad \text{va} \quad \tau_2 = \frac{M_B}{W_{\rho_2}} = \frac{M \cdot a}{\left(a + b \cdot \frac{I_{\rho_1}}{I_{\rho_2}}\right) \frac{\pi \cdot d_2^3}{16}}$$

Masalani shartiga ko'ra  $\tau_1 = \tau_2$

$$\text{Unda } \frac{M \cdot b \cdot \frac{I_{\rho_1}}{I_{\rho_2}}}{\left(a + b \cdot \frac{I_{\rho_1}}{I_{\rho_2}}\right) \frac{\pi \cdot d_1^3}{16}} = \frac{M \cdot a}{\left(a + b \cdot \frac{I_{\rho_1}}{I_{\rho_2}}\right) \frac{\pi \cdot d_2^3}{16}} \quad \text{yoki} \quad \frac{I_{\rho_1}}{I_{\rho_2}} b d_2^3 = a \cdot d_1^3$$

$$\text{Buerda } I_{\rho_1} = \frac{\pi \cdot d_1^4}{32} = \frac{\pi(6)^4}{32} = \frac{\pi \cdot 1296}{32} \quad \text{va} \quad I_{\rho_2} = \frac{\pi \cdot d_2^4}{32} = \frac{\pi(5)^4}{32} = \frac{\pi \cdot 625}{32}$$

Sterjenni chap va o'ng qismlarining kesim yuzalarining qutb inertiya momentlarini hisobga olsak,  $\frac{6}{5}b = a$  hosil bo'ladi.

$a + b = 3,3M$  tenglikdan  $b = 1,5M$  va  $a = 1,8M$  topamiz.

**misol-2.56.** Diametri 6 mm li po'lat simdan tayerlangan tsilindrik vintli prujina 10 o'ramdan iborat. Prujina o'ramining tashqi diametri 66 mm. Engkatta urinma kuchlanish  $24000 \frac{H}{cm^2}$  dan oshmaydigan sterjendagi o'q bo'ylab yo'nalgan

cho'zuvchi kuchni aniqlang. Shunda prujinaning uzayishi, elastik deformatsiyaning to'liq ishi va prujinaning bikrligi, ya'ni prujinani 1 sm cho'zish uchun zarur kuch nimaga teng?

**javob:** 323 N; 5,38 sm; 869 H · cm; 60 H / cm

**misol-2.57.** Diametrlari  $D=32$  mm;  $d=4$  mm bo'lgan prujina  $F=300$  N kuch bilan siqiladi.  $\tau_{\max}$  kuchlanish aniqlansin.

**javob:**  $\tau_{\max} = 450 \frac{H}{mm^2}$

**misol-2.58.** Diametrlari  $D=40$  mm;  $d=5$  mm bo'lgan prujina  $F=400$  N kuch bilan cho'ziladi. Prujina materialining ruxsat etilgan kuchlanishi  $[\tau]=500 \frac{H}{mm^2}$ . Prujinaning cho'zilishga mustahkamligi tekshirilsin.

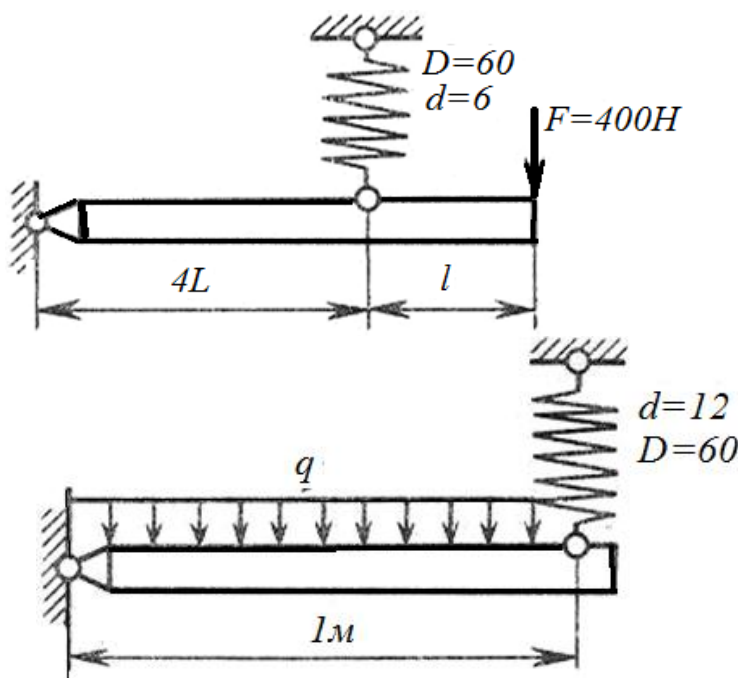
**javob:**  $\tau_{\max} = 0,768[\tau]$

**misol-2.59** Prujina o'rtacha diametrining ( $D$ ) o'ramining diametriga ( $d$ ) nisbati  $C=6$  bo'lib  $F=1,2$  kN kuch ta'sirida. Ruxsat etilgan kuchlanish  $[\tau]=500 \frac{H}{mm^2}$ . Prujina o'ramining diametri nimaga teng?

**javob:**  $d = 7$  mm

**misol-2.60.** Diametrlari  $D=80 \text{ mm}$ ;  $d=8 \text{ mm}$  bo'lgan prujina materialining ruxsat etilgan kuchlanishi  $[\tau]=600 \frac{H}{\text{mm}^2}$ . Ruxsat etilgan kuchni hisoblang

**javob:**  $F=1,31 \text{ kN}$



rasm-2.26

**misol-2.61.**  $[\tau]=500 \frac{H}{\text{mm}^2}$

ruxsat etilgan kuchlanish dan foydalanib prujina mustahkamligi tekshirilsin

**javob:**  $\tau_{\max}=406 \frac{H}{\text{mm}^2}$

**misol-2.62.**  $[\tau]=600 \frac{H}{\text{mm}^2}$

ruxsat etilgan kuchlanish asosida teng taqsimlangan kuch intensivligi -  $q$  - aniqlansin

**javob :**  $q=10,4 \frac{kH}{\text{m}}$

**misol-2.63.** Absolyut qattiq tarelkalar orasidagi ikkita prujinaning o'lchamlari:  $d_1=5 \text{ mm}$ ;  $d_2=6 \text{ mm}$ ;  $n_1=12$ ;  $n_2=10$ ;  $D_1=30 \text{ mm}$ ;  $D_2=60 \text{ mm}$ ; uzunliklari bir xil; ruxsat etilgan kuchlanish  $[\tau]=500 \frac{H}{\text{mm}^2}$ .

Prujinalar tarelkalarga qo'yilgan  $F=1 \text{ kN}$  ta'sirida siqiladi. Prujinalarga ta'sir etuvchi kuchlarni toping?

**echish.**  $F$  kuch ta'sirida, prujinalarda  $X_1$  va  $X_2$  hosil bo'ladi.

Muvozanat shartga asosan  $X_1 + X_2 = F$  (a)

Deformatsiya tenglamasiga asosan  $\lambda_1 = \lambda_2$  (b)

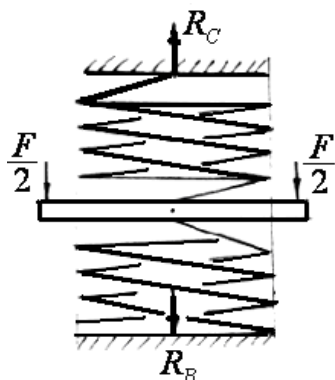
$\lambda_1$  va  $\lambda_2$  deformatsiyalarni  $X_1$  va  $X_2$  kuchlar orqali

ifodalaymiz:  $\frac{8X_1 D_1^3 n}{G d_1^4} = \frac{8X_2 D_2^3 n}{G d_2^4}$  buerdan  $X_1 = \left(\frac{D_2}{D_1}\right)^3 \cdot \left(\frac{d_2}{d_1}\right)^4 \cdot \frac{n_1}{n_2} \cdot X_2$

yoki  $X_1 = \left(\frac{60}{30}\right)^3 \cdot \left(\frac{5}{6}\right)^4 \cdot \frac{10}{12} \cdot X_2 = 3,2 X_2$  (v)

(a) va (v) tengliklarni birgalikda echish asosida  $X_1=0,762 F$  va  $X_2=0,238 F$  larni hosil qilamiz.

**misol – 2.64.** Yrtacha radiuslari  $R = 10 \text{ sm}$ , o'ramning diametri  $d = 2 \text{ sm}$  bo'lgan po'latdan tayyorlangan ikkita prujinalar C va B nuqtalarda tayanchlarga tayangan. Yuqori prujinada  $n_1 = 4$  ta va pastki prujinada  $n_2 = 5$  ta o'ramlari bor. Ikkala prujinalar o'rtasiga  $G' = 450 \text{ kg}$  kuch qo'yilgan plita o'rnatilgan. Prujinalarga taqsimlangan kuchning miqdori, yuk o'rnatilgan plitaning vertikal ko'chishi, prujina sterjenida hosil bo'lgan urinma kuchlanish topilsin.



**echish:**  $F$  kuch ta'sirida yuqori prujina cho'ziladi, pastki prujina – siqiladi. C va B tayanchlarda  $R_C$  va  $R_B$  reaksiya kuchlari hosil bo'ladi.  $R_C$  reaksiya kuchi miqdor jihatdan yuqori prujinadagi cho'zuvchi kuchga,  $R_B$  reaksiya kuchi pastki prujinadagi siquvchi kuchga teng buladi.  $R_C$  va  $R_B$  kuchlarni topish uchun sistemaning muvozanat tenglamasini tuzamiz.

$$\sum y = R_C - F - R_B = 0$$

Bitta tenglamada ikkita noma'lum kuchlar .

Demak, masala statik noaniq. Shuning uchun qo'shimcha deformatsiya tenglamasini tuzamiz.  $F$  kuch ta'sirida yukori prujinaning chuzilishi pastki pog'onani siqilishiga teng, ya'ni  $\lambda_1 = \lambda_2$  bu

erda  $\lambda_1 = \frac{4R_C R^3 n_1}{G \cdot r^4}$  va  $\lambda_2 = \frac{4R_B R^3 n_2}{G \cdot r^4}$ ,

unda  $\frac{4R_C R^3 n_1}{G \cdot r^4} = \frac{4R_B R^3 n_2}{G \cdot r^4}$  yoki  $R_C = R_B \frac{n_2}{n_1}$  va  $R_C = R_B \frac{5}{4}$  ifodani

muvozanat tenglamasiga keltirib qo'ysak  $R_B$  kuchni topamiz:

$$R_B = \frac{F \cdot 4}{9} = \frac{450 \cdot 4}{9} = 200 \text{ kN}; \quad R_C = \frac{4F}{9} \cdot \frac{5}{4} = \frac{450 \cdot 4}{9} = 250 \text{ kN}$$

Plitaning vertikal ko'chishini topamiz

$$\lambda = \frac{4R_C R^3 h_1}{G \cdot r^4} = \frac{4 \cdot 250 \cdot 10^3 \cdot 4}{8 \cdot 10^5 \cdot 1^3} = 5 \text{ cm}$$

Yuqori prujina sterjenidagi kuchlanish

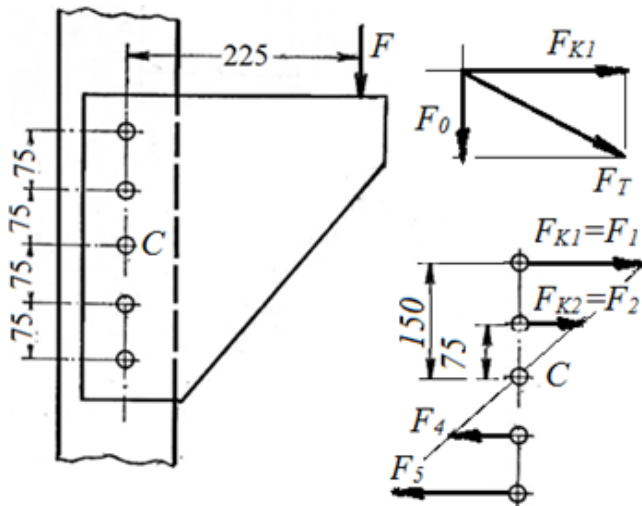
$$\tau_1 = \frac{R_C \cdot 4}{\pi \cdot d^2} + \frac{2R_C \cdot R}{\pi \cdot r^3} = \frac{250 \cdot 4}{\pi \cdot (2)^2} + \frac{2 \cdot 250 \cdot 10}{\pi \cdot 1^3} = 1672 \frac{\text{kg}}{\text{cm}^2}$$

Pastki prujina sterjenidagi kuchlanish

$$\tau_2 = \frac{R_B \cdot 4}{\pi \cdot d^2} + \frac{2R_B \cdot R}{\pi \cdot r^3} = \frac{200 \cdot 4}{\pi \cdot (2)^2} + \frac{2 \cdot 200 \cdot 10}{\pi \cdot 1^3} = 1338 \frac{\text{kg}}{\text{cm}^2}$$

**misol-2.65.** Parchin mixli birikma (2.27-rasm)  $F$  kuchdan tushadigan yukni qabul qiladi. Parchin mixlarning diametri  $20 \text{ mm}$ . Parchin mixlar yakka qirqilishga ishlaydi. Eng ko'p yuk tushadigan parchin mixdagi urinma kuchlanishlar qiymatini aniqlang

**echish.**  $G'$  kuchning parchin mixli birikmaning markazi  $C$  nuqtaga ko'chiramiz. Bitta chiziqli kuchlar  $M_G = F\ell$  burovchi momentini



2.27 – rasm

hosil qiladi.

Parchin mixli birikma  $M_b$  momenti ta'sirida bo'ladi  $F$  kuch ta'siri beshta parchin mix orasida teng tarqaladi. Har bir parchin mixga

$$F_0 = F : 5 = 3500 : 5 = 700 \text{ kN}$$

qirquvchi kuch ta'sir qiladi.

$M_b$  burovchi momenti ta'sirida har bir parchin mixda  $F_k$  kuchi hosil bo'ladi va u  $C$  nuqtadan o'tgan to'g'ri

chiziqqa perpendikulyar yo'naladi

(2.27 – rasm) dan  $\frac{F_{K1}}{15} = \frac{F_{K2}}{7,5}$  va  $F_{K1} = 2F_{K2}$  ni hosil qilamiz va  $F_{K1} = F_{K5}$  va

$F_{K2} = F_{K4}$  ekanligini aniqlab olamiz. Birikmani burovchi momenti

$$3500 \cdot 22,5 = 2F_{K1} \cdot 15 + 2F_{K2} \cdot 7,5; \quad 78750 = 4F_{K2} \cdot 15 + 2F_{K2} \cdot 7,5 \text{ va bu}$$

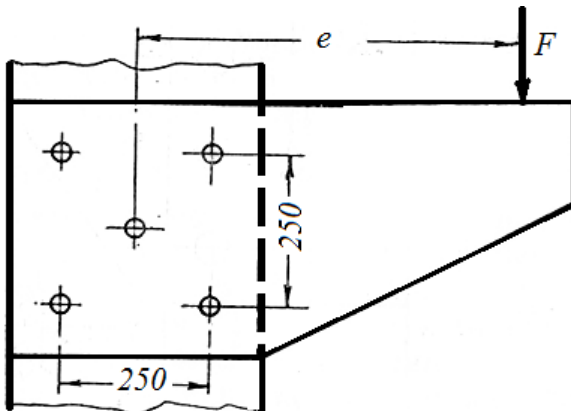
erdan  $2F_{K2} = 1050 \text{ kN}$  kuchni hosil qilamiz.  $F_{K1} = 2F_{K2} = 2100 \text{ kN}$

Demak, birikmani chetki, parchin mixlari ko'proq xavfli holatda bo'lar ekan. 1 va 5 parchin mixlardagi to'liq kuchni topamiz

$$F_{5T} = F_{1T} = \sqrt{F_{K1}^2 + F_0^2} = \sqrt{(2100)^2 + (700)^2} = 2213 \text{ kN}$$

Chetki parchin mixlarda hosil bo'ladigan urinma kuchlanishlarni topamiz:

$$\tau_{\max} = \frac{F_{1T}}{A_K} = \frac{2213}{3,14 \frac{d^2}{4}} = \frac{2213}{3,14 \frac{(2)^2}{4}} = 704 \frac{\text{kN}}{\text{cm}^2}$$



rasm-2.28

**misol-2.62.** Qalin po'lat listdan qilingan kronshteyn po'lat ustunga vertikal kuch  $F = 30000 \text{ N}$  ni qo'yilgan. Boltlar yakka qirqishga ishlaydi, ularning diametri  $23 \text{ mm}$ . Qirqilishga ruxsat etiladigan kuchlanish  $10000 \text{ N/cm}^2$ . Konsolning ruxsat etiladigan chiqarish o'lchami  $e$  qancha?

## EGILISH.

Egilishga qarshilik ko'rsatuvchi bruslar balka deyiladi. Ikki tayanchga tayangan va egilish deformatsiyasiga uchraydigan brus – balka deyiladi. Balkalarning turlari:

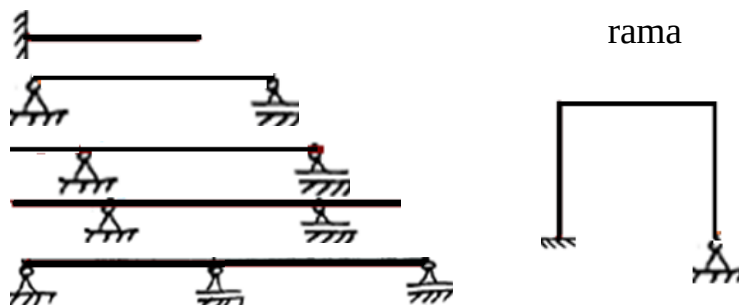
konsol

ikki tayanchli balka

bitta konsolli balka

ikki konsolli balka

uzluksiz balka



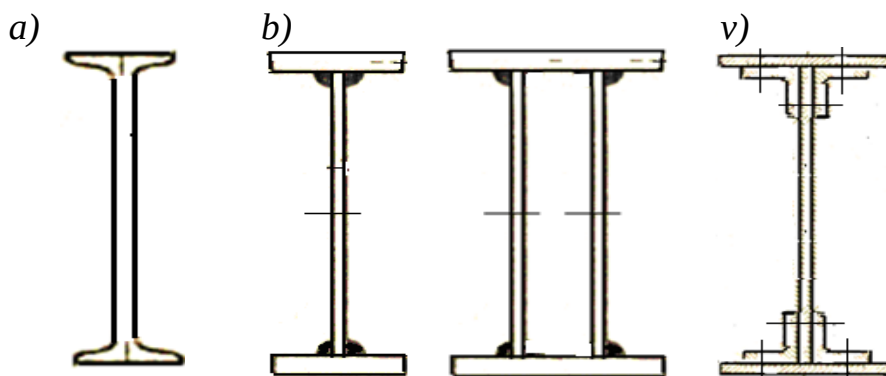
*Konsol deb tayanchdan bir tomonda joylashgan balkaning bir qismiga aytiladi. O'zaro biki yoki sharnirlar vositasida biriktirilgan siniq chiziqli sterjenlar rama deyiladi. Uzluksiz balka deb, kamida uchta tayanchga tayanuvchi va oraliq sharnirlar bo'lmagan balkaga deyiladi. Ikkita tayanch orasidagi masofa balka proleti deyiladi*

**Balkalar va balkali konstruksiyalar.** Balka deb, egilishga ishlovchi to'liq kesimli konstruktiv elementlarga aytiladi.

Oddiyligi va tayyorlanishdagi kam xarajatligi, konstruktiv shaklini qulayligi va qurilishdagi uncha katta bo'lmagan balandligi evvaziga ko'ra balkalar turli yopuvchi inshootlarda, estakadalarda, ko'priklarda va qurilish konstruksiyalarida keng ko'lamda qo'llaniladi.

Metall balkalarning quyidagi turlari mavjud:

- statik sxemaga ko'ra konsol, uzlukli va uzluksiz. Metall konstruksiyalarda erkin tayanuvchi ( biki mahkamlanmagan) uzlukli balkalar ishlatiladi. Uzluksiz va bir prolyotli biki mahkamlangan balkalar metall miqdori yoki sarfi jihatidan iqtisodiy samarali, lekin tayyorlash nuqtai nazaridan murakkab.

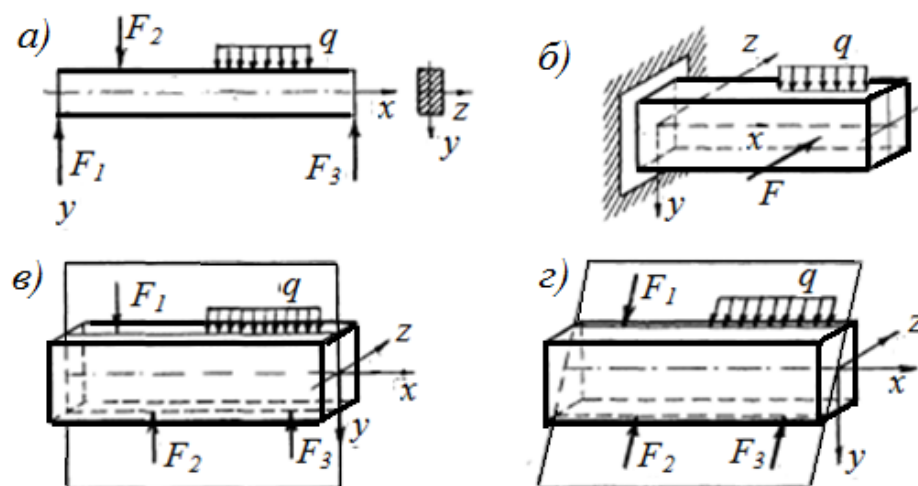


rasm-2.29. Balka kesimlarining turlari:

- a) prokat;
- b) payvandlangan tarkibiy
- v) xomutlangan

Kesimining turiga ko'ra metall balkalar prokat va tarkibiy balkalarga bo'linadi. Prokat balkalar ( 2.29-rasm, a ) odiy arzon. Lekin prokat balkalar sortamentining kamligi tarkibiy balkalarni tadbiq etishga olib keladi. Tarkibiy balkalar payvandlangan ( 2.29-rasm, b ) va boltli yoki xomutlangan (2.29-rasm, v) shaklda hosil qildinadi

Egilish nazariyasini o'rganish uchun egilish gepotezalarini bilish kerak. Bu gepotezalar egilishga ishlovchi konstruksiyalarni mustahkamlikka va bikrlikka tekshirishda amaliy ahamiyatga ega



2.30-rasm.  
Egilishning  
turlari:  
a) taqi kuchlar;  
b) fazoviy  
egilish;  
v) tekis to'g'ri  
egilish  
g) tekis qiyshiq  
egilish

Egilish deb, sterjenni shunday deformatsiyalanishiga aytiladiki, bunda tashqi kuchlar (to'planma, taqsimlangan, juft kuch) uning bo'ylama o'qiga perpendikulyar ta'sir etadi.

Tashqi kuchlarni qo'yilish usuliga ko'ra egilishni turli shakllari mavjud. Yuklar turli tekisliklarda ta'sir qilsa fazoviy egilish deyiladi (2.30-rasm, b). Agar tashqi kuchlar bir tekislikda ta'sir qilsa tekis egilish deyiladi. Tashqi kuchlarning ta'sir chizig'i birorta bosh markaziy o'qlardan o'tsa tekis to'g'ri egilish deyiladi (2.30-rasm, v). Tashqi kuchlarning ta'sir chizig'i birorta bosh markaziy o'qlarda joylashmasa tekis qiyshiq egilish deyiladi (2.30-rasm, g).

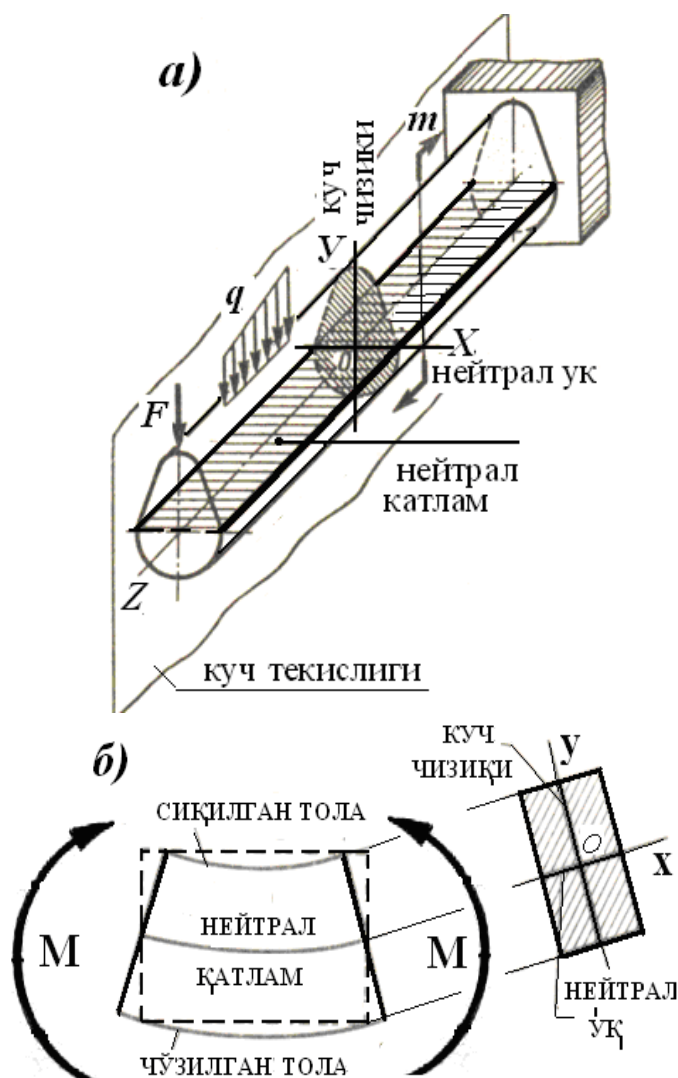
Fazoviy va tekis qiyshiq egilishda balkaning ko'ndalang kesim yuzasida ikkita eguvchi moment va ikkita ko'ndalang kuchlar hosil bo'ladi. Tekis to'g'ri egilishda ikkita ichki kuch faktori eguvchi moment va ko'ndalang kuch hosil bo'ladi.

**Egilishda ichki kuch-faktorlarini aniqlash.** Egilishda barcha tashqi va reaksiya kuchlari–kuch tekisligi deb ataladigan bitta tekislikda ta'sir qiladi (2.31 – rasm, a). Kuch tekisligini brusning ko'ndalang kesim yuzasi bilan kesishish chiziqi- kuch chiziqi deyiladi. Egilishda brusning egilgan o'qi kuch tekisligida yotadi. Egilishga ishlaydigan brus balka deyiladi.

Egilishda balka materialining bir qatlami siqiladi ya'ni tola uzunligi qisqaradi va unga qarama – qarshi qatlam cho'ziladi, ya'ni bu qatlam materialining tolasi uzayadi (2.31–rasm,b). Balkani egilishda o'zining boshlang'ich uzunligini o'zgartir- maydigan material qatlami neytral qatlam deyiladi.

Balkaning ko'ndalang kesim yuzasi bilan neytral qatlamni kesi-shish chiziqi neytral o'q deyiladi.





2.31 – rasm. Egilishda ichki kuchlar:

- a) brusni yuklanish sxemasi;  
b) neytral qatlam holati.

To'rtta o'zaro teng  $F$  kuch ta'sirida muvozanatda bo'lgan brusni o'rganamiz (2.32–rasm, a). Brusning ixtiyoriy kesimidagi ichki kuchlarni kesish usulidan foydalanib topamiz.

Masalan, brusni  $n - n$  tekislik bilan kesib, uning o'ng tomonini tashlab yuboramiz va chap tomonini olib qolamiz. Natijada brus chap qismining muvozanati buziladi.

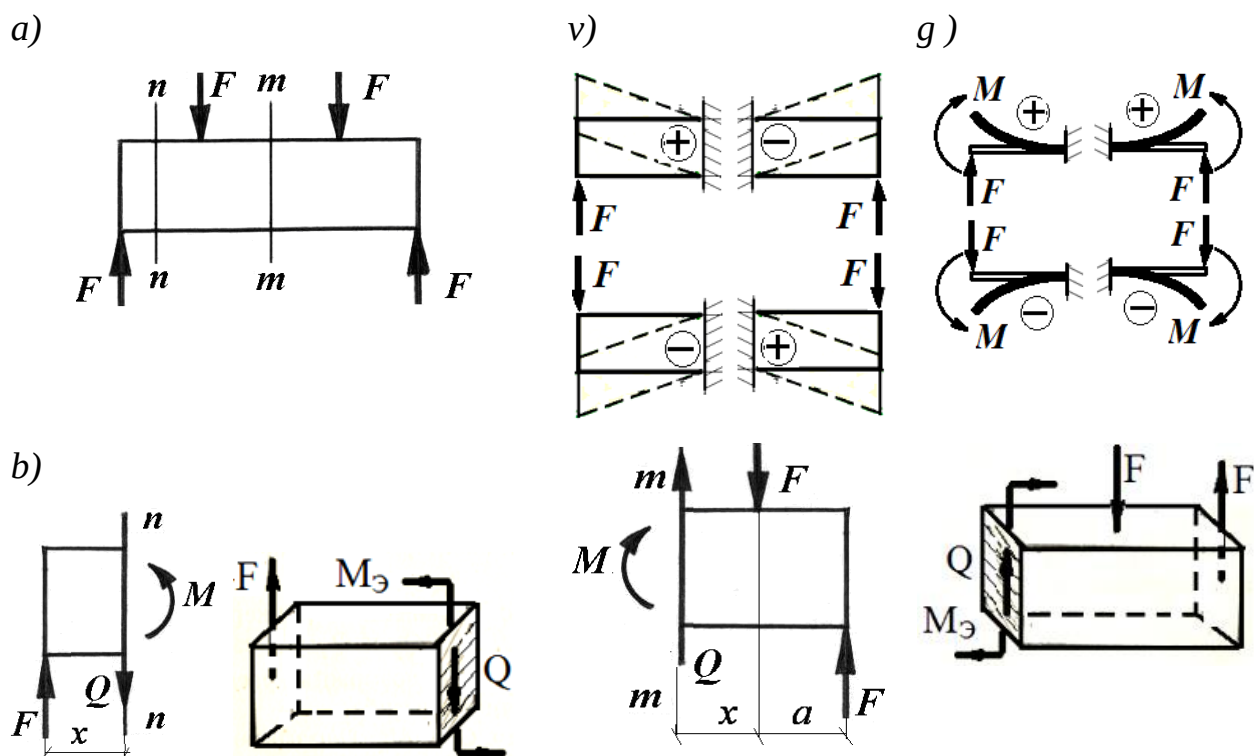
Brusni ajratib olingan qismining muvozanatini ta'minlash uchun, uni kesilgan yuzasiga tashlab yuborilgan qismining ta'sirini almashtiruvchi bosh kuch vektori  $Q$  va bosh moment vektori  $M$  – ni keltirib qo'yamiz.  $Q$  kuchni ko'ndalang kuch yoki kesuvchi kuch deb qabul qilamiz. Ko'ndalang kuchni topish uchun brusni ajratib olingan qismidagi tashqi kuchni  $n - n$  qirqim tekisligiga proektsiyalaymiz:

$$F - Q = 0 \text{ yoki } Q = F.$$

Brusni keyingi  $m - m$  kesimidagi ko'ndalang kuch  $Q$  shu oraliqdagi barcha tashqi kuchlarni  $m - m$  tekislikka proektsiyalarining algebraik yig'indisiga teng:

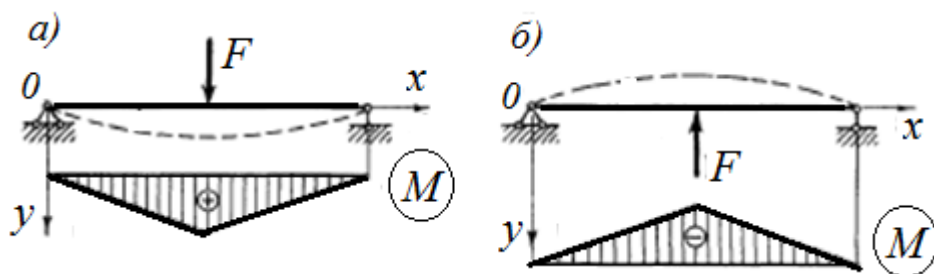
$F - F - Q = 0$  yoki  $Q = 0$  (2.32 – rasm, b). Demak,  $Q$  ko'ndalang kuch brusning ajratib olingan qismidagi barcha kuchlarni algebraik yig'indisiga teng. Brusning kesilgan kesimiga nisbatan tashqi kuchning yo'nalishi soat strelkasining harakat yo'nalishi bilan mos tushsa, ko'ndalang kuchning ishorasi musbat, teskari holatda esa manfiy bo'ladi.

Bosh moment vektori  $M$ , eguvchi moment deyiladi. Eguvchi momentni topish uchun, brusni ajratib olingan kesimidagi barcha kuchlarni kesim markaziga nisbatan moment olamiz:  $m - m$  kesimdan chap tomon uchun  $M = F(a + x) - Fx$  tenglamani hosil qilamiz. Qirqim tekisligi bilan brus bo'ylama o'qining kesishgan nuqtasi kesim markazi deyiladi (2.31–rasm, b-da O nuqta). Demak, eguvchi moment brusni ajratib olingan qismidagi barcha kuchlarning, shu oraliq kesim markaziga nisbatan momentlarining algebraik yig'indisiga teng. Agar tashqi kuch brusni yuqoriga egiltirsa, eguvchi moment ishorasi musbat, pastga egiltirsa–manfiy qabul qilinadi (2.32–rasm, v) Brusni



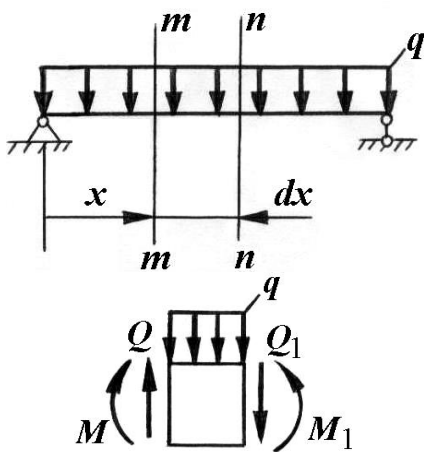
2.32 – rasm. Ichki kuch faktorlari:  
a – b )  $Q$  va  $M$  ni aniqlash; v-g)  $Q$  va  $M$  ishorasini tanlash

egilishida kesim markazi qabariq chiziqda qolsa eguvchi moment manfiy va botiq chiziqda qolsa musbat ishorali bo'ladi. Yuqoridagi ko'ndalang kuch va eguvchi moment tenglamalaridan ko'rinishicha, brusning uzunligi bo'ylab  $Q$  va  $M$  o'zgarib boradi.  $Q$  va  $M$  ning brus o'qi bo'ylab o'zgarish grafikasiga ko'ndalang kuch va eguvchi moment epyurasi deyiladi.



Eguvchi moment  
ishorasini  
tanlashga oid

**$M$ ,  $Q$  va  $q$  orasidagi differentsial bog'lanishlar.** Taqsimlangan kuch intensivligi ta'sirida bo'lgan balkadan ajratilgan elementar uzunlikdagi bo'lakning muvozanat holatini tekshiramiz (2.33–rasm). Taqsimlangan kuch intensivligi  $q$  ta'siridagi elementar  $dx$  uzunlikdagi ajratilgan element balkani tashlab yuborilgan qismlari ta'sirini almashtiruvchi ko'ndalang kuchlar  $Q$  va  $Q_1 = Q + dQ$ , momentlar  $M_x$  va  $M_1 = M_x + dM_x$  ta'sirida bo'ladi (2.33- rasm).



2.33 – rasm

Ajratilgan elementning muvozanat sharti quyidagicha yoziladi:

$$\sum y = Q - qdx - (Q + dQ) = 0 \quad (2.9)$$

(2.9) tenglamadan  $-qdx - dQ = 0$  tenglikni hosil qilamiz.

$$\text{Bu erdan} \quad q = -\frac{dQ}{dx} \quad (2.10)$$

Demak, balkaning ixtiyoriy kesimidagi ko'ndalang kuchning abstsissa bo'ylab birinchi tartibli hosilasi shu kesimdagi taqsimlangan kuch intensivligi  $q$  - ga teng ekan.

Agar  $q$  - kuch yuqoriga yo'nalsa (2.10) tenglamaning ishorasi musbat bo'ladi.

Ajratilgan elementning ikkinchi muvozanat shartini yozamiz:

$$M_x + Qdx - qdx \frac{dx}{2} - (M_x + dM_x) = 0 \quad (2.11)$$

$$(2.11) \text{ tenglamadan} \quad Qdx - dM_x = 0 \quad \text{va} \quad Q = \frac{dM_x}{dx} \quad (2.12)$$

hosil bo'ladi, ya'ni balkaning ixtiyoriy kesimidagi ko'ndalang kuch, shu kesimdagi eguvchi momentning abstsissa bo'yicha birinchi tartibli hosilasiga teng. (2.11) va (2.12) tenglamalar asosida

$$\frac{d^2 M_x}{dx^2} = \frac{dQ}{dx} = -q \quad (2.13)$$

tenglik hosil bo'ladi, ya'ni eguvchi momentning abstsissa bo'ylab ikkinchi tartibli hosilasi shu kesimdagi taqsimlangan kuch intensivligi  $q$  - ga teng. Yuqoridagi differentsial bog'lanishlardan  $M$  va  $Q$  epyuralarini qurishda foydalanish mumkin. Masalan: balkani biror kesimida  $Q = \text{const}$  bo'lsa, shu kesimida (2.10) differentsial bog'lanishga asosan,  $q = 0$ , ya'ni taqsimlangan kuch intensivligining ta'siri nolga teng yoki  $q$  kuch ta'sir qilmas ekan. Taqsimlangan kuch intensivligi ta'sir qilgan oraliqda ko'ndalang kuch to'g'ri chiziqli qonuniyat bilan o'zgaradi.  $Q$  ning epyurasi abstsissa o'qini kesib o'tadi, ya'ni abstsissaga og'ishgan burchak bilan joylashadi.

(2.12) differentsial bog'lanishga asosan, agar balkani biror kesimida eguvchi moment o'zgarmas bo'lsa, ya'ni  $M = \text{const}$ , shu kesimdagi ko'ndalang kuch nolga teng bo'ladi. Eguvchi moment balka uzunligining biror qismida to'g'ri chiziqli qonuniyat bilan o'zgarsa, ya'ni  $M$  grafikasi to'g'ri chiziq bo'lib abstsissaga biror burchak bilan joylashsa, shu kesimdagi ko'ndalang kuch o'zgarmas va  $Q$  ni epyurasi abstsissaga parallel chiziq bo'ladi. Balkani taqsimlangan kuch intensivligi  $-q$  ta'sir qilgan oraliqda,  $M$  epyurasi egri chiziq bilan chegaralanadi.

-  $Q$  epyurasi abstsissani kesib o'tadigan nuqtada, eguvchi moment ekstremal qiymatda.

- Balkaga to'planma  $F$  kuch qo'yilgan nuqtada ko'ndalang kuch epyurasining shu nuqtasida miqdori  $F$  kuchga teng sakrash bo'ladi, eguvchi moment epyurasida siniq chiziq hosil bo'ladi. Taqsimlangan kuch ta'sir qilgan oraliqda  $M$  epyurasi botiq parabola bo'ladi.  $M$  epyurasining to'g'ri va egri chiziqli qismlari silliq tutashadi.

- Balkani biror kesimiga juft kuch momenti qo'yilgan bo'lsa, eguvchi moment epyurasining shu nuqtasida miqdori juft kuch momentiga teng sakrash bo'ladi.

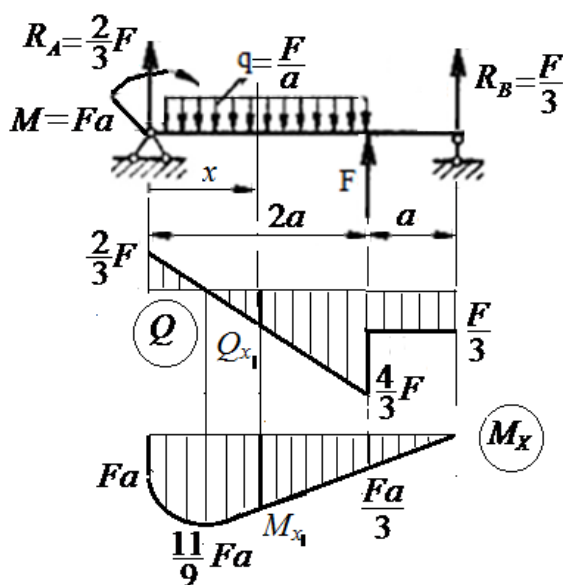
- Balkani oxirgi yoki boshlang'ich kesimida ko'ndalang kuch shu kesimdagi to'planma (reaktsiya) kuchiga teng, eguvchi moment esa shu kesimdagi juft kuch momentiga teng. Agar, balkani oxirgi yoki boshlang'ich kesimiga juft kuch momenti qo'yilgan bo'lmasa, bu kesimda eguvchi moment nolga teng.

**misol -2.63.** Balkani reaksiya kuchlarini topamiz:

$$\sum M_A = 0 \quad -M - q \frac{(2a)^2}{2} + F \cdot 2a + R_B 3a = 0 \quad \text{buerdan} \quad R_B = \frac{F}{3}$$

$$\sum M_B = 0 \quad -M - R_A 3a + q 2a \left( \frac{2a}{2} + a \right) - Fa = 0 \quad \text{buerdan} \quad R_A = \frac{2F}{3}$$

Balka ikkita uchatkadan iborat. Har bir oraliq uchun ko'ndalang kuch va eguvchi moment tenglamalarini tuzamiz.



Balkani  $x$  oraliqida teng taqsimlangan kuch ta'sir etganligi uchun ko'ndalang kuch tenglamasi

$$Q_{x1} = R_A - qx$$

bo'ladi. Bu oraliqda ko'ndalang

kuch o'zgarmas  $R_A = \frac{2}{3}F$  reaksiyaga

va  $x$  oraliqdagi taqsimlangan kuchning teng ta'sir qiluvchisi  $qx$  ga bog'liq.  $x$  masofa kamayishi bilan  $qx$  kuchikla-shadi, aksincha ortishi bilan  $qx$  kuch ham katalashadi.

$q = -\frac{dQ}{dx}$  differentsial bog'lanishga asosan,

ko'ndalang kuchdan abstsissa bo'yicha olingan birinchi tartibli hosila

$$\text{taqsimlangan kuchga teng, ya'ni} \quad q = \frac{d}{dx}(R_A - qx) = -q = -\frac{F}{a}$$

$$0 \leq x \leq 2a \quad \text{oraliqda eguvchi moment tenglamasi} \quad M_{x1} = M + R_A x_1 - q \frac{x_1^2}{2}$$

$$Q = \frac{dM_x}{dx} \text{ bog'lanishga asosan } Q = \frac{d}{dx}(M + R_A x_1 - q \frac{x_1^2}{2}) = R_A - q \cdot x_1$$

$$\frac{d^2 M_{x1}}{dx^2} = \frac{dQ}{dx} = -q \text{ ga asosan } \frac{d^2}{dx^2}(M + R_A x_1 - q \frac{x_1^2}{2}) = \frac{d}{dx}(R_A - q \cdot x_1) = -q$$

Taqsimlangan kuchning teng ta'sir etuvchisi  $Qx$  ni  $0 \leq x \leq 2a$  oraliqda o'zgarish sohasida ishorasini almashtirishi mumkin. Buning uchun  $Q_{x1}$  ko'ndalang kuchning epyurasi abstsissani kesib o'tishi kerak.  $Q_{x1}$  epyurasini abstsissani kesib o'tish nuqtasida ko'ndalang kuch nolga teng bo'ladi, ya'ni  $Q_{x1} = R_A - qx_1 = 0$ .

$$\text{Buerdan } x_1 = \frac{R_A}{q} = \frac{2}{3}a \text{ masofada } Q_{x1} = 0 \text{ kelib chiqadi.}$$

Ko'ndalang kuch nolga teng bo'lgan nuqtada (ushbu oraliqda) eguvchi moment ekstremal  $M_{x1\max} = \frac{11}{9}Fa$  qiymatga erishadi.

$$x_1 = 0 \text{ bo'lsa } M_{x1} = M = Fa \text{ hosil bo'ladi va}$$

$$x_1 = 2a \text{ bo'lsa } M_{x1} = \frac{F}{3}a \text{ hosil bo'ladi}$$

$0 \leq x \leq 2a$  oraliqda eguvchi moment parabola qonuniyati bilan o'zgaradi, chunki eguvchi moment taqsimlangan kuch intensivligi bilan ikkinchi tartibli bog'lanishda.

Balkani  $0 \leq x \leq a$  oraliqda taqsimlangan kuch ta'sir qilmaydi. Bu oraliqdagi ko'ndalang kuch taqsimlangan kuchlarning teng ta'sir qiluvchisi

$$q \cdot 2a = \frac{F}{a} \cdot 2a = 2F \text{ ga bog'liq.}$$

$$\text{Ko'ndalang kuch tenglamasidan } Q_{x2} = R_A - qa = \frac{2}{3}F - \frac{F}{a} \cdot a = -\frac{F}{3} = \text{const}$$

ya'ni ko'ndalang kuch o'zgarmas. O'zgarmas sonning hosilasi nolga teng,

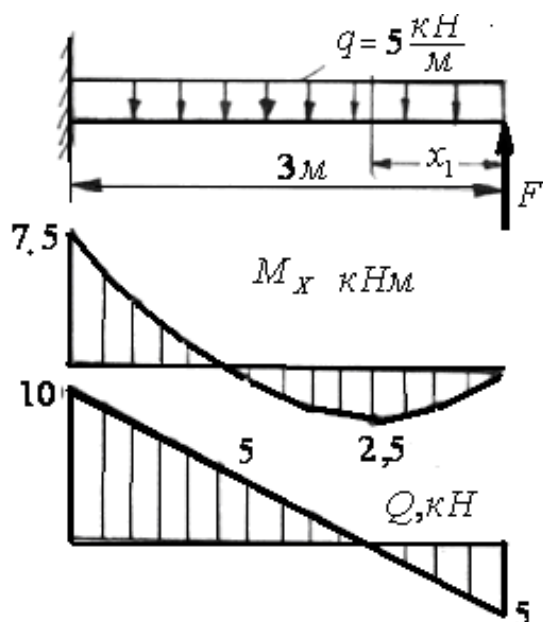
$$\text{ya'ni } q = -\frac{d}{dx}\left(\frac{F}{3}\right) = 0. \text{ Chunki bu oraliqda taqsimlangan kuch intensivligi ta'sir qilmaydi.}$$

$$\text{Eguvchi moment tenglamasi } M_{x2} = R_A(a + x_2) - q2a\left(\frac{2a}{2} + x_2\right)$$

$$Q = \frac{dM_x}{dx} \text{ differentsial bog'lanishga asosan}$$

$$Q = \frac{d}{dx}\left[R_A(a + x_2) - 2qa\left(\frac{2a}{2} + x_2\right) + Fx_2\right] = R_A - 2qa = \frac{2F}{3} - 2\frac{F}{a}a + F = -\frac{F}{3}$$

$0 \leq x \leq a$  oraliqda eguvchi moment abstsissaga nisbatan qiya joylashgan to'g'ri chiziqli qonuniyat bilan o'zgaradi.



2.34 - rasm. Balkani ko'ndalang kuch va eguvchi moment epyuralari

**misol –2.64.** Berilgan balkanig, eguvchi moment ( $M_x$ ) va ko'ndalang kuch ( $Q$ ) epyuralari qurilsin (2.34 – rasm )

**echish.** Konsol balkaning  $x_1$  oraliqida yuqoriga yo'nalgan to'planma kuch  $G' = 5 \text{ kN}$  va pastga yo'nalgan teng taqsimlangan kuch  $q$  ta'sir qiladi. Eguvchi moment va ko'ndalang kuch

tenglamalari:  $M_{x1} = Fx_1 - q \frac{x_1^2}{2}$  va

$$Q_1 = -F + qx_1$$

Tenglamalar shuni ko'rsata-diki, ko'ndalang kuch balkaning uzunligi bo'ylab to'g'ri chiziq qonuniyati, eguvchi moment esa kvadrat parabola bo'yicha o'zgaradi.

O'zgaruvchan  $x_1$  ga  $0 \dots 3 \text{ m}$  oraliqda qiymat berib  $Q$  uchun kamida ikkita,  $M_x$  uchun esa uchta qiymatlarini hisoblaymiz.

$$x_1 = 0 \text{ da} \quad M_{x1} = 0; \quad Q_1 = -F = -5\kappa H$$

$$x_1 = 1\text{m}; \quad M_{x1} = 2,5\kappa H\text{m}; \quad Q_1 = 0$$

$$x_1 = 2\text{m}; \quad M_{x1} = 0 \quad Q_1 = 5\kappa H$$

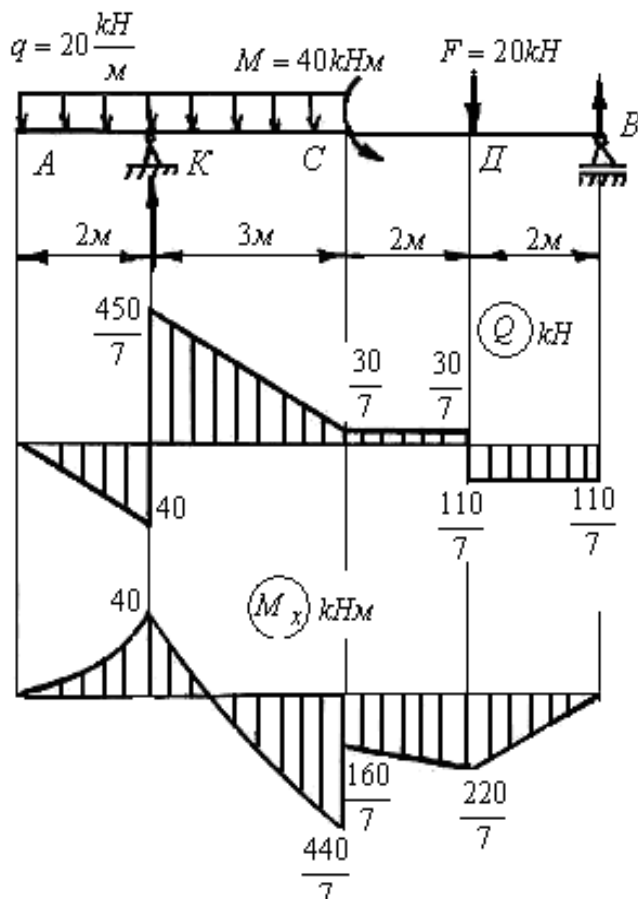
$$x_1 = 3\text{m}; \quad M_{x1} = -7,5\kappa H\text{m} \quad Q_1 = 10\kappa H$$

Hisoblashlar natijasiga ko'ra  $Q$  va  $M_x$  epyuralari qurilgan. Ko'ndalang kuch musbat qiymatlarini nol chiziqdan (neytral qatlam ) yuqoriga,  $M_x$  epyurasini balkaning cho'zilgan tolalarida o'lchab qo'yamiz. Balkani  $F$  kuch qo'yilgan nuqtasida ko'ndalang kuch manfiy ishorali va  $5 \text{ kN}$ . ga teng, tayanch kesimda esa musbat ishorali va  $10 \text{ kN}$ . ga teng. Epyura  $Q$  qiya to'g'ri chiziq bilan tasvirlangan va qiya to'g'ri chiziq bilan abstsissani kesishgan nuqtasida  $Q=0$  bo'ladi, ya'ni

$$Q_1 = -F + qx_1 = 0. \text{ buerdan } x = \frac{F}{q} = 1\text{m}.$$

Eguvchi moment balkani  $F$  kuch qo'yilgan nuqtasida nolga teng va tayanch kesimida minus ishorali bo'lib  $7,5 \text{ kNm}$ .ga teng. Balkani uzunligi bo'ylab eguvchi moment parabola qonuniyati bilan o'zgaradi va  $Q = 0$  nuqtada, ya'ni  $x = 1 \text{ m}$ . da musbat ishorali bo'lib  $2,5 \text{ kNm}$ .ga teng. Parabola abstsissa bilan kesishgan nuqtada

nolga teng, ya'ni  $M_{x1} = Fx_1 - q \frac{x_1^2}{2} = 0$ . Buerdan  $x = \frac{2F}{q} = 2M$



**misol-2.65.** Ikki tayanchli balkaning (2.35 - rasm) K va B tayanch nuqtalaridagi reaksiya kuchlarini yuqoriga yo'naltirib, muvozanat tenglamalarini tuzamiz va ularni hisoblaymiz.

2.35-rasm. Balkani yuklanish sxemasi va ko'ndalang kuch va eguvchi moment epyuralari

$$\sum M_k = M - 5F + 7B - q \frac{(3)^2}{2} + q \frac{(2)^2}{2} = 0 \quad \text{va} \quad B = \frac{110}{7} \text{ kN}$$

$$\sum M_B = M - 7K + q \cdot 5 \left( \frac{5}{2} + 4 \right) + 2F = 0 \quad \text{va} \quad K = \frac{730}{7} \text{ kN}$$

Balkani to'rtta oraliqlarga ajratib, har bir oraliq uchun ko'ndalang kuch va eguvchi moment tenglamalarini tuzamiz:

**AK (I-I) - oraliq.**  $0 \leq x_1 \leq 2 \text{ m}$   $Q_1 = -qx_1$  va  $M_{x1} = -q \frac{x_1^2}{2}$

**KC (II-II) - oraliq.**  $2 \leq x_2 \leq 5 \text{ m}$

$$Q_2 = K - qx_2 \quad \text{va} \quad M_{x2} = -q \frac{x_2^2}{2} + K(x_2 - 2)$$

**CD - oraliq.**  $0 \leq x_3 \leq 2 \text{ m}$

$$Q_3 = K - 5q = \frac{730}{7} - 100 = \frac{30}{7} \text{ kN}; \quad M_{x3} = -q \cdot 5 \left( \frac{5}{2} + x_3 \right) + K(3 + x_3) - M$$

**DB - oraliq.**  $0 \leq x_4 \leq 2 \text{ m}$   $Q_4 = -B = -\frac{110}{7} \text{ kN}; \quad M_{x4} = B \cdot x_4$

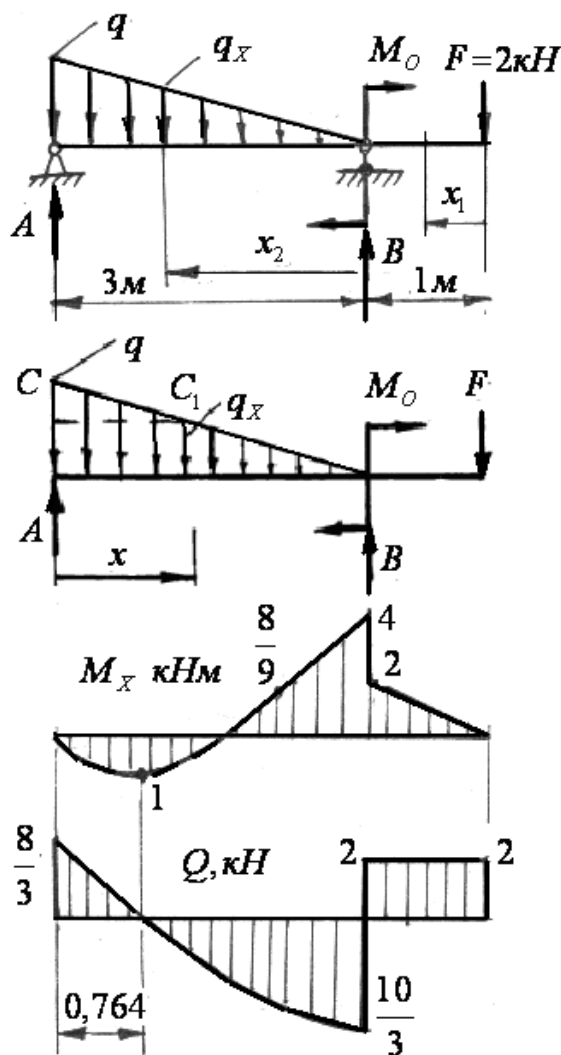


2.35- rasmda ko'ndalang kuch ( $Q$ ) va eguvchi moment ( $M$ ) epyuralari ko'rsatilgan. Balkani  $D$  nuqtasida  $F = 20 \text{ kN}$  tashqi kuch va  $K$  tayanch nuqtasida  $K = \frac{730}{7} \kappa H$  reaksiya kuchi bor. Shuning uchun ko'ndalang kuch epyurasining

shu nuqtalarida miqdori  $\frac{30}{7} + \frac{110}{7} = 20 \kappa H$  va  $\frac{450}{7} + 40 = \frac{730}{7} \kappa H$  ga teng bo'lgan sakrashlar mavjud.

Balkani  $CD$  va  $DB$  oraliqlarida taqsimlangan kuch ta'sir qilmaydi, shuning uchun bu oraliqda  $Q$  epyurasi abstsissaga parallel chiziq.

Balkani  $A, B$  nuqtalarida eguvchi moment nolga teng,  $C$  nuqtaga juft kuch momenti  $M = 40 \kappa Hm$  qo'yilgan. Shuning uchun eguvchi moment epyurasining shu nuqtasida miqdori  $40 \text{ kNm}$  bo'lgan sakrash bor, ya'ni  $\frac{440}{7} - \frac{160}{7} = \frac{280}{7} = 40 \kappa Hm$ . Taqsimlangan kuch ta'sir qilgan oraliqlarda eguvchi moment epyurasi botiq porabola.



2.36 – rasm. Balkani yuklanish sxemasi va ko'ndalang kuch va eguvchi moment epyuralari

**misol -2.66.** (2.36-rasm). Berilgan balka uchun o'ndalang kuch va eguvchi moment epyuralari qurilsin.

**echish.** Taqsimlangan kuch intensivligi  $q$  - balka uzunligi bo'yicha uchburchak qonuniyati bilan o'zgaradi.  $q$  - kuchlarni teng ta'sir qiluvchisi uchburchak yuzasi bilan o'lchanadi va

$A$  nuqtadan  $\frac{\ell}{3} = 1m$  masofada joylashadi. Reaksiya kuchlari:

$$\sum M_A = 0$$

$$F \cdot 4 + M_0 - B \cdot 3 + q \cdot 3 \cdot \frac{1}{2} \cdot \frac{1}{3} \cdot 3 = 0$$

$$\sum M_B = 0$$

$$A \cdot 3 - \frac{q \cdot 3}{2} \cdot \frac{2}{3} \cdot 3 + M_0 + F \cdot 1 = 0 \quad \text{va}$$

tenglamalardan

$$B = \frac{16}{3} \kappa H \quad \text{va} \quad A = \frac{8}{3} \kappa H$$

Tekshirish:

$$\sum y = A - q \cdot \frac{3}{2} + B - F = 0;$$

Eguvchi moment  $M_x$  va ko'ndalang kuch  $Q$  ni topish uchun balkaning uzunligi bo'ylab ikkita oraliqqa bo'lamiz

**I – I qirqim.**

$$0 \leq x_1 \leq 1\mathcal{M}$$

$$M_{x_1} = -Fx_1; \quad Q_1 = F_1 = 2\kappa H;$$

$$x_1 = 0; \quad M_{x_1} = 0;$$

$$x_1 = 1\mathcal{M}; \quad M_{x_1} = -2\kappa H\mathcal{M}$$

**II – II qirqim.**

$$0 \leq x_2 \leq 3\mathcal{M}$$

$$M_{x_2} = -F(1+x_2) - M_0 + Bx_2 - q_x \frac{x_2}{2} \cdot \frac{x_2}{3}$$

$$Q_2 = F - B + q_x \cdot \frac{x_2}{2}$$

$q_x$  - o'zgaruvchan intensiv yukni  $B$  tayanchdan  $x_2$  masofada joylashgan

qiymati bo'lib,  $\frac{q}{3} = \frac{q_x}{x_2}$  yoki  $q_x = q \cdot \frac{x_2}{3}$  ifoda bilan topiladi.

$$Q_2 = F - B + q \frac{x_2^2}{6}$$

$$M_{x_2} = -F(1+x_2) - M_0 + Bx_2 - q \frac{x_2^3}{18}$$

$$x_2 = 0; \quad M_2 = -4\kappa H\mathcal{M}; \quad Q_2 = -\frac{10}{3}\kappa H;$$

$$x_2 = 1\mathcal{M}; \quad M_{x_2} = -\frac{8}{9}\kappa H\mathcal{M}; \quad Q_2 = -\frac{16}{6}\kappa H$$

$$x_2 = 3\mathcal{M}; \quad M_{x_2} = 0; \quad Q_2 = -\frac{8}{3}\kappa H; \quad Q = F - B + q \cdot \frac{x_2^2}{6} = 0$$

$$x_2 = 2,236\mathcal{M} \text{ bo'lsa } Q_2 = 0; \quad M_{x_2} = M_{\max} = 1\kappa H\mathcal{M}$$

Ikkinchi oraliqda ko'ndalang kuch kvadrat parabola bo'yicha, eguvchi moment esa kubik parabola bo'yicha o'zgaradi

Oraliqlar boshlanishini  $A$  nuqtadan boshlab olish mumkin.

$$Q_{x_1} = A - q_x \cdot x_1 \frac{q - q_x}{2} \cdot x_1; \quad M_{x_1} = Ax_1 - q_x \frac{x_1^2}{2} - \frac{(q - q_x)x_1}{2} \cdot \frac{2}{3} x_1$$

$0 \leq x \leq 3\mathcal{M}$  oraliq.  $x_1$  - oraliqda yuk yuzasi balandligi  $q_x$  ga teng to'g'ri to'rtburchakdan va balandligi bo'lgan  $q - q_x$  uchburchakdan iborat. Katta va

kichik uchburchaklarni o'xshashligida  $\frac{q}{3} = \frac{q_x}{3 - x_1}$  yoki

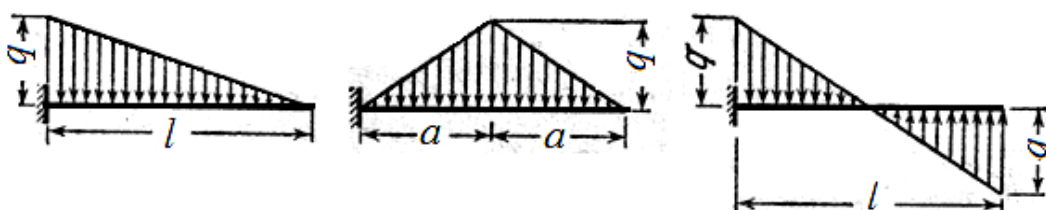
$$q_x = q \frac{3 - x_1}{3} = q \left( 1 - \frac{x_1}{3} \right) \text{ ifodani hisobga olsak,}$$

$$Mx_1 = Ax_1 - q\left(1 - \frac{x_1}{3}\right) \frac{x_1^2}{2} - \frac{\left[q - q\left(1 - \frac{x_1}{3}\right)\right] x_1}{2} \cdot \frac{2}{3} x_1 = Ax_1 - q \frac{x_1^2}{2} +$$

$$+ q \frac{x_1^3}{6} - q \frac{x_1^3}{9} = Ax_1 - q \frac{x_1^2}{2} + q \frac{x_1^3}{18};$$

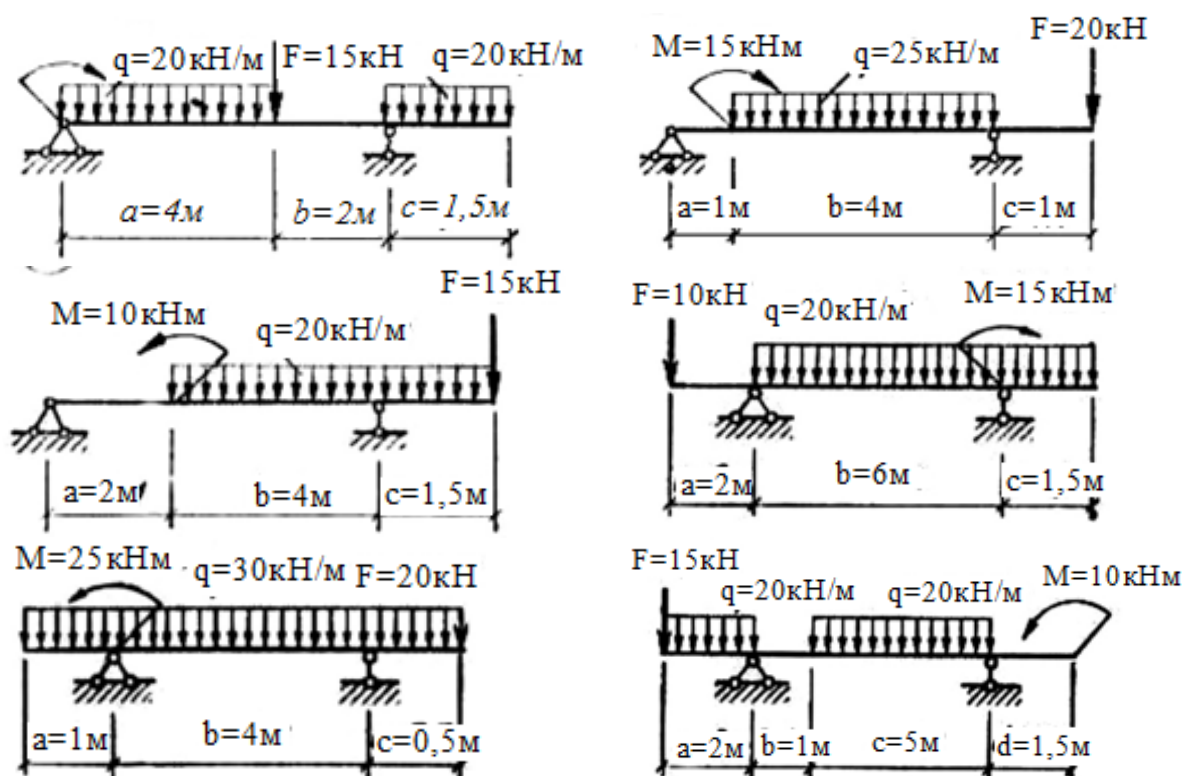
$$Q_1 = A - qx_1 + q \frac{x_1^2}{3} - \frac{\left[q - q\left(1 - \frac{x_1}{3}\right)\right] x_1}{2} = A - qx_1 + q \frac{x_1^2}{6}$$

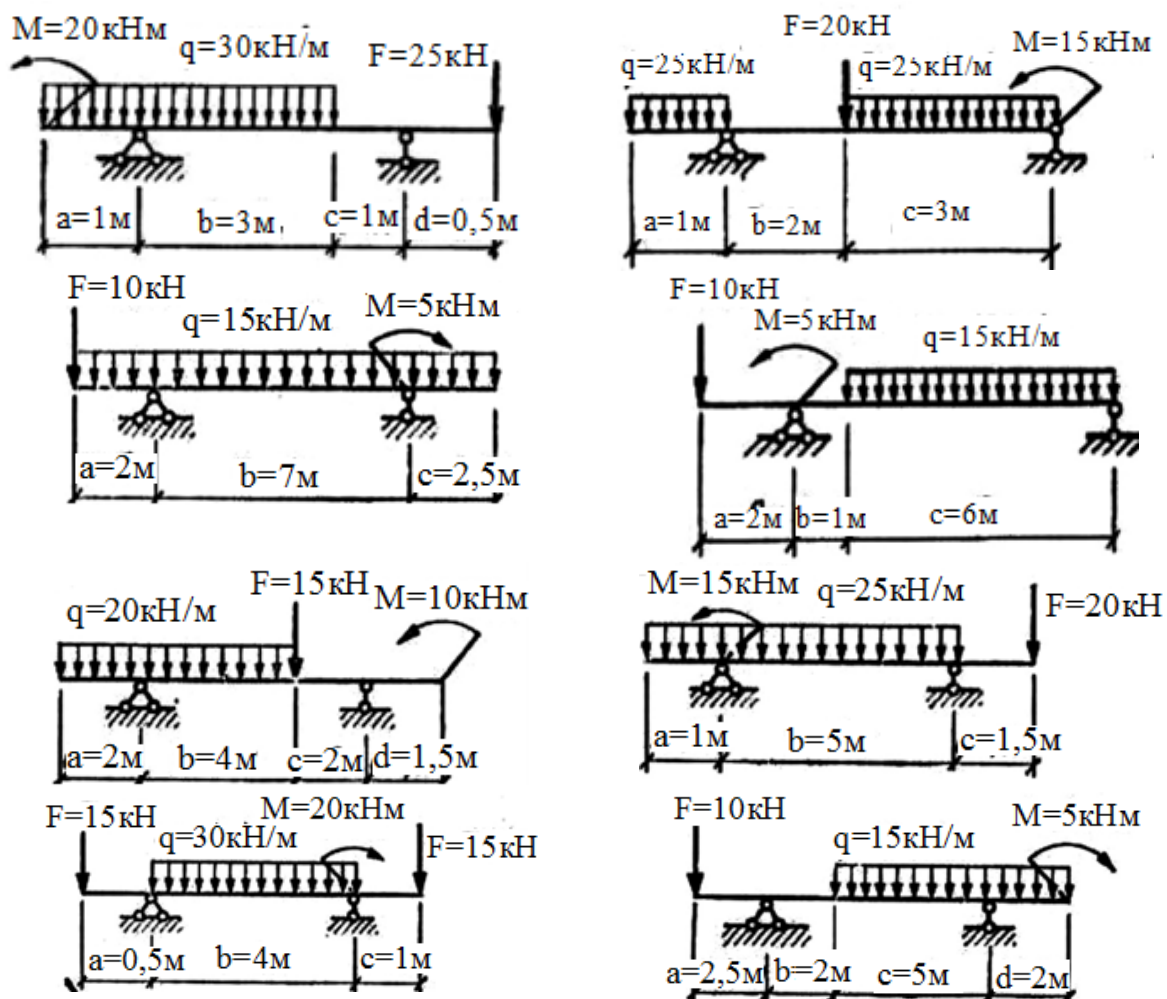
**Berilgan balkalar uchun  $Q$  va  $M_x$  epyuralari qurilsin?**



*rasm-2.37*

**Ko'ndalang kuch va eguvchi moment epyuralari qurilsin**





rasm-2.38

|   |  |    |  |
|---|--|----|--|
| 1 |  | 10 |  |
| 2 |  | 11 |  |
| 3 |  | 12 |  |
| 4 |  | 13 |  |

|   |  |    |  |
|---|--|----|--|
| 5 |  | 14 |  |
| 6 |  | 15 |  |
| 7 |  | 16 |  |
| 8 |  | 17 |  |
| 9 |  | 18 |  |

rasm-2.39

Berilgan balkalar uchun ko'ndalang kuch  $Q$  va eguvchi moment  $M$  epyuralari qurilsin ( rasm-2.37,2.38,2.39 ).

Yog'och konsol balka kesimining diametri tanlansin. Ikki tayanchli balka uchun qo'shtavr profili tanlansin, normal va urinma kuchlanishlar bo'yicha mustahkamligi tekshirilsin

Hisoblashda quyidagi kattaliklardan foydalanilsin:

yog'och material uchun  $[\sigma]_{\text{dep}} = 10 \text{ MPa}$  ;

po'lot materiali uchun  $[\sigma] = 160 \text{ MPa}$ ;  $[\tau]_{\text{cm}} = 16 \text{ MPa}$

jadval – 3

| №                             | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|-------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| $q, \text{kH/m}$              | 10  | 10  | 20  | 60  | 40  | 20  | 40  | 20  | 10  | 70  |
| $F, \text{kH}$                | 80  | 50  | 40  | 80  | 75  | 30  | 85  | 60  | 20  | 60  |
| $M, \text{kH} \cdot \text{m}$ | 15  | 40  | 10  | 20  | 15  | 10  | 20  | 40  | 50  | 30  |
| $a, (\text{m})$               | 1,2 | 1,4 | 1,3 | 1,5 | 1,5 | 1,1 | 1,6 | 1,2 | 1,1 | 1,2 |
| $b, (\text{m})$               | 1,5 | 1,1 | 1,6 | 1,2 | 1,1 | 1,2 | 1,4 | 1,3 | 1,5 | 1,6 |
| $s, (\text{m})$               | 1,2 | 1,4 | 1,3 | 1,5 | 1,6 | 1,5 | 1,1 | 1,6 | 1,2 | 1,1 |
| $l, (\text{m})$               | 1,5 | 1,1 | 1,6 | 1,2 | 1,1 | 1,2 | 1,4 | 1,3 | 1,5 | 1,6 |

## Ramalarda ichki kuch faktorlarini aniqlash.

**misol-2.67.** Ramani sterjenlari uchun buylama kuch -  $Q$  va eguvchi moment -  $M_x$  - epyuralari qurilsin:  $\ell = 4m$  va  $q = 2 \frac{m}{m}$

**echish.** 1) Reaksiya kuchlarni aniqlaymiz.

$$\sum x = 0 \quad q\ell - H_B = 0, \text{ buerdan } H_B = q\ell = 8m$$

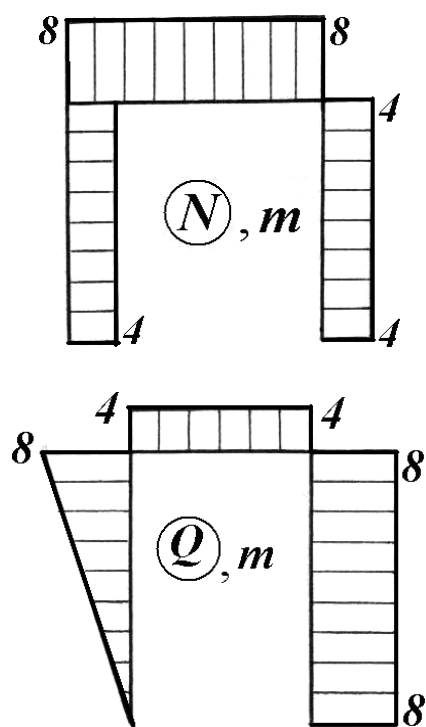
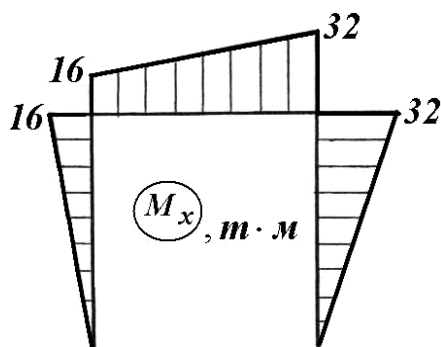
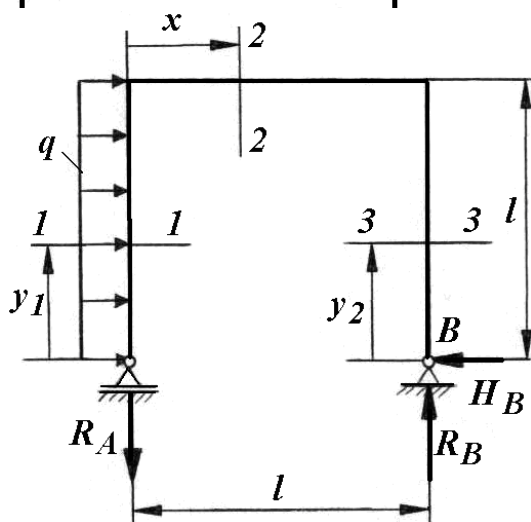
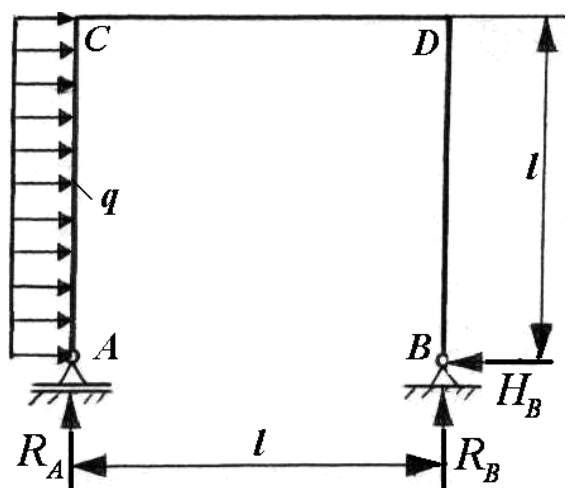
$$\sum y = 0; \quad -R_A + R_B = 0$$

$$\text{buerdan } R_A = R_B$$

$$\sum M_B = 0; \quad R_A \cdot \ell - q \frac{\ell^2}{2} = 0.$$

$$\text{buerdan } R_A = \frac{q\ell}{2} = 4m$$

2.40 - rasm. Ramani yuklanish sxemasi



2.41 - rasm. Rama uchun  $N, Q, M$  epyuralari

2) Buylama kuch - rama sterjenining buylama o'qiga barcha tashqi kuchlar proektsilarining yig'indisiga teng (2.40 –rasm)

$$\text{I – I qirqim (AS- oraliq)} \quad N_1 = R_A = 4m \quad (\text{cho'zilish}).$$

$$\text{II–II qirqim (SD- oraliq)} \quad N_2 = -q\ell = -8m \quad (\text{siqilish})$$

$$\text{III–III qirqim (BD- oraliq)} \quad N_3 = -R_B = -4m \quad (\text{siqilish})$$

3) Ko'ndalang kuch – tashqi kuchlarni qirqim tekisligiga proektsiyalarining yig'indisiga teng (2.40 –rasm).

Agar, rama sterjenining qirqilgan kesim markaziga nisbatan kesilgan qismni soat strelkasining harakat yo'nalishiga mos ravishda aylantirsa, ko'ndalang kuch musbat ishorali.

$$\text{I – I qirqim.} \quad Q_1 = -qy_1$$

$$\text{Agar } y_1 = 0 \text{ va } Q_1 = 0; \text{ agar } y_1 = \ell; Q_1 = -q\ell = -8m$$

$$\text{II – II qirqim.} \quad Q_2 = -R_A = -4m$$

$$\text{III – III qirqim.} \quad Q_3 = H_B = 8m$$

4) Eguvchi moment tenglamalari (2.40–rasm ).

$$\text{I – I qirqim.} \quad M_{x_1} = -q \frac{y_1^2}{2} \quad 0 \leq y_1 \leq \ell = 4m$$

$$y_1 = 0 \text{ bo'lsa } M_{x_1} = 0 \text{ va } y_1 = \ell \text{ bo'lsa } M_{x_1} = -16m\ell.$$

$$\text{II – II qirqim.} \quad M_{x_2} = -R_A x - q \frac{\ell^2}{2} \quad 0 \leq y_2 \leq 4m$$

$$\text{III – III qirqim.} \quad M_{x_3} = -H_B \cdot y_2 \quad 0 \leq y_2 \leq \ell$$

$$y_2 = 0 \text{ bo'lsa } M_{x_3} = 0 \text{ va } y_2 = \ell \text{ bo'lsa } M_{x_3} = -32m\ell$$

**Egilishda normal kuchlanish bo'yicha mustahkamlik shart.**

Egilishda normal kuchlanish bo'yicha mustahkamlik shart quyidagicha

$$\text{yoziladi:} \quad \sigma_{\max} = \frac{M_{\max}}{W} \leq [\sigma] \quad (2.14)$$

(2.14) formula asosida, materiallar qarshiligida uch xil masala echilishi mumkin.

1. Konstruktsiyaga qo'yilishi mumkin bo'lgan yukning qiymati topiladi:

$$M_{\max} = [\sigma] \cdot W \quad (2.15)$$

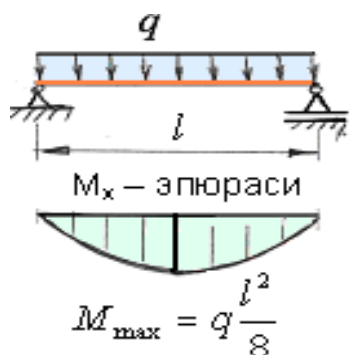
$$2. \text{ Konstruktsiyaning kesimi tanlanadi:} \quad W \geq \frac{M_{\max}}{[\sigma]} \quad (2.16)$$

3. Konstruktsiyaning mustahkamlik (2.14) shartdan tekshiriladi:

Agar, balkaning materiali cho'zilish va siqilishga har xil qarshilik ko'rsatsa, ya'ni  $[\sigma]_q \neq [\sigma]_c$  bo'lsa, unda



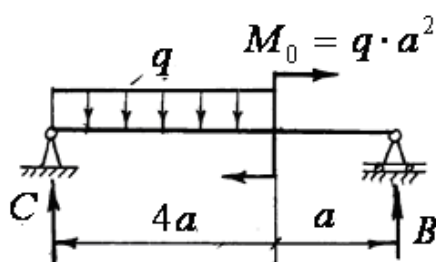
$$\sigma_{\max .q} = \frac{M_{\max}}{W_1} \leq [\sigma]_q \quad \text{va} \quad \sigma_{\max .c} = \frac{M_{\max}}{W_2} \leq [\sigma]_c \quad (2.17)$$



**misol.** Berilgan doiraviy kesimli balkaning yuklanish sxemasi uchun - ruxsat etilgan kuchlanishdan foydalanib ruxsat etilgan yuk topilsin.

Eguvchi moment epyurasidan xavfli kesimdagi eguvchi momentni e'tiborga olsak

$$q = \frac{\pi \cdot d^3}{4 \cdot l^2} [\sigma]$$



rasm-2.43

**misol - 68.** Uzunligi  $\ell = 3m$  bo'lgan, kesimi to'g'ri burchakli balka 2.29 - rasmda ko'rsatilgandek yuklangan. Ylchamlari  $h = 0,2 m$ ;  $b = 0,12 m$  bo'lgan balkani xavfli kesimdagi eng katta normal kuchlanish  $\sigma_{\max} = 1,21 \frac{\kappa H}{M^2}$  dan foydalanib, taqsimlangan kuch intensivligi-  $q$  topilsin.

**echish:** Reaksiya kuchlarini topamiz:

$$\begin{aligned} \sum M_c &= q4a \cdot \frac{4a}{2} + M_0 - B5a = 0; & B &= \frac{9}{5} q \cdot a \\ \sum M_B &= C \cdot 5a - q4a \left( \frac{4a}{2} + a \right) + M = 0; & C &= \frac{11}{5} q \cdot a \end{aligned}$$

$$M_x \text{ va } Q \text{ tenglamalarini tuzamiz: } M_x = c \cdot x - q \frac{x^2}{2} \quad \text{va} \quad Q = c - qx$$

$$x = 0 \text{ bo'lsa } M_x = 0 \quad \text{va} \quad Q = c = \frac{11}{5} qa \text{ teng bo'ladi, } x = 4a \text{ bo'lsa}$$

$M_x = 0,8qa^2$  va  $Q = -1,8qa$  hosil bo'ladi. Demak, ko'ndalang kuch ushbu oraliqda ishorasini o'zgartiradi. Ishorani o'zgartirish nuqtada  $Q = 0$  eguvchi moment maksimumga erishadi. Bu nuqtaning koordinatasi  $x$ -ni topamiz.

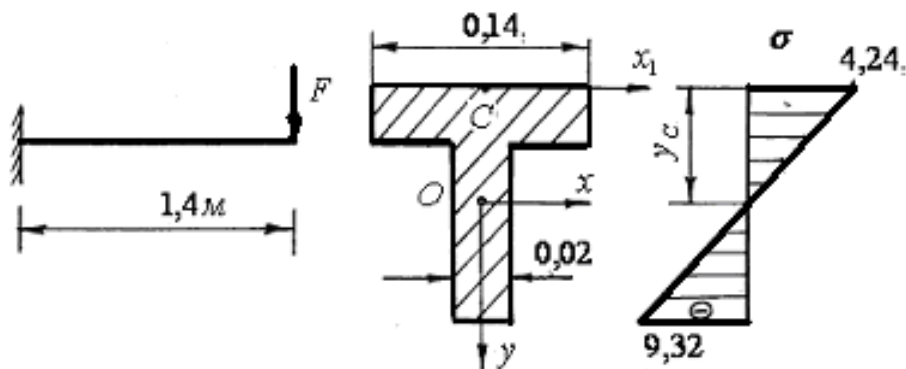
$$C - qx = 0 \text{ yoki } x = \frac{c}{q} = \frac{11 \cdot q \cdot a}{5q} = \frac{11a}{5}, \text{ unda } M_{\max} = 2,42qa^2$$

Balka xavfli kesimining mustahkamlik shartini yozamiz:

$$\sigma_{\max} = \frac{M_{\max}}{W} = \frac{2,42qa^2}{\frac{bh^2}{6}} = 1,21 \frac{\kappa H}{M^2}$$

$$\text{Bu erdan } q = \frac{1,21 \cdot b \cdot h^2}{2,42 \cdot 6 \cdot a^2} = \frac{1,21 \cdot 0,12 \cdot (0,21)^2}{2,42 \cdot 6 \cdot 1} = 4 \cdot 10^{-4} \frac{\kappa H}{\text{m}}$$

**misol – 2.68.** Uzunligi  $\ell = 1,4\text{m}$  konsol balkaning xavfli kesimidagi cho'zuvchi normal kuchlanish  $\sigma = 4,24 \frac{\kappa H}{\text{m}^2}$ . Balkaga qo'yilgan  $F$  kuch va siquvchi normal kuchlanish topilsin



*Konsolni yuklanish sxemasi, kesimi va normal kuchlanish epyurasi*

**echish.** Balkaning tayanch kesimi eng xavfli hisoblanadi, chunki bu kesimda  $M_x = M_{\max} = -F \cdot \ell = -1,4F$ .  $F$  kuch ta'siridan balkani egilishida yuqori tolalar cho'ziladi, pastki tolalari esa siqiladi. Yuqori tolalardagi eng katta cho'zuvchi kuchlanish bo'yicha balkani xavfli holatidagi materialining mustahkamlik sharti:

$$\sigma_{\max} = \frac{M_{\max} \cdot y_0}{I_x} = 4,24 \frac{\kappa H}{\text{m}^2}$$

Bu erda:  $y_0 = \frac{\sum S_{x1}}{\sum A}$  – balka kesimining neytral o'qidan  $S$  nuqttagacha

bo'lgan masofa:

$I_x$  - balka kesimning neytral o'qqa nisbatan inertsia momenti

$S_{x1}$  - balka kesimining  $X_1$  o'qiga nisbatan statik momenti

$$\sum S_{x1} = 0,14 \cdot 0,02 \cdot 0,01 + 0,14 \cdot 0,02 \left( \frac{0,14}{2} + 0,02 \right) = 2,8 \cdot 10^{-4} \text{ m}^3;$$

$$\sum A = 2 \cdot 0,14 \cdot 0,02 = 5,6 \cdot 10^{-3} \text{ m}^2;$$

Unda 
$$y_0 = \frac{2,8 \cdot 10^{-4}}{5,6 \cdot 10^{-3}} = 0,05 \text{ m}$$

$$I_x = \frac{0,14(0,02)^3}{12} + 0,14 \cdot 0,02(y_0 - 0,01)^2 + \frac{0,02(0,14)^3}{12} + 0,02 \cdot 0,14(0,02 + 0,07 - y_0)^2 = 1,3623 \cdot 10^{-5} \text{ m}^4$$

formuladan foydalanib  $F$  kuchni topamiz:  $\frac{1,4Fy_0}{I_x} = 4,24 \frac{\kappa H}{m^2}$  va

$$F = \frac{4,24 \cdot I_x}{1,4 \cdot y_0} = \frac{4,24 \cdot 1,3623 \cdot 10^{-5}}{1,4 \cdot 0,05} \approx 8,25 \cdot 10^{-5} \kappa H$$

Kesimni V nuqtasidagi normal kuchlanishni topamiz:

$$M_{\max} = 82,5 \cdot 10^{-5} \cdot 1,4 = 115,5 \cdot 10^{-5} \kappa H \cdot m$$

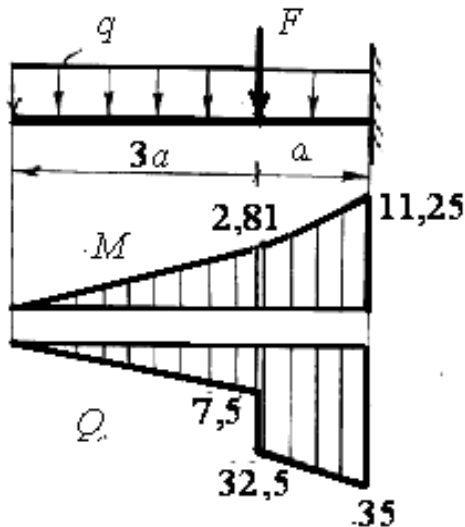
$$\sigma_B = \frac{115,5 \cdot y_B \cdot 10^{-5}}{1,3623 \cdot 10^{-5}} = -\frac{115,5 \cdot 10^{-5} (0,16 - 0,05)}{1,3623 \cdot 10^{-5}} = 9,32 \frac{\kappa H}{m^2}$$

**misol -2.69.** Yog'ochdan tayyorlangan balka uchun  $h = 1,5b$  nisbatdan foydalanib to'g'ri burchakli kesim tanlansin (2.44 – rasm ).

Berilgan:  $a = 0,25m$ ;  $q = 10 \frac{\kappa H}{m}$ ;  $F = 10qa = 25\kappa H$ ;

$$[\sigma] = 10 \frac{\kappa H}{m^2};$$

$$[\tau] = 0,12 \frac{\kappa H}{m^2}$$



**echish:** Bir tomoni qistirib mahkamlangan balkaning xavfli kesimidagi eguvchi moment va ko'ndalang kuchini topamiz

**I – qirqim**  $0 \leq x_1 \leq 0,75m$

$$M_{x_1} = -q \frac{x_1^2}{2} \quad \text{va} \quad Q_1 = -qx_1$$

**II – qirqim**  $0,75 \leq x_2 \leq 1m$

$$M_{x_2} = -q \frac{x_2^2}{2} - F(x_2 - 0,75); \quad Q_2 = -qx_2 - F$$

Balkaning xavfli kesimi tayanch

2.44 - rasm

nuqtasida ekan:  $M_{\max} = -11,25\kappa Hm$  va  $Q_{\max} = -35\kappa H$ .

Xavfli kesim uchun normal va urinma kuchlanishlar bo'yicha mustahkamlik

shartlar:  $\sigma_{\max} = \frac{M_{\max}}{W_x} \leq [\sigma]$  va  $\tau_{\max} = \frac{Q_{\max} \cdot S_x}{I_x \cdot b} \leq [\tau]$ .

bu erda:  $W_x = \frac{bh^2}{6}$  kesimning  $x$  o'qiga nisbatan qarshilik momenti ( $m^3$ ),

### Egilishda balkalarning ko'chishini aniqlash

Balkaning bikrligini tekshirish uchun uning o'qida yotuvchi ayrim nuqtalarining ko'chishlarini topishni o'rganish lozim

Egilishda ko'chishni aniqlashni ikkita maqsadi bor:

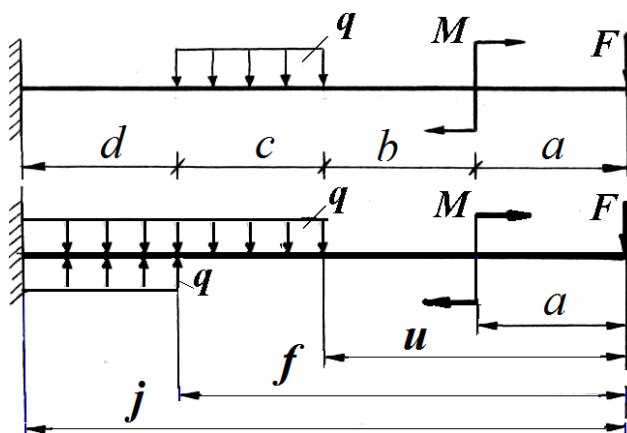
1) yuklanish ta'sirida balkaning elastik deformatsiyasini naqadar kichik bo'lishini ta'minlash;

2) statik noaniq masalalarni, masalan uzluksiz balkalar va statik noaniq ramalarni echish.

Balka bikrligini tekshirish uchun eng katta salqilik  $y_{\max} = f$  balka prolyotining qandaydir ulushidan oshib ketmasligini ta'minlash, ya'ni

$$f = \frac{\ell}{300 \dots 1000}.$$

|                                                           |                                                                                                  |
|-----------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| Salqilik va kesimni aylanish burchagini aniqlash usullari | balka egilish o'qining takribiy differentsial tenglamasi $EIy'' = M_x$ -ni uzluksiz integrallash |
|                                                           | boshlang'ich parametrlar usuli                                                                   |
|                                                           | grafoanalitik usul: $y = \frac{M_c}{EI}$ va $\theta = \frac{Q_c}{EI}$                            |
|                                                           | energetik usul: Mor integralini tadbik etish<br>$y = \int \frac{M \overline{M}_1 dx}{EI}$        |



#### Boshlang'ich parametrlar usuli.

Berilgan balkadagi kuchlar orasidagi masofalar balkani boshlang'ich O nuqtaga nisbatan chizmada ko'rsatilgani kabi ketma-ketlikda belgilanadi. Bunda  $u = a + b$ ,  $f = a + b + c$  va  $j = a + b + c + d$  qabul qilinadi.

kesimni aylanish burchagining hisoblash formulasi

$$\theta = \theta_0 + \frac{1}{EI} \left[ -F \frac{x^2}{2} - M(x-u)' - q \frac{(x-f)^3}{6} + q \frac{(x-j)^3}{6} \right]$$

salqilik formulasi

$$y = y_0 + \theta_0 x + \frac{1}{EI} \left[ -F \frac{x^3}{6} - M \frac{(x-u)^2}{2} - q \frac{(x-f)^4}{24} + q \frac{(x-j)^4}{24} \right]$$

buerda:  $y_0, \theta_0$  - balka boshlang'ich nuqtasining salqiligi va boshlang'ich kesimining aylanish burchagi bo'lib, balka uchlarini tayanchlarga tayanish shartlaridan topiladi

**misol – 2.70.** Balkani egilishda kesimni aylanish burchagi va salqiligini hisoblash. (2.45-rasm )

1) Balkaning reaksiya kuchlarini xisoblaymiz.

$$\Sigma M_B = 0; \quad -6A + q \cdot 2 \left( \frac{2}{2} + 4 \right) - 4F + M = 0 \quad \text{va} \quad A = \frac{100}{6} kH$$

$$\Sigma M_A = 0; \quad 2F - q \cdot \frac{(2)^2}{2} + M + 6B = 0 \quad \text{va} \quad B = -\frac{100}{6} kH$$

$$\text{Tekshirish: } \Sigma Y = A + F + B - 2q = 0 \quad \text{va} \quad \frac{100}{6} + 40 - \frac{100}{6} - 2 \cdot 20 = 0$$

2) Balkani ko'ndalang kuch va eguvchi moment epyuralarini quramiz I-oralik.

$$0 \leq x_1 \leq 2m. \quad Q_1 = A - qx_1 \quad \text{va} \quad M_{x_1} = A_{x_1} - q \frac{x_1^2}{2}$$

$Q_1 = 0$  bo'lganda nuqtada  $M_{x_1}$  eguvchi moment maksimumga erishadi.

$$Q_1 = A - qx_1 = 0; \quad x_1 = \frac{A}{q} = \frac{100}{6 \cdot 20} = \frac{5}{6} m$$

$$M_{x_1 \max} = \frac{100}{6} \cdot \frac{5}{6} - 20 \frac{\left(\frac{5}{6}\right)^2}{2} = \frac{125}{18} kHm$$

$$\text{Birinci va ikkinchi oraliklarda} \quad M_{x_1} = A_{x_1} - q \frac{x_1^2}{2} = 0;$$

$$x_1 = \frac{100}{60} = \frac{5}{3} m \quad \text{va} \quad M_{x_1} = A(2 + x_2) - q \cdot 2 \left( \frac{2}{2} + x_2 \right) + Fx_2 = 0$$

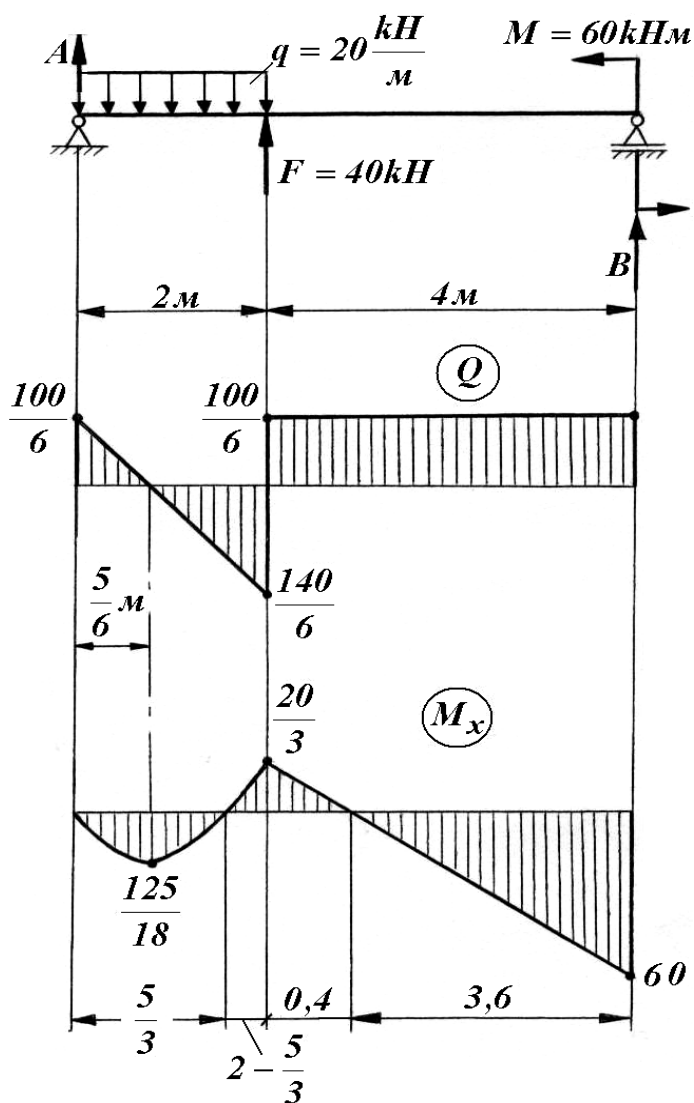
$x_2 = 0,4m$  nuqtada  $M_x$  ishorasini o'zgartiradi.

2. Balkani xavfli kesimi uchun normal kuchlanish bo'yicha mustahkamlik shartidan qo'shtavrli profil tanlaymiz.  $\sigma_{\max} = \frac{M_{\max}}{W_x} \leq [\sigma]$

Bu erda.  $M_{\max} = 60 kHm$  - balkani B xavfli kesimidagi eguvchi moment;

$[\sigma] = 160 mPa$ , - balkani materiali uchun ruxsat etilgan kuchlanish Mustahkamlik shartidan xavfli kesimni talab etilgan qarshilik momentini xisoblaymiz.

$$W_x = \frac{M_{\max}}{[\sigma]} \quad \text{yoki} \quad W_x = \frac{60}{160 \cdot 10^3} = 0,375 \cdot 10^{-3} m^3$$



Qo'shtavrli kesimning tartib raqamini tanlaymiz:

$$W_T = 0,371 \cdot 10^{-3} \text{ m}^{-3}$$

qarshilik momentli № 27 va

$$W_T = 0,407 \cdot 10^{-3} \text{ m}^{-3}$$

qarshilik momentli - qo'shtavrlar.

2.46–rasm. Berilgan balka uchun ko'ndalang kuch va eguvchi moment epyurlari.

Tanlangan -  $W_T$  qarshilik momentlar asosida – mustahkamlik shartni tekshiramiz.

$$\sigma_{\max}^{27} = \frac{M_{\max}}{W_x} = \frac{60}{0,371 \cdot 10^{-3}} = 161,725 \cdot 10^{-3} \frac{\text{kH}}{\text{m}^2} > [\sigma]$$

$$\sigma_{\max}^{27a} = \frac{60}{0,407 \cdot 10^{-3}} = 147,42 \cdot 10^{-3} \frac{\text{kH}}{\text{m}^2} < [\sigma]$$

$$\text{№ 27 – raqamli qo'shtavr} - \frac{161,725 - 160}{160} \cdot 100\% = 1,08\%$$

yuqori kuchlanishda va № 27a – raqamli qo'shtavr

$$\frac{147,42 - 160}{160} \cdot 100\% = -7,86\% \text{ to'liq yuklanmagan vaziyatda ishlaydi.}$$

Qo'shtavrlar mustahkamligini balkani ko'ndalang kuch bo'yicha xavfli kesimidagi urinma kuchlanishlar asosida tekshiramiz.

$$\tau_{\max}^{27} = \frac{Q_{\max} \cdot S_{\max}}{I_x} = \frac{\frac{140}{6} \cdot 100 \cdot 210}{5010 \cdot 0,6} = 163 \frac{\text{kz}}{\text{cm}^2} < [\tau]$$

$$\tau_{\max}^{27a} = \frac{Q_{\max} \cdot S_{\max}}{I_x \cdot d} = \frac{\frac{140}{6} \cdot 100 \cdot 229}{5500 \cdot 0,6} = 162 \frac{\text{kg}}{\text{cm}^2} < [\tau]$$

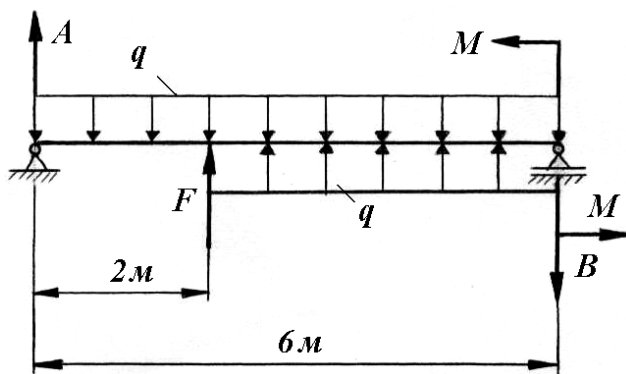
Bu erda  $Q_{\max} = \frac{140}{6} \cdot 100 \text{ kg}$  - balkadagi eng katta ko'ndalang kuch;

$S_{\max}, I_{\max}$  va  $d$  - qo'shtavrli kesimni tegishli geometrik xarakte risti-kalari

Balkani xavfli kesimida mustahkamlikni ta'minlash uchun № 27a - qo'shtavrni tanlaymiz va uning geometrik xarakteristikalarini yozamiz:

$$h = 270 \text{ mm}, \quad e = 135 \text{ mm}, \quad d = 6 \text{ mm}, \quad t = 10,2 \text{ mm} \quad I_x = 5500 \text{ cm}^4$$

$$S_x = 229 \text{ cm}^3 \quad W_T = 407 \text{ cm}^3$$



2.47 – rasm

5. Balkani egilishdagi ko'chishini boshang'ich parametrlar usuli bilan hisoblaymiz.

- balkani berilgan sxemasini 2.47-rasmda ko'rsatilganidek chizamiz va universal formulani tuzamiz.

-Kesim aylanish burcha-gining formulasi:

$$\theta = \theta_0 + \frac{1}{EI} \left[ A \frac{x^2}{2} - q \frac{x^3}{6} + F \frac{(x-2)^2}{2} + q \frac{(x-2)^3}{6} \right] \quad \text{va salqilik}$$

$$\text{formulasi} \quad y = y_0 + \theta_0 x + \frac{1}{EI} \left[ A \frac{x^3}{6} - q \frac{x^4}{24} + F \frac{(x-2)^3}{6} + q \frac{(x-2)^4}{24} \right]$$

Balka boshlang'ich kesimining aylanish burchagi  $\theta_0$  va salqiligi  $y_0$  larni balka uchlarining tayanch turlariga bog'liq ravishda aniqlaymiz.

Masalan,  $x_0 = 0; \theta = \theta_A = \theta_0 \neq 0; y = y_A = y_0 = 0$ , ya'ni A tayanch kesimning aylanish burchagi nolga teng emas, lekin vertikal ko'chishi cheklangan. Shuning uchun bu tengliklardan  $y_0 = 0$  va  $\theta_0$  -ni topib bo'lmaydi.  $x = 6 \text{ m}$ . bo'lsa  $\theta = \theta_B \neq 0$  va  $y = y_B = 0$ . Unda ikkinchi tenglamadan

$$6\theta_0 + \frac{1}{EI} \left[ \frac{100}{6} \frac{6^3}{6} - 20 \frac{6^4}{24} + 40 \frac{(4)^3}{6} + 20 \frac{(4)^4}{24} \right] = 0 \quad \text{yoki} \quad \theta_0 = \frac{-26,7}{EI}$$



Balka kesimini aylanish burchagi

$$\theta = \theta_0 + \frac{1}{EI} \left[ A \frac{x^2}{2} - q \frac{x^3}{6} + F \frac{(x-2)^2}{2} + q \frac{(x-2)^3}{6} \right] -$$

va salqilik tenglamasi

$$y = \frac{-3840}{144EI} x + \frac{1}{EI} \left[ A \frac{x^3}{6} - q \frac{x^4}{24} + F \frac{(x-2)^3}{6} + q \frac{(x-2)^4}{24} \right]$$

Balkani turli kisimlar uchun  $y$  va  $\theta$  ni hisoblaymiz.

$$x = 2m, y = \frac{-3840 \cdot 2}{144EI} + \frac{1}{EI} \left[ \frac{100 \cdot 8}{6} - 20 \frac{16}{24} \right] = \frac{44,4}{EI}$$

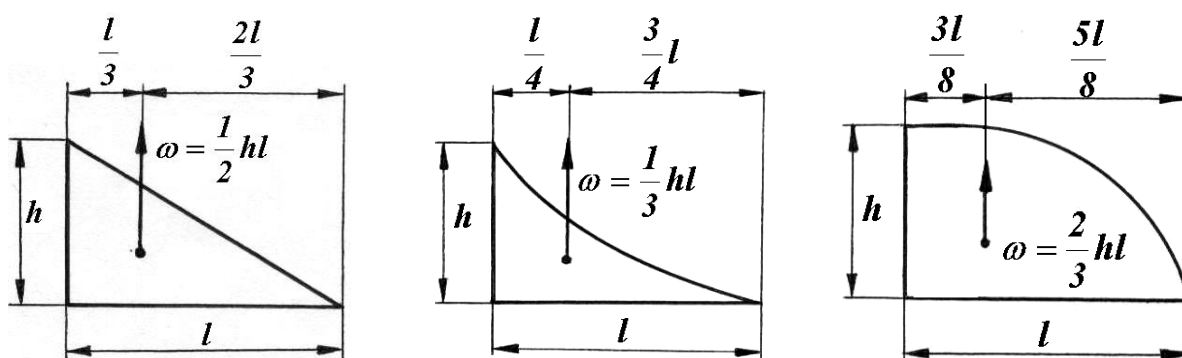
$$x = 6m, \theta_B = \frac{-3840}{144EI} + \frac{1}{EI} \left[ \frac{100 \cdot 36}{6} - 20 \frac{216}{6} + 40 \frac{16}{2} + 20 \frac{64}{6} \right] = \frac{86,63}{EI}$$

6. Balkani egilishdagi ko'chishini grafoanalitik usul bilan hisoblaymiz. Balkani berilgan sxemasi uchun soxta balka tanlaymiz. Soxta balkani berilgan balka uchun qurilgan eguvchi moment epyurasi bilan yuklaymiz (2.49 -rasm) . Soxta kuch  $q_f = M_x$  - soxta balkani uzunligi buylab to'g'ri chiziqli yoki parabola qonuniyati bilan o'zgarishi mumkin, yoki soxta balkani ma'lum oraliqida o'zgarmas bo'lishi mumkin. 2.48 –rasmda har xil kuch yuzalar va ularning og'irlik markazlari koordinatalarining hisoblash formulalari keltirilgan.

Soxta balkani reaksiya kuchlarini topamiz

$$\sum M_b = 0 \quad A_f \cdot 6 - \omega_1 \left( 6 - \frac{5}{6} \right) + \omega_2 \left( 4 + \frac{1}{12} \right) + \omega_3 \left( 3,6 + \frac{0,8}{3} \right) - \omega_4 \frac{3,6}{3} = 0$$

$$\text{buerda } \omega_1 = \frac{2}{3} \cdot \frac{4}{3} \cdot \frac{125}{18} \approx 7,71605 \text{ kNm}^2 \quad \omega_2 = \frac{1}{3} \cdot \frac{20}{3} \cdot \frac{1}{3} = \frac{20}{27} \text{ kNm}^2$$



2.48 – rasm. Turli shaklli kesim yuzalar og'irlik markazlarining koordinatalari

$$\omega_3 = \frac{1}{2} \cdot \frac{20}{3} \cdot 0,4 = \frac{4}{3} \text{ kNm}^2 \quad \omega_4 = \frac{1}{2} \cdot 60 \cdot 3,6 = 108 \text{ kNm}^2$$

$$\text{Unda } A_f \cdot 6 - \frac{156770}{972} = 0; \quad A_f = \frac{156770}{6 \cdot 972} \approx 26,9 \text{ kNm}^2$$



**echish.** Berilgan yuklanishda eng katta eguvchi moment balka prolyotining o'rtasida hosil bo'ladi. Eguvchi moment har bir kuch ta'siridan hosil bo'lgan eguvchi momentlarning yig'indisiga teng:

$$M_{x,\max} = \frac{ql^2}{8} + \frac{Fl}{4} = \frac{5 \cdot 5^2}{8} + \frac{10 \cdot 5}{4} = 28,1 \text{ kNm}$$

Talab etilgan qarshilik momentini mustahkamlik shartdan topamiz

$$W_x \geq \frac{M_{x,\max}}{[\sigma]} = \frac{28,1 \cdot 10^6}{160} = 175 \cdot 10^3 \text{ mm}^3 = 175 \text{ cm}^3$$

Hisobiy qarshilik momentiga yaqin qarshilik momenti sortament-dan № 20 qo'shtavrga ( $I \geq 1840 \text{ cm}^4$ ) tegishlilikini aniqlaymiz.

Eng katta salqilik balka prolyotining o'rtasida hosil bo'ladi. Bu salqilik har bir kuch ta'siridan hosil bo'lgan salqiliklarning yig'indisiga teng va u tayyor formulalar asosida topiladi:

$$y_{\max} = \frac{5ql^4}{384EI} + \frac{Fl^3}{48EI}$$

Bikrlik shartiga ko'ra mazkur salqilik ruxsat etilgan salqilikdan katta bo'lmasligi lozim.

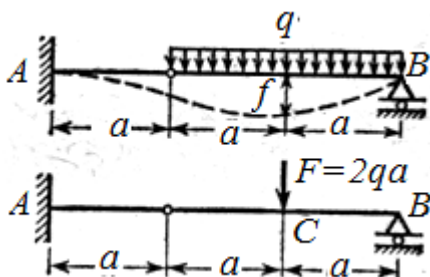
$$y_{\max} = \frac{5ql^4}{384EI} + \frac{Fl^3}{48EI} \leq \frac{l}{600}$$

Tenglikni  $l$  ga qisqartirib sonli raqamlarni kiritsak

$$\frac{5 \cdot 5 \cdot 5000^3}{384 \cdot 2 \cdot 10^5 \cdot I} + \frac{10 \cdot 10^3 \cdot 5000^2}{48 \cdot 2 \cdot 10^5 \cdot I} \leq \frac{1}{600} \text{ ni hosil qilamiz.}$$

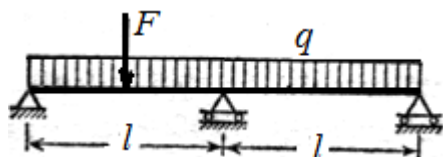
Buerdan talab etilgan inertsia momenti  $I \geq 4002 \text{ cm}^4$

Mustahkamlik shartidan tanlangan № 20 ( $I \geq 1840 \text{ cm}^4$ ) qo'shtavr bikrlikni ta'minlamaydi, shuning uchun inertsia momenti  $I \geq 5010 \text{ cm}^4$  bo'lgan № 27 qo'shtavrni tanlaymiz.



**misol-2.72.** Teng taqsilangan kuchni  $F$  kuch bilan almashtirilsa balka perimetrining o'rtasida siqilish qanday o'zgaradi?

**javob:** a)  $f = -\frac{3qa^4}{8EI}$ ,  $f = -\frac{qa^4}{2EI}$ .



**misol-2.74.** Balka uzunligi bo'yiga taqsimlangan kuch bilan yuklangan. O'ng tayanchda balkani ko'tarilmasligi uchun chap proletning o'rtasida qo'yilgan  $F$  kuch nimaga teng bo'lishi kerak?

**javob:**  $F = 4ql$ .

**misol-2.75.** Rasmda ko'rsatilgan bir konsolli balkalar proletining o'rtasi va konsolning oxirgi nuqtasining salqiligi, chap tayanch kesimining aylanish burchagi hisoblansin. Balka proletining uzunligi  $l = 4a = 4m$ , konsolning uzunligi  $a=1m$ .

Balkaning havfli kesimi uchun ruxsat etilgan kuchlanish  $[\sigma]=1600 \frac{\kappa\epsilon}{\text{cm}^2}$  dan foydalanib qo'shtavr profili tanlansin.

| sxema | № | qo'shtavr № | javoblar          |                   |                         |
|-------|---|-------------|-------------------|-------------------|-------------------------|
|       |   |             | $u_s, \text{ sm}$ | $u_K, \text{ sm}$ | $\theta_A, \text{ rad}$ |
|       | 1 | 27          | -0,866            | 0,266             | -0,01067                |
|       | 2 | 27          | -0,931            | 0,196             | -0,00931                |
|       | 1 | 33          | 0,169             | -0,474            | 0,00068                 |
|       | 2 | 30a         | -0,343            | -0,129            | -0,00343                |
|       | 1 | 27          | -0,067            | -0,566            | -0,00133                |
|       | 2 | 30          | -0,799            | 0,494             | -0,00659                |
|       | 1 | 27          | -0,498            | 2,413             | -0,00732                |
|       | 2 | 18          | 0                 | -0,711            | -0,00518                |
|       | 1 | 24a         | -0,658            | 0,844             | -0,00438                |
|       | 2 | 18          | 0                 | -0,194            | 0                       |
|       | 1 | 24a         | -1,272            | 1,37              | -0,00965                |
|       | 2 | 33          | -0,881            | 0,89              | -0,00678                |

Balkalarning har bir sxemasi uchun yuklanish ikkita variantda beriladi:

$$1) \quad q = 20 \frac{\kappa H}{\text{m}}; F = 40\kappa H; M = 60\kappa H \cdot \text{m}.$$

$$2) \quad q = 40 \frac{\kappa H}{\text{m}}; F = 60\kappa H; M = 20\kappa H \cdot \text{m}.$$

| sxema | № | qo'shtavr № | javoblar          |                         |                          |
|-------|---|-------------|-------------------|-------------------------|--------------------------|
|       |   |             | $u_s, \text{ sm}$ | $\theta_A, \text{ rad}$ | $\Delta u_s, \text{ sm}$ |
|       | 1 | 33          | -1,355            | 0,00926                 | -0,031                   |
|       | 2 | 40          | -1,197            | 0,00806                 | -0,022                   |
|       | 1 | 27a         | -1,212            | 0,00707                 | -0,045                   |
|       | 2 | 30          | -1,319            | 0,00675                 | -0,038                   |
|       | 1 | 36          | -1,295            | 0,00822                 | -0,027                   |
|       | 2 | 45          | -1,117            | 0,00692                 | -0,017                   |
|       | 1 | 27          | 0,355             | -0,00488                | -0,046                   |
|       | 2 | 30          | -1,130            | 0,00832                 | -0,038                   |
|       | 1 | 27          | -0,444            | 0,000866                | -0,046                   |
|       | 2 | 20          | 0                 | 0,00785                 | -0,084                   |
|       | 1 | 27a         | -1,858            | 0,01192                 | -0,045                   |
|       | 2 | 36          | -1,046            | 0,00775                 | -0,027                   |

**misol-2.76.** Rasmda ko'rsatilgan ikki tayanchli balkalarning C kesimi -dagi salqiligi va B-o'ng tayanch kesimining aylanish burchagi topilsin. Balkaning havfli kesimi uchun ko'shtavr profili tanlansin. Balkalar ikki variantda yuklanadi:

$$1) q = 20 \frac{\kappa H}{\mathcal{M}}; \quad F = 40\kappa H; \quad M = 60\kappa H\mathcal{M}.$$

$$2) q = 40 \frac{\kappa H}{\mathcal{M}}; \quad F = 60\kappa H; \quad M = 30\kappa H\mathcal{M}; \quad l = 3a = 6\mathcal{M}.$$

### QIYSHIQ EGILISH

Qiyshiq egilishda sterjenning kesim yuzasidan tanlangan ixtiyoriy nuqtaning to'liq kuchlanishi quyidagi formuladan topiladi:

$$\sigma_C = -M \left( \frac{\cos \varphi \cdot X_c}{I_Y} + \frac{\sin \varphi \cdot Y_c}{I_X} \right) \quad (2.18)$$

bu erda:  $I_Y$  va  $I_X$  sterjen kesimining  $u$  va  $x$  o'qlariga nisbatan inertsia momenti.

$x_C$  va  $y_C$  sterjen kesimidan ajratilgan nuqtaning koordinatalari  
Qiyshiq egilishda neytral o'q tenglamasi

$$\left( \frac{\cos \varphi \cdot X_o}{I_Y} + \frac{\sin \varphi \cdot Y_o}{I_X} \right) = 0 \quad (2.19)$$

Qiyshiq egilishda mustahkamlik shart

$$\sigma_{\max} = M_{\max} \left( \frac{\cos \varphi}{W_y} + \frac{\sin \varphi}{W_z} \right) \leq [\sigma] \quad (2.20)$$

bu erda:  $W_Y$  va  $W_X$  sterjen kesimining  $u$  va  $x$  o'qlariga nisbatan qarshilik momenti.

**misol-2.77.** Berilgan:  $P = 15\kappa H$ ;  $\ell = 2\mathcal{M}$ ;  $h : b = 2,5$

Balka kesimining o'lchamlari aniqlansin va xavfli nuqtalardagi kuchlanishlar topilsin. Balkaning tayanch kesimidagi  $M_x$  va  $M_y$  eguvchi momentlarni aniqlaymiz va epyurasini quramiz.

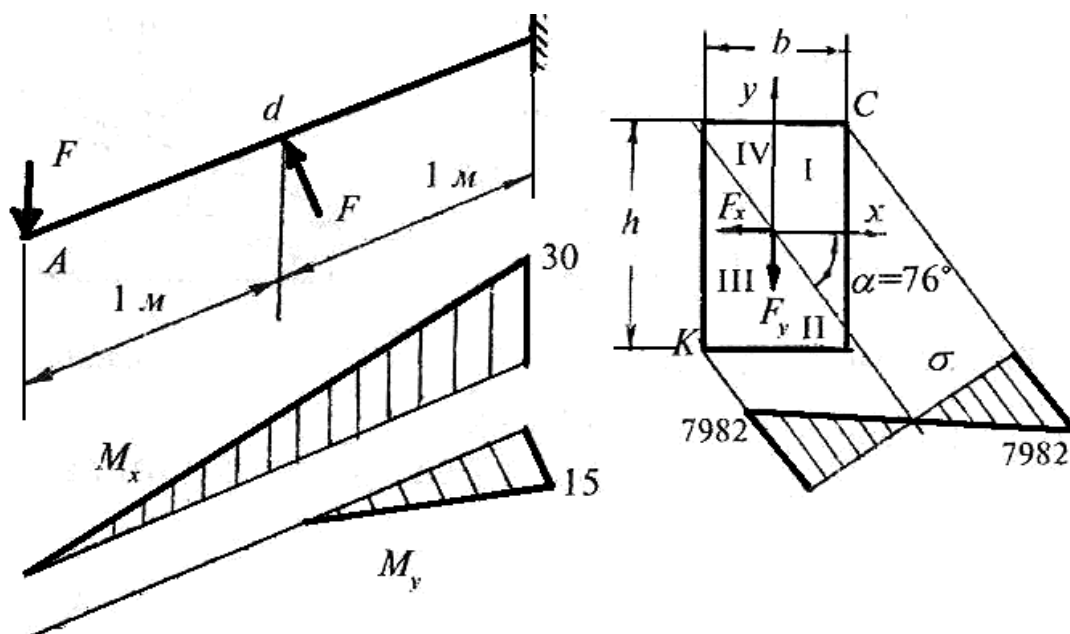
$$M_x = 2R = 30 \text{ kNm}; \quad \text{va} \quad M_y = R = 15 \text{ kNm}.$$

Balkaning mustahkamlik shartini yozamiz

$$\sigma_{\max} = \frac{M_x}{W_x} + \frac{M_y}{W_y} \leq [\sigma] \quad \text{va} \quad \frac{6M_x}{bh^2} + \frac{6M_y}{b^2h} \leq [\sigma]$$

Agar  $h = 2,5 b$  ni va  $M_x$  va  $M_y$  momentlarning qiymatlarini hisobga olsak, mustahkamlik shartidan kesimning eni  $b$ -ni topamiz:

$$b = \sqrt[3]{\frac{405}{6,25 \cdot 8 \cdot 10^3}} \approx 0,2\mathcal{M}$$



2.51 –  
rasm.  
kuchla-  
nish  
epyurasi

Kesimning balandligi  $h = 2,5 \cdot 0,2 = 0,5 \text{ m}$ . Neytral o'qning holatini

aniqlaymiz:

$$|tg\varphi| = \left| \frac{M_y}{M_x} \cdot \frac{I_x}{I_y} \right| = tg\beta \frac{I_x}{I_y}$$

Bu erda  $I_x = \frac{bh^3}{12}$  va  $I_y = \frac{b^3h}{12}$  kesimning  $x$  va  $y$  o'qlariga nisbatan inertsia momentlari;

$$I_x = \frac{0,2 \cdot (0,5)^3}{12} = 2,1 \cdot 10^{-3} \text{ m}^4; \quad I_y = \frac{0,5 \cdot (0,2)^3}{12} = 3,4 \cdot 10^{-4} \text{ m}^4$$

$$tg\varphi = \frac{2,1 \cdot 10^{-3}}{3,4 \cdot 10^{-4}} \cdot 0,5 = 4,242 \quad \text{ëku} \quad \varphi = 76^\circ.$$

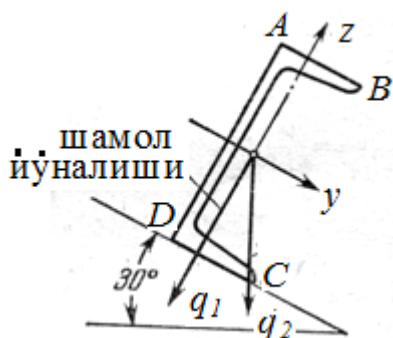
Neytral o'q kuchning ta'sir chizig'i joylashgan chorakga karama-karshi chorakdan o'tadi. Kesimning  $S$  neytral o'qdan eng uzoqda joylashganligi uchun unda normal kuchlanish katta qiymatga erishadi.  $C$  nuqtaning koordinatlari:

$$x_c = \frac{b}{2} = 0,1 \text{ m}, \quad y_c = \frac{h}{2} = 0,25 \text{ m}$$

$$\sigma_c = \frac{M_x}{I_x} \cdot y_c + \frac{M_y}{I_y} \cdot x_c \quad \text{va} \quad \sigma_c = -7982 \frac{\text{N}}{\text{m}^2}$$

Balka erkin uchining ( $A$  nuqta) to'liq salqiligini topamiz

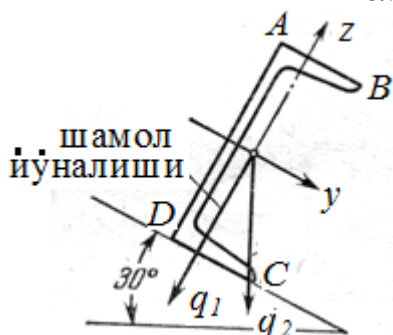
$$\begin{aligned} f &= \sqrt{f_x^2 + f_y^2} = \sqrt{\left( \frac{Pl^3}{3EI_y} \right)^2 + \left( \frac{Pl^3}{3EI_x} \right)^2} = \frac{Pl^3}{3E} \sqrt{\frac{1}{(8I_y)^2} + \frac{1}{(I_x)^2}} = \\ &= \frac{15 \cdot 8}{3 \cdot 2 \cdot 10^8} \sqrt{\frac{1}{(8 \cdot 0,00034)^2} + \frac{1}{(0,0021)^2}} = 33,34 \cdot 10^{-5} \text{ m}. \end{aligned}$$



**misol-278.** Tomning stropilalari bir-biridan 3m masofada va gorizontga 30° qiyalikda joylashgan. Unga bir-biridan 2m masofada №20 nomerli shvellerlar oʻrnatilgan. Shamol tom tekisligiga perpendikular yoʻnalgan va  $q_1 = 75 \text{ kN/m}^2$  intensivlikka ega. Shvellerlar sistemasining hususiy ogʻirligi  $q_2 = 50 \text{ kN/m}$  intensivlikka ega.

Havfli kesimning A,B,C va D nuqtalaridagi normal kuchlanishlar hisoblansin va epyuralari qurilsin.

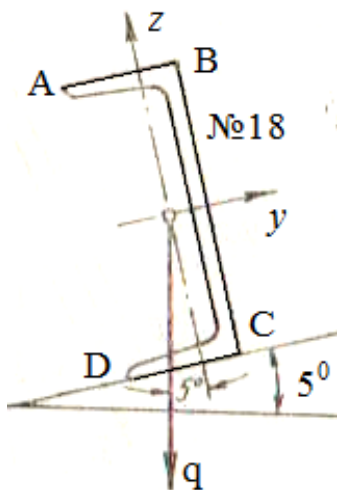
**javob:**  $\sigma_A = -273 \frac{\text{N}}{\text{cm}^2}$ ,  $\sigma_B = 105 \frac{\text{N}}{\text{cm}^2}$ ,  $\sigma_C = 446 \frac{\text{N}}{\text{cm}^2}$ ,  $\sigma_D = 67 \frac{\text{N}}{\text{cm}^2}$ .



**misol-2.79.** Tomning stropilalari bir-biridan 3m masofada va gorizontga 30° qiyalikda joylashgan. Unga bir-biridan 2m masofada №20 nomerli shvellerlar oʻrnatilgan. Shamol tom tekisligiga perpendikular yoʻnalgan va  $q_1 = 75 \text{ kN/m}^2$  intensivlikka ega. Shvellerlar sistemasining hususiy ogʻirligi  $q_2 = 50 \text{ kN/m}$  intensivlikka ega.

Havfli kesimning A,B,C va D nuqtalaridagi normal kuchlanishlar hisoblansin va epyuralari qurilsin.

**javob:**  $\sigma_A = -273 \frac{\text{N}}{\text{cm}^2}$ ,  $\sigma_B = 105 \frac{\text{N}}{\text{cm}^2}$ ,  $\sigma_C = 446 \frac{\text{N}}{\text{cm}^2}$ ,  $\sigma_D = 67 \frac{\text{N}}{\text{cm}^2}$ .

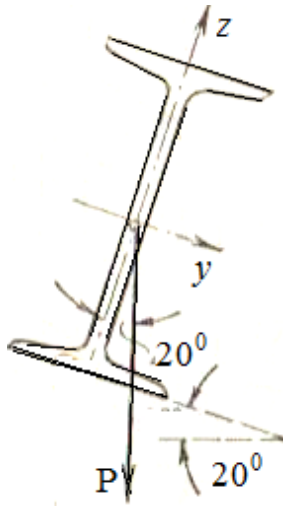


**misol-2.80.** Uchlari sharnirli tiralgan 4 m uzunlikdagi balkaga  $q=5 \text{ kN/m}$  intensivlikdagi teng tarqalgan yuk taʼsir qiladi. Balkaning koʻndalang kesimi № 18 li shveller. Shvellerning devori yuklanish taʼsir taʼsir qiladigan tekislikka  $\alpha=5^\circ$  qiya. Balkaning xavfli kesimidagi A, B, C va D nuqtalardagi normal kuchlanishlarni aniqlang va AB, BC va DC chiziqlar boʻyicha shu kuchlanishlar epyuralarini yasang. Balkaning eng katta egilish qiymati va yoʻnalishini ham toping. Shvellerning buralishi xisobga olinmaydi.

**javob:**  $\sigma_A = -309 \cdot 10^5 \text{ N/m}^2$ ,  $\sigma_V = -1019 \cdot 10^5 \text{ N/m}^2$ ;

$\sigma_S = 626 \cdot 10^5 \text{ N/m}^2$ ;  $\sigma_D = 1336 \cdot 10^5 \text{ N/m}^2$ ;  $f = 1,14 \text{ sm}$ ;  $\alpha = 47^\circ 57'$   
(devor tekisligiga).





**misol-2.81.** Uchlari sharnirli tiralgan qo'shtavr balka qulochi  $l = 5 \text{ m}$  o'rtasiga to'plangan kuch  $R = 8000 \text{ N}$  qo'yilgan. Qo'shtavr devori tekisligi yuk ta'sir qiladigan tekislik bilan  $\alpha = 20^\circ$  burchak tashkil qiladi (rasmga qarang). Yo'l qo'yilgan kuchlanish

$[\sigma] = 16 \cdot 10^7 \text{ N/m}^2$  bo'lganda balka kesimini tanlang

**echimi:** Bu holda mustahkamlik sharti quyidagi ko'rinishni oladi:

$$M_{\max} = \frac{8000 \cdot 500}{4 \cdot 16 \cdot 10^3} + \frac{21,38}{23,1} = 0,319 + 0,925 = 1,244 > 1$$

Mustahkamlik sharti qoniqarli bo'lmaydi, maksimal kuchlanish yo'l qo'yiladigan kuchlanishdan 24,4 % katta chiqadi. Shuning uchun qo'shtavrning

nomerini kattalashtirish kerak. Endi № 22 li qo'shtavrni olib ko'ramiz, unda  $W_u = 232 \text{ sm}^3$  va  $W_z = 28,6 \text{ sm}^3$ . O'ta kuchlanish 0,1 % ga yo'l qo'yish mumkin. Demak, № 22 li qo'shtavrni tanlaymiz.

## MARKAZLASHMAGAN ChO'ZILISH YoKI SIQILISH

Nuqtadagi to'liq kuchlanish quyidagicha topiladi:

$$\sigma_c = \frac{F}{A} \left( 1 + \frac{Y_F Y_c}{i_x^2} + \frac{X_F X_c}{i_y^2} \right) \quad (2.21)$$

buerda,  $A$ -sterjenning kesim yuzasi,

$i_x^2$   $i_y^2$  sterjen kesim yuzasini tegishlicha  $x$  va  $y$  o'qlariga nisbatan

inertiya radiuslari:  $i_x^2 = \frac{I_x}{A}$  va  $i_y^2 = \frac{I_y}{A}$

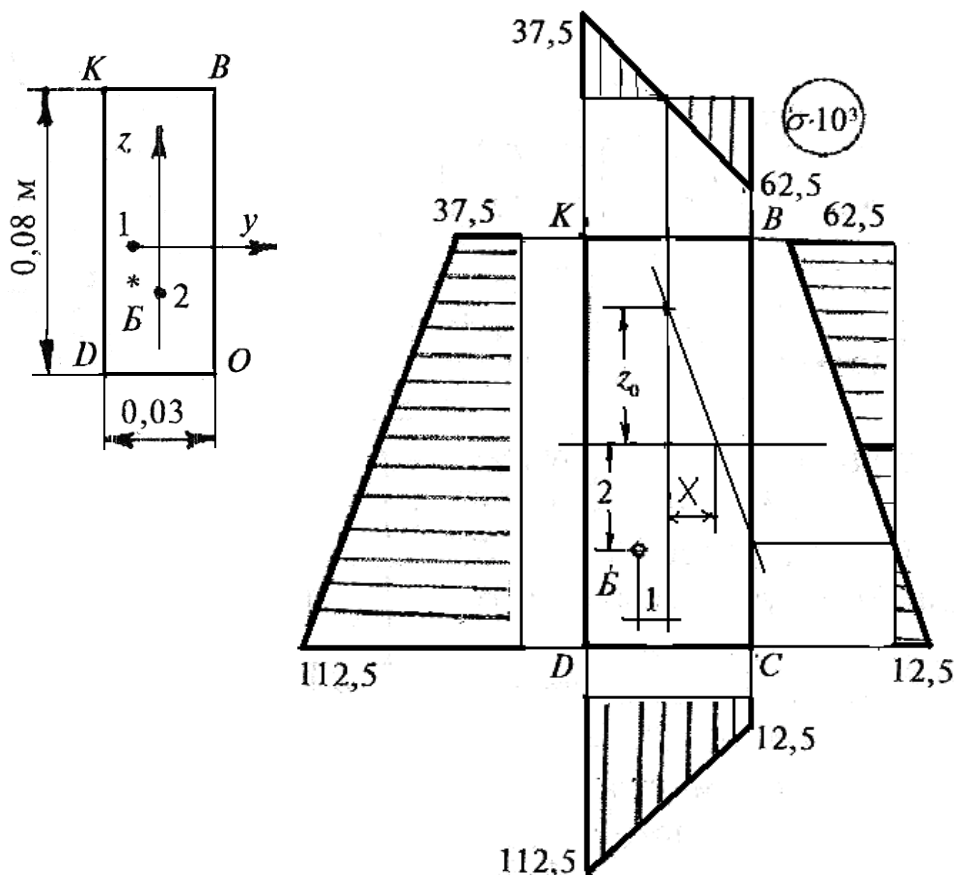
Neytral o'q tenglamasi:

$$1 + \frac{X_F X_o}{i_y^2} + \frac{Y_F \cdot Y_o}{i_x^2} = 0 \quad (2.22)$$

$X_o$  va  $Y_o$  - neytral o'q ustida joylashgan nuqtaning koordinatalari

**misol-2.82.** Uzunligi  $\ell = 1,5M$  bo'lgan po'lat sterjen  $F = 60 kN$  kuch ta'sirida cho'ziladi. To'g'ri burchakli kesimning  $K, C, B, D$  nuqtalarining kuchlanishlari topilsin.

2.53-rasm.  
Sterjenning kesim  
yuzasi va normal  
kuchlanish  
epyrasi



**echish:** Kesim B nuqtasining koordinatalari  $y_B = -1cm$ ,  $Z_B = -2cm$ . Sterjen ko'ndalang kesim yuzasining geometrik tavsiflarini topamiz:

Kesim yuzasi  $A = 3 \cdot 8 = 24cm^2 = 2,4 \cdot 10^{-3} M^2$

Inertsia radiuslari:

$$i_y^2 = \frac{0,03(0,08)^3}{12 \cdot 2,4 \cdot 10^{-3}} = 0,0534 \cdot 10^{-2} M ; i_z^2 = \frac{0,08(0,03)^3}{12 \cdot 2,4 \cdot 10^{-3}} = 0,075 \cdot 10^{-3} M^2;$$

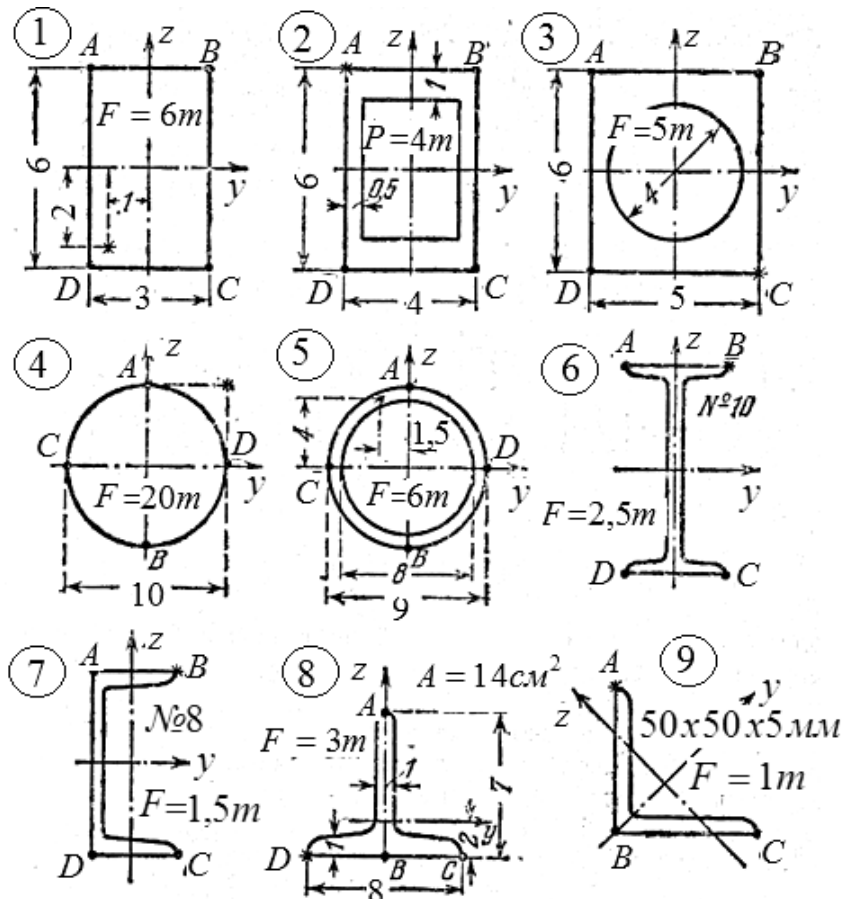
Kesim neytral o'qining tenglamasi.  $1 + \frac{y_F \cdot y_O}{i_z^2} + \frac{z_F \cdot z_O}{i_y^2} = 0$

agar  $z_O = 0$  bo'lsa  $y_0 = -\frac{i_z^2}{y_F} = \frac{0,075 \cdot 10^{-3}}{0,01} = 7,5 \cdot 10^{-3} M$

agar  $y_O = 0$  bo'lsa  $z_0 = -\frac{i_y^2}{z_F} = \frac{0,0534 \cdot 10^{-2}}{0,02} = 2,67 \cdot 10^{-2} M.$

Neytral o'q kesimning ZOU koordinata o'qlarining musbat chorakidan  $y_0$  va  $z_0$  masofalarda kesib o'tadi.

| Kesimning $KBCD$ nuqtalaridagi normal kuchlanishlar, $\frac{\kappa H}{M^2}$ |                                                                    |                                                                   |                                                                    |
|-----------------------------------------------------------------------------|--------------------------------------------------------------------|-------------------------------------------------------------------|--------------------------------------------------------------------|
| $z_k = 0,04M;$<br>$y_k = -0,015M$<br>$\sigma_k = 37,5 \cdot 10^3$           | $z_B = 0,04M;$<br>$y_B = -0,015M$<br>$\sigma_B = -62,5 \cdot 10^3$ | $z_c = 0,04M;$<br>$y_c = -0,015M$<br>$\sigma_c = 12,5 \cdot 10^3$ | $z_d = 0,04M;$<br>$y_d = -0,015M$<br>$\sigma_d = 112,5 \cdot 10^3$ |



**misol-2.82.** Uzunligi  $l=1,5m$ . bo'lgan ko'ndalang kesim yuzasi rasmda ko'rsatilgan sterjen  $F$  kuch ta'sirida kesimning yulduzcha bilan belgilangan nuqtalarida cho'ziladi. Kesim neytral o'qining vaziyati,  $A, B, C, D$  nuqtalardagi kuchlanishlar hisoblansin, epyuralari qurilsin, sterjen prolyotining o'rtasida salqilik topilsin.

rasm-2.54

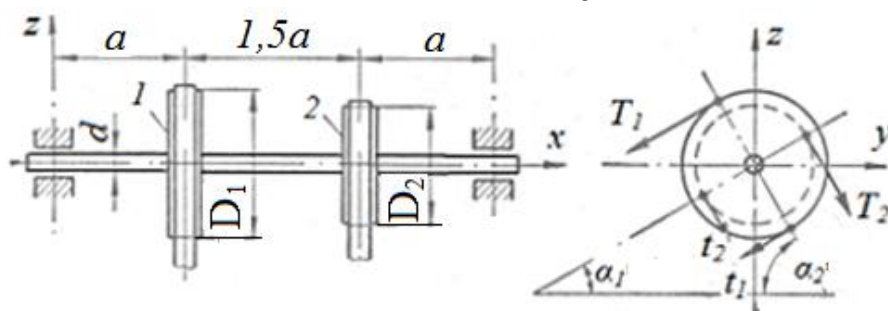
**javoblar:**

| № | Neytral uk nuqtalarining koordinatalari |        | Kesimning nuqtalaridagi kuchlanishlar, $kG/sm^2$ |            |            |            |                | salkilik, $f, sm$ |
|---|-----------------------------------------|--------|--------------------------------------------------|------------|------------|------------|----------------|-------------------|
|   | $a_u$                                   | $a_z$  | $\sigma_A$                                       | $\sigma_V$ | $\sigma_S$ | $\sigma_D$ | $\sigma_{max}$ |                   |
| 1 | + 0,75                                  | + 2,67 | +375                                             | -625       | +125       | +1125      | 1125           | 0,49              |
| 2 | + 0,96                                  | -1,56  | +1672                                            | +281       | -1005      | +386       | 1672           | 0,57              |
| 3 | -1,15                                   | +1,48  | -919                                             | +331       | +1493      | +243       | 1493           | 0,45              |
| 4 | -1,25                                   | -1,25  | +1273                                            | -764       | -764       | +1273      | 1695           | 0,41              |
| 5 | + 6,04                                  | -2,27  | +1342                                            | -443       | +784       | +115       | 1403           | 0,30              |
| 6 | -0,54                                   | -3,30  | -532                                             | +1580      | +949       | -1164      | 1580           | 0,55              |
| 7 | -0,53                                   | -2,49  | +23                                              | +1283      | +747       | -514       | 1283           | 0,45              |
| 8 | + 0,77                                  | +2,17  | -280                                             | +412       | -700       | +1524      | 1524           | 0,41              |
| 9 | -0,63                                   | +1,05  | +1415                                            | -454       | +10        | -          | 1415           | 0,54              |

## BURALISH BILAN EGILISHNI BIRGALIKDAGI TA`SIRI

**misol-2.83.** Transmissiya valining diametri topilsin.

Berilgan:  $N = 50 \text{ kNm}$ ,  $\omega = 40 \frac{\text{P}}{\text{c}}$ ,  $D_1 = 1,0 \text{ m}$ ,  $D_2 = 0,8 \text{ m}$ ,



$$\alpha_1 = 30^\circ, \alpha_2 = 60^\circ$$

rasm-2.55

**echish.** 1. Berilgan quvvat  $N$  va burchak tezlik  $\omega$  qiymatlari bo'yicha 1 va 2 shkiylardagi o'zaro teng bo'lgan burovchi momentlarni topamiz:

$$M_{\phi 1} = M_{\phi 2} = \frac{N}{\omega} = \frac{50 \cdot 10^3}{40} = 1250 \text{ Hm}$$

2. Shkiylardagi doiraviy kuchlarni topamiz:

$$F_{\phi 1} = \frac{M_{\phi} \cdot 2}{D_1} = \frac{1250 \cdot 2}{1} = 2500 \text{ H} \quad \text{va} \quad F_{\phi 2} = \frac{M_{\phi} \cdot 2}{D_2} = \frac{1250 \cdot 2}{0,8} = 3125 \text{ H}$$

3. Tasmalarning etaklovchi va etaklanuvchi tarmoqlaridagi taranglik kuchlarini topamiz:

$$\text{etaklanuvchi tarmoq} \quad t_1 = 2500 \text{ H} \quad \text{va} \quad t_2 = 3125 \text{ H}$$

$$\text{etaklovchi tarmoq} \quad T_1 = 2 \cdot 2500 = 5000 \text{ H} \quad \text{va} \quad T_2 = 6250 \text{ H}$$

4. Valni eguvchi  $t_1, T_1, t_2, T_2$  kuchlarning tashkil qiluvchilarini hisoblaymiz:

a) gorizontall tekislikdagi tashkil qiluvchilar

$$H_1 = (T_1 + t_1) \cos \alpha_1 = (5000 + 2500) \cdot 0,866 = 6495 \text{ H}$$

$$H_2 = (T_2 + t_2) \cos \alpha_2 = (3125 + 6250) \cdot 0,5 = 4687,5 \text{ H}$$

b) vertikal tekislikdagi tashkil qiluvchilar

$$P_1 = (T_1 + t_1) \sin \alpha_1 = (5000 + 2500) \cdot 0,5 = 3750 \text{ H}$$

$$H_2 = (T_2 + t_2) \sin \alpha_2 = (3125 + 6250) \cdot 0,866 = 818 \text{ H}$$

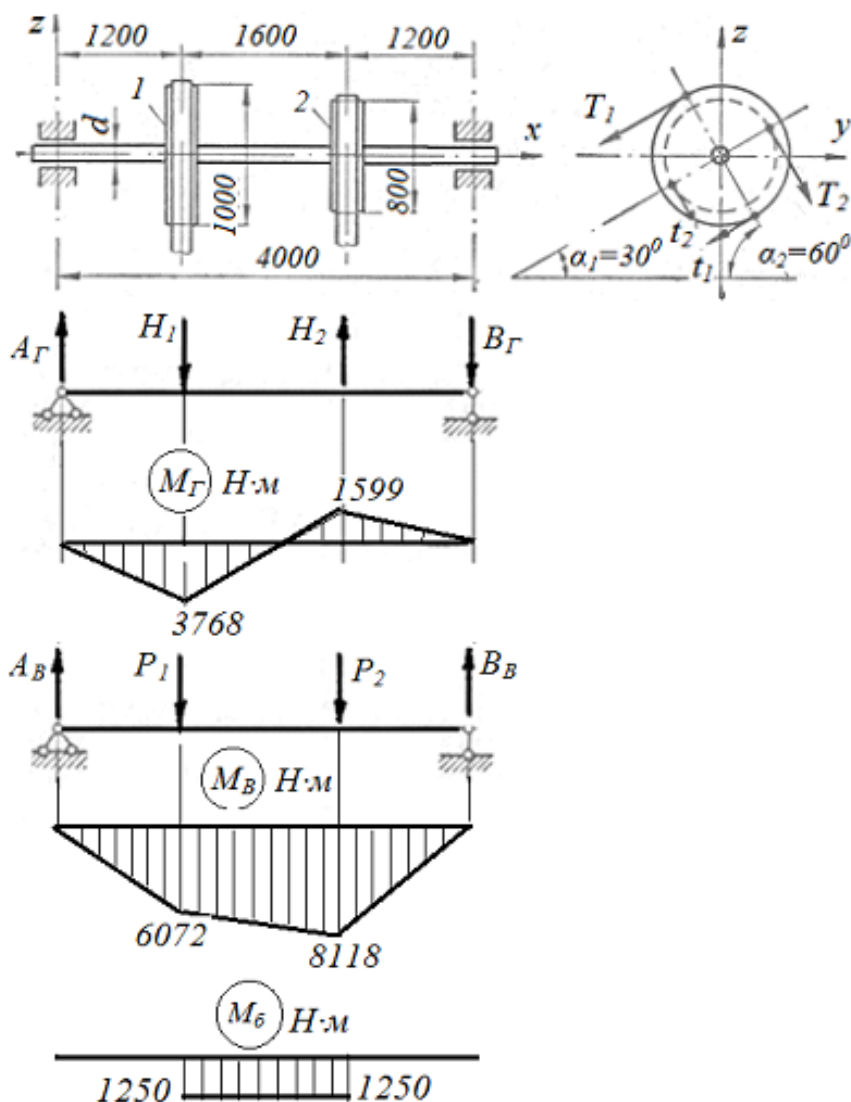
5. Valni ikki tayanchli balka deb qarab, uni  $H_1, P_1, H_2, P_2$  kuchlar bilan yuklaymiz, gorizontall va vertikal reaksiya kuchlarini hisoblaymiz:

a) gorizontall tekislik

$$\sum M_B = -A_R \cdot l + H_1 \cdot 2,8 - H_2 \cdot 1,2 = 0$$

$$A_R = \frac{H_1 \cdot 2,8 - H_2 \cdot 1,2}{4,0} = \frac{6495 \cdot 2,8 - 4687 \cdot 1,2}{4,0} = 3140,5 \text{ H}$$

$$\sum M_A = -B_R \cdot l - H_1 \cdot 1,2 + H_2 \cdot 2,8 = 0$$



rasm-2.56

$$B_{\Gamma} = \frac{-H_1 \cdot 1,2 + H_2 \cdot 2,8}{4,0} = \frac{-6495 \cdot 1,2 + 4687 \cdot 2,8}{4,0} = 1332,5H$$

$$\text{tekshirish: } \sum z = A_{\Gamma} - H_1 + H_2 - B_{\Gamma} = 0$$

b) vertikal tekislik

$$\sum M_B = -A_B \cdot l + P_1 \cdot 2,8 + P_2 \cdot 1,2 = 0$$

$$A_B = \frac{P_1 \cdot 2,8 - P_2 \cdot 1,2}{4,0} = \frac{3750 \cdot 2,8 + 8118 \cdot 1,2}{4,0} = 5060 H$$

$$\sum M_A = B_B \cdot l - P_1 \cdot 1,2 - P_2 \cdot 2,8 = 0$$

$$B_B = \frac{P_1 \cdot 1,2 + P_2 \cdot 2,8}{4,0} = \frac{3750 \cdot 1,2 + 8118 \cdot 2,8}{4,0} = 6807 H$$

$$\text{tekshirish: } \sum z = A_B - P_1 - P_2 + B_B = 0$$

6.  $H_1, P_1, H_2, P_2$  kuchlar qo'yilgan kesimlardagi eguvchi momentlarni aniqlaymiz:

$$M_{\Gamma_1} = A_{\Gamma} \cdot 1,2 = 3140,5 \cdot 1,2 = 3768 H \cdot m$$

$$M_{\Gamma_2} = -B_{\Gamma} \cdot 1,2 = -1332 \cdot 1,2 = -1599 H \cdot m$$

$$M_{B_1} = A_B \cdot 1,2 = 5060 \cdot 1,2 = 6072 H \cdot m$$

$$M_{B_2} = B_B \cdot 1,2 = 6807 \cdot 1,2 = 8168 H \cdot m$$

7. Umumiy eguvchi momentlarni hisoblaymiz:

$$M_{\Theta_1} = \sqrt{(M_{\Gamma_1})^2 + (M_{B_1})^2} = \sqrt{3768^2 + 6072^2} = 7146 H \cdot m$$

$$M_{\Theta_2} = \sqrt{(M_{\Gamma_2})^2 + (M_{B_2})^2} = \sqrt{1599^2 + 8168^2} = 8323 H \cdot m$$

8. Gorizontaal va vertikal tekisliklarda eguvchi moment epyuralarini quramiz ( rasm). Umumiy eguvchi moment epyurasidan ko'rinishicha eng katta eguvchi moment ikkinchi shki ostidagi val kesimida hosil bo'ladi.

9. Uchinchi mustahkamlik nazariyasiga asosan keltirilgan momentni topamiz:

$$M_{\kappa\epsilon\lambda} = \sqrt{(M_{\Theta_2})^2 + (M_{\delta})^2} = \sqrt{8323^2 + 1250^2} = 8416 H \cdot m$$

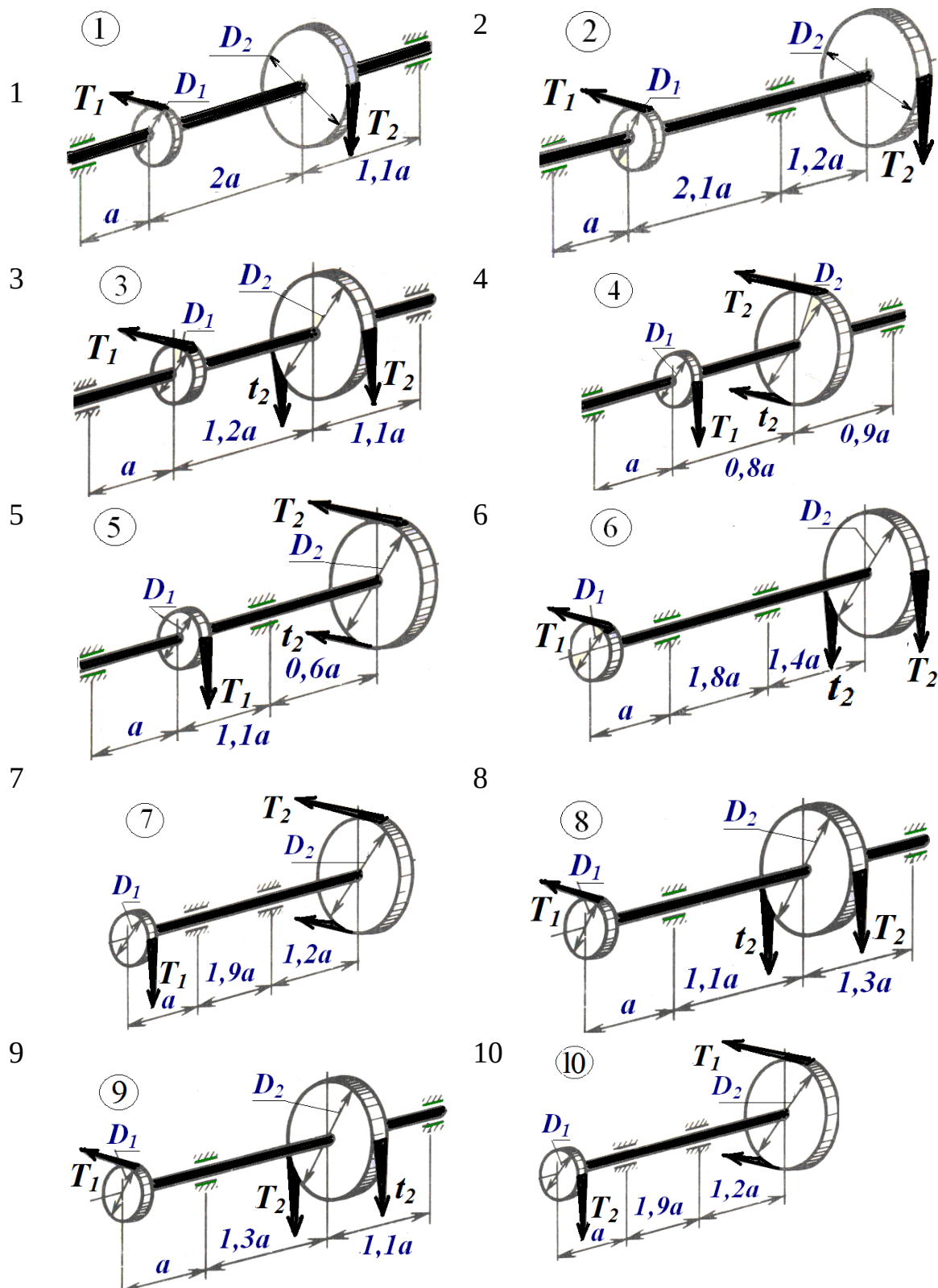
10. Val diametrini hisoblaymiz:

$$d \geq \sqrt[3]{\frac{32 M_{\kappa\epsilon\lambda}}{\pi \cdot [\sigma]}} = \sqrt[3]{\frac{32 \cdot 841600}{3,14 \cdot 1600}} = 17,5 cm$$

**misol-2.84.** Transmissiya vali  $\omega$  (r/s) burchak tezlik bilan aylanadi va N (kvt) quvvatni uzatadi.  $[\sigma]=1600$  kG/sm<sup>2</sup> ruxsat etilgan kuchlanishdan foydalanib valning diametri topilsin. Bunda etaklovchi tasmaning taranglik kuch etaklanuvchi tasmaning taranglik kuchidan ikki marotaba katta, ya'ni  $T=2t$  deb qaraladi. Birinchi shki ostidagi tasma etaklovchi tarmoqining taranglik kuchi  $T_1$  va ikkinchi shki ostidagi etaklovchi tarmoqining taranglik kuchi  $T_2$ .

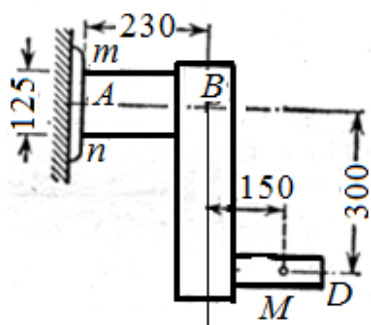
Masalaning berilishi quyidagi jadvalda va sxemasi 2.57-rasmda keltirilgan.

| N <sub>o</sub> | N, kvt | $\omega$ (r/s) | a, m | D <sub>1</sub> , m | D <sub>2</sub> , m | $\alpha_1$ , grad | $\alpha_2$ , grad |
|----------------|--------|----------------|------|--------------------|--------------------|-------------------|-------------------|
| 1              | 10     | 10             | 1,0  | 1,0                | 0,8                | 30                | 60                |
| 2              | 15     | 15             | 1,1  | 1,1                | 0,9                | 45                | 45                |
| 3              | 20     | 20             | 1,2  | 1,2                | 1,0                | 60                | 30                |
| 4              | 25     | 25             | 1,3  | 1,3                | 1,1                | 30                | 60                |
| 5              | 30     | 30             | 1,4  | 1,4                | 1,2                | 45                | 45                |
| 6              | 35     | 35             | 1,5  | 1,5                | 1,3                | 60                | 30                |
| 7              | 40     | 40             | 1,1  | 1,1                | 0,8                | 30                | 30                |
| 8              | 45     | 45             | 1,2  | 1,2                | 0,9                | 45                | 45                |
| 9              | 50     | 50             | 1,3  | 1,3                | 1,0                | 60                | 60                |
| 10             | 60     | 60             | 1,4  | 1,4                | 1,1                | 30                | 30                |



rasm-2.57

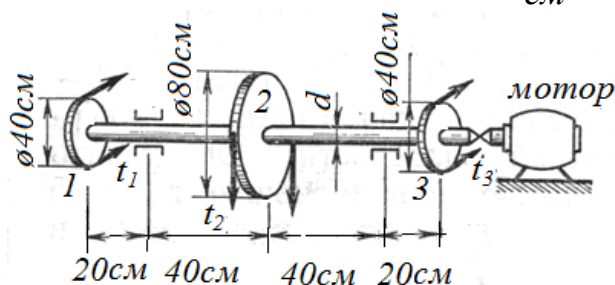




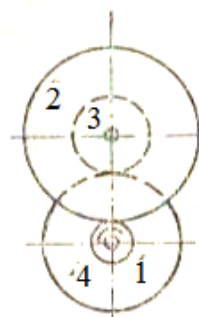
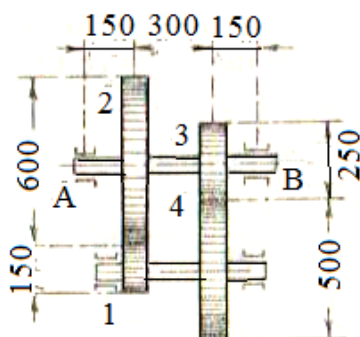
**misol-2.85.** ABCD kopen valning AB qismi doiraviy kesimli, diametri 125mm. 20kN kuch  $M$  nuqtaga qo'yilgan va chizma tekisligiga tik yo'nalgan. Urinma kuchlanishlarni e'tiborga olmasdan,  $mm$ -havfli kesimdagi bosh kuchlanishlar hisoblansin. III va IV mustahkamlik nazariyalaridan hisobiy kuchlanishlar aniqlansin.

**javob:**  $\sigma_1 = 451 \frac{k\bar{z}}{cm^2}$ ,  $\sigma_{II} = -54 \frac{k\bar{z}}{cm^2}$ ,  $\sigma_{III} = 505 \frac{k\bar{z}}{cm^2}$ ,

$\sigma_{IV} = 480 \frac{k\bar{z}}{cm^2}$ .



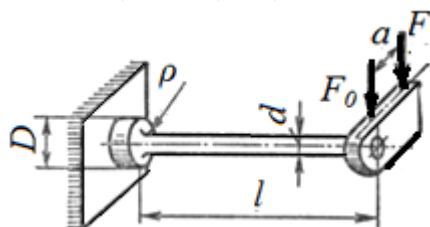
**misol-2.86.** Uchinchi mustahkamlik nazariyasiga asosan po'lotdan tayyorlangan val ko'ndalang kesimining o'lchamlari aniqlansin? Ruxsat etilgan kuchlanish  $[\sigma] = 1600 \text{ kG/sm}^2$



**misol.-2.87.** Tsilindrik tishli uzatma vali AV ning diametrini aniqlang (rasmga qarang). Tishli g'ildirak 1 dagi burovchi moment 30 N ga teng. To'rtinchi mustahkamlik nazariyasidan foydalaning. Tishli g'ildiraklarning xususiy og'irliklarini xisobga olmang Yo'l qo'yiladigan kuchlanish  $[\sigma] = 800 \text{ N/sm}^2$ . Uchinchi mustahkamlik

nazariyasi asosida valning diametrini qancha olish kerak edi?

**javob:** 56,2 mm; 57,8 mm.



**misol-2.88.** Uchinchi mustahkamlik nazariyasiga asosan po'lotdan tayyorlangan po'lotdan tayyorlangan val ko'ndalang kesimining o'lchamlari ruxsat etilgan kuchlanish  $[\sigma] = 1600 \text{ kG/sm}^2$  foydalanib aniqlansin?

$F = 20 \text{ kN}$ ,  $F_0 = 10 \text{ kN}$ ,  $a = 0,5m$ ,  $l = 1m$

## SIQILGAN STERJENLARNI USTUVORLIKKHA HISOBLASH.

Siqilgan sterjenlarni mustahkamlikka hisoblash o'lchamlarini shunday tanlash kerak-ki, ularni ekspluatatsiya qilish jarayonida kuch ta'siridan ustuvorlikni yo'qotilmasligi kerak. Buning uchun siqilgan sterjenning kesimidagi normal kuchlanish kritik kuchlanishdan kichik bo'lishi kerak:

$$\sigma = \frac{N}{A_{\delta}} < \frac{F_k}{A_{\delta}} = \sigma_k \quad (2.23)$$

bu erda:  $N$  - siquvchi kuch;

$A_{\delta}$  - sterjenning zaiflashgan kesim yuzasi.

Kritik kuchlanish materialning oquvchanlik chegarasida plastik material uchun yoki mustahkamlik chegarasida mo'rt materiallar uchun xavfli bo'lishi mumkin. Shuning uchun sterjenni ustuvorlikka amaliy hisoblashda kritik kuchlanishni hosil bo'lishini cheklash kerak, ya'ni ustuvorlikka ehtiyotlik shartini ta'minlash kerak:

$$\sigma_y = \frac{F_k}{A_{\delta}} = [\sigma]_y \quad (2.24)$$

Elastiklik chegarada kritik kuch Eyler formulasidan topiladi:

$$F_k = \frac{\pi^2 EI_{\min}}{(\mu \ell)^2} \quad (2.25)$$

bu erda  $\mu$  - keltirilgan uzunlik koeffitsienti;

$I_{\min}$  ko'ndalang kesimni minimal inertsia momenti

$E$  materialni elastiklik moduli

Kritik kuchlanish Eyler formulasidan topiladi  $\sigma_{kp} = \frac{\pi^2 E}{\lambda^2}$

Sterjenning egiluvchanligi  $\lambda = \mu \frac{\ell}{i}$  (2.26)

Egiluvchanlik  $50 \leq \lambda \leq \lambda_0$  oraliqda bo'lsa

po'lot materiali uchun  $\sigma_k = a - b\lambda$

cho'yan uchun:  $\sigma_k = a - b\lambda + c\lambda^2$  yoki

$$\sigma_k = 762 - 11,8\lambda + 0,52\lambda^2$$

Ustuvorlikka ruxsat etilgan kuchlanish  $[\sigma]_y$  ustuvorlikka ehtiyotlik

koeffitsienti ( $n_y$ ) orqali topiladi:  $[\sigma]_y = \frac{\sigma_k}{n_y}$  (2.27)

$$\text{Unda} \quad \sigma_y = \frac{F_k}{A_{\delta} \cdot \phi} \leq [\sigma] \quad (2.28)$$

Bu shart orqali sterjenning ko'ndalang kesimi tanlanishi mumkin.

### $a, b, \lambda$ larning qiymatlari

| material            | $a, \frac{H}{\text{mm}^2}$ | $b, \frac{H}{\text{mm}^2}$ | $\lambda$ |
|---------------------|----------------------------|----------------------------|-----------|
| Po'lot 10, St.2     | 264                        | 0,70                       | 62        |
| Po'lot 15, St.3     | 310                        | 1,14                       | 61        |
| Po'lot 25, St.5     | 350                        | 1,15                       | 57        |
| Po'lot 10G2SD, 15GS | 429                        | 1,52                       | 50        |
| Dyuralyumin         | 406                        | 2,83                       | 30        |
| Sosna, el           | 29,3                       | 0,194                      | -         |
| chugun              | -                          | -                          | 10        |

Ustuvorlikka ehtiyotlik koeffitsienti  $n_y$  mustahkamlikka ehtiyotlik koeffitsienti  $n$ – dan katta qabul qilinadi:

yog'och –  $n_y = 2,8 \dots 3,2$ ; po'lat –  $n_y = 1,8 \dots 3,0$ ; cho'yan  $n_y = 5 \dots 5,5$

$[\sigma]$ – sterjenning mustahkamlikka ruxsat etilgan kuchlanishi;

$\varphi$  -mustahkamlikka ruxsat etilgan kuchlanishning kamaytirish koeffitsienti.

Koeffitsient -  $\varphi$  - materialning egiluvchanligiga bog'liq ravishda topiladi.

Yog'och uchun koeffitsient  $\varphi$  - quyidagi formulada topiladi:  $\lambda \leq 75$

bo'lsa,  $\varphi = 1 - 0,5 \left( \frac{\lambda}{100} \right)^2$  va

$\lambda \geq 75$  bo'lganida  $\varphi = \frac{3100}{\lambda^2}$

Koeffitsient sterjen kesimining o'lchamlariga bog'liq bo'lganligi uchun uni qiymati oldindan berilgan bo'lmaydi. Shuning uchun kesimni o'lchamlari asta-sekin yaqinlashish usuli bilan topiladi. Birinchi marotaba  $\varphi = 0,5$  deb olinadi.

Keyingi yaqinlashishda  $\lambda$  - ga bog'liq holda koeffitsient  $\varphi$  interpolatsiya

usuli bilan topiladi:  $\varphi_1 = \varphi' - \frac{\varphi' - \varphi''}{10} \cdot K$

Topilgan  $\varphi$  yordamida kuchlanish, aniqlanish va uning kuchlanishini ruxsat etilgan qiymat bilan solishtiriladi. Ikkala kuchlanish orasida farq bo'lishi mumkin. Agar  $\sigma_y < [\sigma]$  bo'lsa, kesim o'lchamining qiymati kichiklashtirilishi kerak, agar  $\sigma_y > [\sigma]$  bo'lsa, kesim o'lchamlarini oshirish kerak. Hisoblangan kuchlanish  $\sigma$  bilan kuchlanishning ruxsat etilgan qiymati orasidagi farq 3-5% olib borilishi kerak. Masalani qo'yilishiga ko'ra hisoblash uch xil variantda olib boriladi. Dastlabki hisoblash – bunda ustuvorlikka ehtiyotlik koeffitsientining haqiqiy qiymati aniqlanadi va talab etilgan qiymati bilan taqqoslab ko'riladi:

$$n_y = \frac{F_{kp}}{F} \leq [n_y]. \quad (2.29)$$

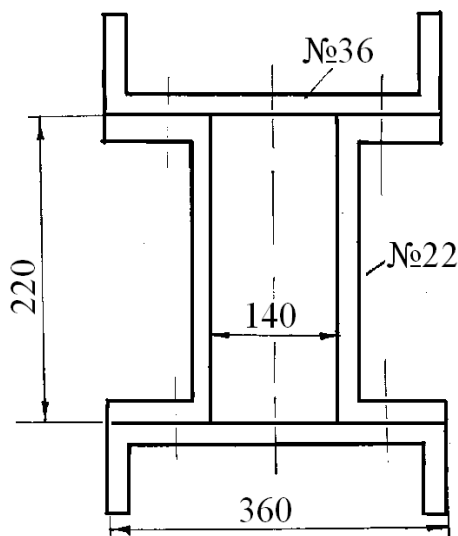
Ruxsat etilgan yuk hisoblanadi  $[F] = \frac{F_{kp}}{[n_y]}$

Loyihaviy hisoblash – sterjen ko'ndalang kesimining talab etilgan o'lchamlari aniqlanadi. Bunda Eyler formulasi yordamida ko'ndalang

kesimining minimal inertsia momenti: 
$$I_{\min} \geq \frac{F \cdot [n_y] \cdot (\mu \cdot \ell)^2}{\pi^2 E}$$

### $\varphi$ -koeffitsientning qiymatlari

| $\lambda = \mu \frac{\ell}{i}$ | $\varphi$ ning qiymati |      |         |          | $\lambda = \mu \frac{\ell}{i}$ | $\varphi$ ning qiymati |      |         |         |
|--------------------------------|------------------------|------|---------|----------|--------------------------------|------------------------|------|---------|---------|
|                                | St.3                   | St.5 | Chu-gun | Yo-g'och |                                | St.3                   | St.5 | Chu-gun | yog'och |
| 0                              | 1,0                    | 1,0  | 1,0     | 1,0      | 110                            | 0,52                   | 0,43 | -       | 0,25    |
| 10                             | 0,99                   | 0,98 | 0,97    | 0,99     | 120                            | 0,45                   | 0,37 | -       | 0,22    |
| 20                             | 0,97                   | 0,96 | 0,91    | 0,97     | 130                            | 0,40                   | 0,32 | -       | 0,18    |
| 30                             | 0,95                   | 0,93 | 0,81    | 0,93     | 140                            | 0,36                   | 0,28 | -       | 0,16    |
| 40                             | 0,92                   | 0,89 | 0,69    | 0,87     | 150                            | 0,32                   | 0,25 | -       | 0,14    |
| 50                             | 0,89                   | 0,85 | 0,57    | 0,80     | 160                            | 0,29                   | 0,23 | -       | 0,12    |
| 60                             | 0,86                   | 0,80 | 0,44    | 0,71     | 170                            | 0,26                   | 0,21 | -       | 0,11    |
| 70                             | 0,81                   | 0,74 | 0,34    | 0,60     | 180                            | 0,23                   | 0,19 | -       | 0,10    |
| 80                             | 0,75                   | 0,67 | 0,26    | 0,48     | 190                            | 0,21                   | 0,17 | -       | 0,09    |
| 90                             | 0,69                   | 0,59 | 0,20    | 0,38     | 200                            | 0,19                   | 0,16 | -       | 0,08    |
| 100                            | 0,60                   | 0,50 | 0,16    | 0,31     |                                |                        |      |         |         |



2.58 – rasm

**2.89 -misol.** Quyidagi ikkita 36 va 22 profilli shvellerlar birikmasidan tayyorlangan kolonnani sxemasi ko'rsatilgan birikmani ikkita uchlari ham sharnirli tayanchda..

Ustuvorlik va mustahkamlik shartlaridan foydalanib kolonnaga qo'yilishi mumkin bo'lgan siquvchi kuchni toping.

Material.St.3.  $[\sigma] = 160 \text{ MPa}$ ,

$$\ell = 9 \text{ m}; \quad \mu = 1$$

**echish:** Kesimdagi shvellerlarni tavsiflarini yozib olamiz. Kesimning o'lchamlarini masshtabda ifodalaymiz

Kolonnaning kesim yuzasini topamiz:

$$A = 2(53,4 + 26,7) = 160,2 \text{ cm}^2$$

Kesimning minimal inertsia momentini parallel o'qlarga nisbatan inertsia momenti formulasidan topamiz:

$$I_x = 2 \left[ 513 + \left( \frac{22}{2} + 2,68 \right)^2 \cdot 53,4 \right] + 2 \cdot 2110 = 25232,808 \text{ cm}^4$$

$$I_y = 2 \cdot 10820 + 2 \left[ 151 + (7 + 2,21)^2 \cdot 26,7 \right] = 26471,607 \text{ cm}^4$$

$$I_x = I_{\min} = 25232,808 \text{ cm}^4$$

Kesimning minimal inertsia radiusini topamiz

$$i_{\min} = \sqrt{\frac{I_{\min}}{A}} = \sqrt{\frac{25232,808}{160,2}} = 12,55 \text{ cm}$$

Kolonning egiluvchanligi:  $\lambda = \mu \frac{\ell}{i_{\min}} = 1 \cdot \frac{900}{12,55} = 71,713$

Jadvaldan foydalanib  $\varphi$  - ni qiymatini topamiz:

$$\lambda = 70; \quad \varphi' = 0,81$$

$$\lambda = 80; \quad \varphi'' = 0,75$$

$$\varphi = 0,81 - \frac{0,81 - 0,75}{10} \cdot 1,713 = 0,7997$$

Ruxsat etilgan siquvchi kuchni topamiz:

$$[F] = \varphi[\sigma] \cdot A = 0,7997 \cdot 1600 \cdot 160,2 = 206979 \text{ kN}$$

Kolonning kesimi to'rtta parchin mix o'rni bilan zaiflashtirilgan.

$$A_H = A - 4d(0,95 + 0,75) = 160,2 - 4 \cdot 2 \cdot 1,7 = 146,6 \text{ cm}^2$$

Kolonning mustahkamlik sharti  $\sigma_{\max} = \frac{F}{A_H} \leq [\sigma]$  dan ruxsat etilgan

siquvchi kuchni topamiz.  $F \leq [\sigma] \cdot A_H = 1600 \cdot 146,6 = 234560 \text{ kN}$

**2.90-misol.** Ikki tomoni sharnirli tayanchdagi sterjen, kesimining og'irlik markaziga quyilgan  $F$  kuch ta'sirida. Sterjenni materiali – St.3; uzunligi  $l = 4 \text{ m}$ ; kesimi -№ 30 – qushtavr. Ruxsat etilgan yuk hisoblansin.

**echish.** Ruxsat etilgan yukni topamiz  $[F] = \varphi[\sigma]_y A$ .

№30–qushtavr uchun:  $I_{\min} = I_y = 337 \text{ cm}^4$ ;  $i_{\min} = 2,69 \text{ cm}$ ;  $A = 46,5 \text{ cm}^2$

Sterjenni egiluvchanligi  $\lambda = \frac{\mu \cdot l}{i_{\min}} = \frac{1 \cdot 400}{2,69} = 148$

Interpolyatsiya usuli bilan  $\varphi = 0,36 - \frac{0,36 - 0,32}{10} 8 = 0,328$

Buerda:  $\lambda = 140$  da  $\varphi^1 = 0,36$  va  $\lambda = 150$  da  $\varphi'' = 0,32$

Unda  $[F] = 0,328 \cdot 160 \cdot 46,5 \cdot 10^2 = 244 \text{ kN}$

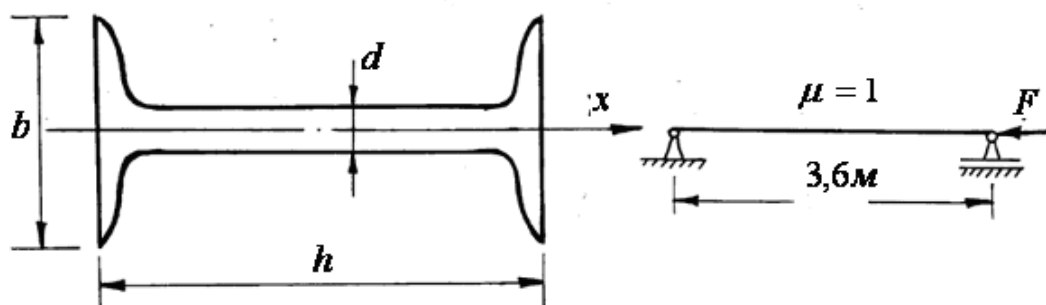
Egiluvchanlik  $\lambda > 100$ , shuning kritik kuchni Eyler formulasidan topamiz:

$$F_{kp} = \frac{\pi^2 EI_{\min}}{(\mu \cdot l)^2} = \frac{(3,14)^2 2 \cdot 10^2 \cdot 337 \cdot 10^4}{(1 \cdot 4000)^2} = 418 \text{ kN}$$

Ustuvorlikka ehtiyotlik koeffitsienti:  $n_y = \frac{F_{kp}}{[F]} = \frac{418}{244} = 1,71$

**misol.-2.91.** Po'latdan tayyorlangan sterjen  $F = 28 \text{ t}$  kuch bilan siqilayapti. Sterjenning uzunligi  $\ell = 3,6 \text{ m}$  va ikkita sharnirli tayanchga tayanadi. Sterjenning ustuvorlik shartidan foydalanib kesimi tanlansin. Ruksat etilgan kuchlanish

$$[\sigma] = 1600 \frac{\text{kgf}}{\text{cm}^2}$$



rasm -2.59

echish: 1 hisoblash sterjenning hisoblangan kesim yuzasini topamiz:

$$A = \frac{F}{\varphi[\sigma]} = \frac{28000}{\varphi \cdot 1600} = \frac{17,5}{\varphi}; \quad \varphi = 0,5; \quad A = \frac{17,5}{0,5} = 35 \text{ cm}^2. \text{ Kesim yuzasi}$$

$A = 35 \text{ cm}^2$  bo'lgan qo'shtavrni katalogdan tanlaymiz.

Qo'shtavr 24:  $A = 34,8 \text{ cm}^2$  va  $I_y = 198 \text{ cm}^4$

Kesimning minimal inertsia radiusi:  $i_{\min} = \sqrt{\frac{I_{\min}}{A}} = \sqrt{\frac{198}{34,8}} = 2,385 \text{ cm}$

Sterjenning egiluvchanligi:  $\lambda = \mu \frac{\ell}{i_{\min}} = 1 \cdot \frac{360}{2,385} = 150,94$

Jadvaldan st.3 material uchun  $\varphi$  - ni qiymatini topamiz:

$$\lambda = 150; \quad \varphi' = 0,32$$

$$\lambda = 160; \quad \varphi'' = 0,29$$

Interpolyatsiya usuli bilan  $\varphi_1 = 0,32 - \frac{0,32 - 0,29}{10} \cdot 0,94 = 0,317$

va  $\varphi_2 = \frac{\varphi + \varphi_1}{2} = \frac{0,5 + 0,317}{2} = 0,4085$  - ni topdik  $\varphi > \varphi_2$

II - hisoblash.  $A = \frac{17,5}{0,4085} = 42,84 \text{ cm}^2$ .

Kesim yuza 27 a qo'shtavrni kesim yuzasiga yaqin:

$$A = 43,2 \text{ cm}^2; \quad I_y = I_{\min} = 337 \text{ cm}^4.$$

$$\text{Sterjenning egiluvchanligi} \quad \lambda = \frac{360}{\sqrt{\frac{337}{43,2}}} = \frac{360}{2,793} = 128,89$$

$$\begin{aligned} \text{Jadvaldan} \quad \lambda = 120; \quad \varphi' &= 0,45 \\ \lambda = 130; \quad \varphi'' &= 0,4 \end{aligned}$$

$$\text{Unda } \varphi_3 = 0,45 - \frac{0,45 - 0,4}{10} \cdot 8,89 = 0,406.$$

$$\text{Haqiqiy kuchlanishni topamiz: } \sigma_x = \frac{28000}{43,2} = 648,15 \frac{\text{kg}}{\text{cm}^2}.$$

Ruxsat etilgan kuchlanish:

$$[\sigma]_y = \varphi_3 \cdot [\sigma] = 0,406 \cdot 1600 = 649,6 \frac{\text{kg}}{\text{cm}^2}; \quad \sigma_x < [\sigma]_y$$

Shuning uchun 27 a qo'shtavrli kesimni tanlaymiz. Sterjenning egiluvchanligi 100. Kritik kuchni Eyler formulasi yordamida topamiz:

$$F_{kp} = \frac{\pi^2 EI_{\min}}{\ell^2} = \frac{(3,14)^2 \cdot 2 \cdot 10^6 \cdot 337}{(360)^2} \approx 52006 \text{ kg}$$

$$\text{Koeffitsient:} \quad K_y = \frac{F_k}{F} = \frac{52006}{28000} \approx 1,86$$

## DINAMIK VA O'ZGARUVCHAN KUCHLANISHLAR

Tekis tezlanishli harakatda dinamik kuchlanish  $\sigma_g = K_g \cdot \sigma_{cm}$

$$\text{Dinamik koeffitsient} \quad K_g = 1 + \frac{a}{g} \quad (2.30)$$

$$\text{Statik kuchlanish} \quad \sigma_{cm} = \frac{Q + \gamma Ax}{A} \quad (2.31)$$

$$\text{Aylanuvchan halqasimon elementda kuchlanish} \quad \sigma_g = \frac{\gamma \omega^2 D^2}{4g}$$

$$\text{Zarb ta'sirida kuchlanish} \quad \sigma_d = \sigma_c \left[ 1 + \sqrt{1 + \frac{2h}{\delta_c}} \right] \quad (2.32)$$

$$\text{Zarb ta'sirida deformatsiya} \quad \delta_g = \delta_c \left[ 1 + \sqrt{1 + \frac{2h}{\delta_c}} \right] \quad (2.33)$$



$$\text{Zarb ta'siri} \quad F_d = Q \left[ 1 + \sqrt{1 + \frac{2h}{\delta_c}} \right] \quad (2.34)$$

$$\text{Dinamik koeffitsient} \quad K_g = \left[ 1 + \sqrt{1 + \frac{2h}{\delta_c}} \right] \quad (2.35)$$

### **Yzgaruvchan kuchlanishlarda mustahkamlik sharti**

Yzgarimas yukda kuchlanishni ruxsat etilgan qiymati quyidagicha topiladi:

$$\text{Plastik material uchun:} \quad [\sigma_{+1}] = \frac{\sigma_{OK}}{K_{01}} \quad (2.36)$$

$$\text{Mo'rt material uchun:} \quad [\sigma_{+1}] = \frac{\sigma_{\beta}}{K_{02} \cdot \alpha_{kg}} \quad (2.37)$$

bu erda:  $K_{01}$  - oquvchanlik chegaraga nisbatan mustahkamlikka ehtiyotlik koeffitsienti.

$K_{02}$  - mustahkamlik chegaraga nisbatan mustahkamlikka ehtiyotlik koeffitsienti.

$\alpha_{kg}$  - kuchlanishlar konsentratsiyasining haqiqiy koeffitsienti.

Simmetrik tsiklda chidamlilik chegarasida ( $\sigma_{-1}$ ) xavfli kuchlanish bo'ladi:

$$\text{Mo'rt material uchun:} \quad [\sigma_{-1}] = \frac{\sigma_{-1}}{K_0 \cdot \alpha_{kg} \cdot \alpha_H} \quad (2.38)$$

$$\text{Plastik material:} \quad [\sigma_{-1}] = \frac{\sigma_{-1}}{K_0 \cdot \alpha_{kg} \cdot \alpha_M \cdot K_T \cdot K_3 \cdot K_g} \quad (2.39)$$

bu erda:  $K_0$  - asosiy mustahkamlikka ehtiyotlik koeffitsienti

$K_T$  - detalni tayyorlashning texnologiyasini kuchlanishga ta'siri;

$K_3$  - detalni ekspluatatsiya qilish sharoitining kuchlanishga ta'siri;

$K_g$  - o'zgaruvchan kuchlanishning zarb ta'siri bilan birgalikdagi ta'sirini hisobga oluvchi dinamik koeffitsient.

Val statik mustahkamlikka ruxsat etilgan kuchlanish bo'yicha hisoblanadi:

$$\sigma_{\max} = \frac{M_{\max}}{M_{HOM}} \sqrt{\sigma_u^2 + 3\tau_K^2} \leq \frac{\sigma_t}{n_t} \quad (2.40)$$

$$\text{Toliqishga ruxsat etilgan kuchlanish} \quad \sigma = \sqrt{\sigma_u^2 + 3\tau_K^2} \leq [\sigma_{-1}]$$

Mustahkamlikka ehtiyotlik tekshiriladi:

$$n_{\sigma} = \frac{\sigma_{-1}}{K_{\sigma} \cdot \sigma_a + \psi_{\sigma} \cdot \sigma_m}; \quad n_{\tau} = \frac{\tau_{-1}}{K_{\tau} \cdot \tau_a + \psi_{\tau} \cdot \tau_m}; \quad (2.41)$$

Bu erda:  $\sigma_{-1}$  va  $\tau_{-1}$  – egilish va buralishda chidamlilik chegara;

$\psi_{\sigma}$  va  $\psi_{\tau}$  – materialni kuchlanishlarga sezgirligini hisobga oluvchi koefitsientlar  $\psi_{\sigma} = \frac{2 \cdot \sigma_{-1} - \sigma_o}{\sigma_o}$  va  $\psi_{\tau} = \frac{2 \cdot \tau_{-1} - \tau_o}{\tau_o}$

$\sigma_o$  va  $\tau_o$  – materialni tsikl takrorlanmaydigan vaqtdagi chidamlilik chegaralari.

$$\text{Umumiy chidamlilik koefitsienti } n = \frac{n_{\sigma} \cdot n_{\tau}}{\sqrt{n_{\sigma}^2 + n_{\tau}^2}} \leq [n_{-1}] \quad (2.42)$$

$[n_{-1}]$  – chidamlilikga ruxsat etilgan ehtiyotlik koefitsienti

**Valning xafli kesimidagi kuchlanishni aniqlash.** Normal kuchlanish simmetrik tsiklda o'zgaradi, bunda kuchlanish amplitudasi egilishdagi

$$\text{kuchlanishga teng bo'ladi: } \sigma_a = \sigma_n = \frac{M \cdot 10^3}{W_{HETTO}} \quad (2.43)$$

Urinma kuchlanish pulsatsiyali tsiklda o'zgaradi, kuchlanish buralishdagi kuchlanishning yarmiga teng bo'ladi:

$$\tau_a = \frac{\tau_{\delta}}{2} = \frac{M_{\delta}}{2 \cdot W_{HETTO}} \quad (2.44)$$

$$\text{Ekvivalent kuchlanish } \sigma_{\text{ЭК}} = \sqrt{\sigma_a^2 + 3\tau_a^2} \leq [\sigma] \quad (2.45)$$

Vallarni hisoblashda qo'llaniladigan ruxsat etilgan kuchlanishlar:

- toliqish chegaralari  $\sigma_{-1} \approx (0,4...0,5)\sigma_{\epsilon}$ ;  $\tau_{-1} \approx (0,2...0,3)\sigma_{\epsilon}$ ;

$$\tau_u \approx (0,55...0,65)\sigma_{\epsilon}$$

- ruxsat etilgan kontakt kuchlanishlar:

$$\text{po'lot g'ildirak uchun } [\sigma_K] = 2,6HB \frac{H}{MM^2};$$

$$\text{qora cho'yon } [\sigma_K] = 1,5HB \frac{H}{MM^2};$$

po'lot va cho'yon g'ildirak bilan ilashadigan plastmassa g'ildirak

$$[\sigma_K] = 45...57 \frac{H}{MM^2} \text{ (tekstolit)}$$

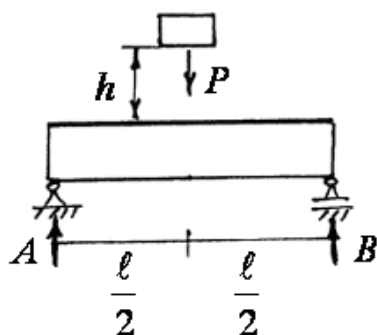
Egilish bilan buralishning birgalikdagi statik yuk ta'sirida mustahkamlik sharti:

$$\frac{\sigma^2}{[\sigma]^2} + \frac{\tau^2}{[\tau]^2} \leq 1$$

va o'zgaruvchan yuk ta'sirida:

$$\sigma = \sigma_a + \sigma_{yp} \quad \text{va} \quad \tau = \tau_{yp} + \tau_a \quad \text{yoki} \quad [\sigma] = [\sigma_r^{\sigma}] \quad \text{va} \quad [\tau] = [\tau_r^{\tau}]$$

**2.92-misol.** Ikki tayanchli qo'shtavrli balkaga  $h = 20 \text{ sm}$  balandlikdan  $R=1500 \text{ N}$  yuk kelib tushadi (2.60 – rasm) Balkaning eng katta dinamik normal kuchlanishini topamiz. Y'ng tayanch o'rnini elastik prujina bilan almashtirib birinchi savolga javob beramiz.



2.60 – rasm

Berilgan: qo'shtavr  $N - 22$

$$\ell = 2M; \quad 10^3 \alpha = 30 \frac{M}{\kappa H}; \quad \alpha = \frac{30}{10^3};$$

$$E = 2 \cdot 10^8 \frac{\kappa H}{M^2}; \quad I_x = 2550 \cdot 10^{-2} M^4$$

$$W_x = 232 \cdot 10^{-6} M^3$$

**echish.** Balkaning xususiy og'irligini hisobga olmaymiz.  $R$  yuk ta'siridan  $A$  va  $B$  tayanchlaridagi reaksiya kuchlari

$$A = B = \frac{P}{2} = 750H \text{ bo'ladi. Eng katta dinamik}$$

kuchlanishi quyidagi formula bilan topiladi:  $\sigma_g = k_g \cdot \sigma_{cm}$ , bu erda

$K_g = 1 + \sqrt{1 + \frac{2h}{\Delta_{cm}}}$  dinamik koeffitsient bo'lib, statik ko'chish  $\Delta_{cm}$  - ga bog'liq

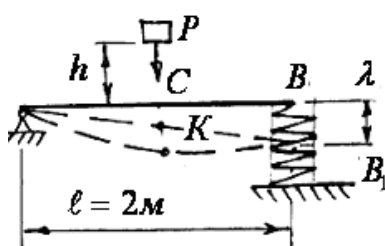
$\Delta_{cm} = f_{cm} = \frac{P\ell^3}{48EI_x}$  balkaning  $R$  yuk statik ta'sir qilgandagi to'liq ko'chishi.

$\sigma_{cm} = \frac{M_{cm}}{W_x} = \frac{P\ell}{4W_x}$  statik yuk  $R$  ta'siridagi eng katta normal kuchlanish

$$\text{Dinamik kuchlanish } \sigma_d = \left[ 1 + \sqrt{1 + \frac{2h \cdot 48EI_x}{P\ell^3}} \right] \cdot \frac{P\ell}{4W_x} \quad \sigma_d = 0,295 \cdot 10^6 \frac{\kappa H}{M^2}$$

Endi, balkaning o'ng tayanchini prujina bilan almashtiramiz. Dinamik kuchlanish  $\sigma_g = \kappa_g \cdot \sigma_{cm}$  formula bilan topiladi. Dinamik koeffitsient  $K_d$  ni aniqlashda. Balkaning statik ko'chishi prujinaning o'ng tayanch kuchining deformatsiyasiga bog'liq bo'ladi ( 2.61 - rasm ).  $\Delta_{cm} = \Delta_\delta + \beta\lambda$  bu erda

$$\Delta_\delta = f_{cm} = \frac{P\ell^3}{48EI_x}$$



2.61 – rasm

$$\lambda = \frac{P}{2} \cdot \alpha = \frac{P}{2} \cdot \frac{30}{10^3} = \frac{1,1 \cdot 30}{2 \cdot 10^3} = 0,0165 M$$

Prujinaning  $B$  reaksiya kuchi ta'siridan ko'chishi.  $\beta$  - prujinaning deformatsiyasi bilan balkaning  $R$  yuk ta'siridagi to'liq ko'chishi orasidagi bog'lanish.

$$\Delta_{BB_1} A \propto \Delta_{CK} A \text{ dan } CK = \frac{BB_1}{2} = \frac{\lambda}{2} = \beta\lambda$$

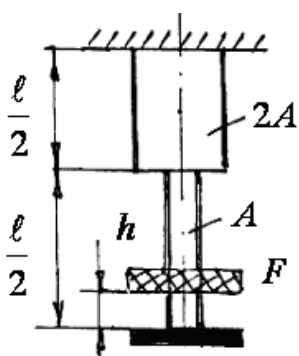
$$f_{cm} = \frac{P\ell^3}{48EI_x} = \frac{1,5 \cdot 8}{48 \cdot 2 \cdot 10^8 \cdot 2550 \cdot 10^{-8}} = 4,9 \cdot 10^{-5} \text{ m}$$

hosil bo'ladi. Demak,  $\beta = 0,5$ .

$$\text{Natijada } \Delta_{cm} = 4,9 \cdot 10^{-5} + 0,5 \cdot 0,0165 = 8,299 \cdot 10^{-3} \text{ m}.$$

$$\text{Dinamik koeffitsient } \kappa_g = 1 + \sqrt{1 + \frac{2 \cdot 0,2}{8,299 \cdot 10^{-3}}} \approx 8 \quad \text{va kuchlanish}$$

$$\sigma_g = \kappa_g \frac{P\ell}{4W_x} = 8 \cdot \frac{1,5 \cdot 2}{4 \cdot 232 \cdot 10^{-6}} = 0,0258 \cdot 10^6 \frac{\kappa H}{\text{m}^2}$$



2.62 – rasm

**2.93-misol.** Pog'onali brusning  $K$  nuqtasi  $h = 5 \text{ mm}$  balandlikdan tushayotgan  $Q = 400 \text{ kg}$  yuk ta'sirida zarbga uchraydi. Brusning uzunligi  $l = 5 \text{ m}$  ko'ndalang kesim yuzasi  $A = 2 \text{ m}^2$ , materiali po'lat. Eng katta normal kuchlanish topilsin. Agar  $K$  elementga zarb ta'sirini yumshatuvchi tsilindrik prujina o'rnatilsa, kuchlanishni toping.  $1 \text{ kg}$  statik yuk ta'sirida prujina  $4 \cdot 10^{-3} \text{ mm}$  siqiladi.

**echish:** Pog'onali brusning statik kuch

ta'siridagi uzayishini va normal

kuchlanishini topamiz:

$$\text{statik uzayish} \quad \delta_{cn} = \Delta \ell_{cn} = \frac{F \frac{\ell}{2}}{EA} + \frac{F \frac{\ell}{2}}{E2F} = \frac{3F\ell}{4EA}$$

va kuchlanish

$$\sigma_{cm} = \frac{F}{A} = \frac{400}{2} = 200 \frac{\kappa \mathcal{Z}}{\text{cm}^2}$$

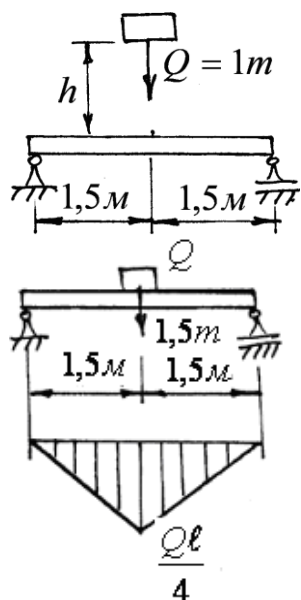
Eng katta dinamik kuchlanishni topamiz

$$\sigma_g = \sigma_{cm} \kappa_g = \sigma_{cm} \left( 1 + \sqrt{1 + \frac{2h}{\Delta \ell_{cm}}} \right) = 200 \left( 1 + \sqrt{1 + \frac{2 \cdot 0,06 \cdot 16 \cdot 10^6}{3 \cdot 400 \cdot 500}} \right) = 1349 \frac{\kappa \mathcal{Z}}{\text{cm}^2}$$

elementga tsilindrik prujina o'rnatilganda,  $\delta_{cm}$  statik deformatsiya pog'onali brusni va prujinani siqilishiga teng bo'ladi, ya'ni

$$\delta_{cm} = \Delta \ell_{cm} + \lambda_{cm} = \frac{3F\ell}{4EA} + F \cdot 4 \cdot 10^{-4} = \frac{3 \cdot 400 \cdot 500}{4 \cdot 2 \cdot 10^6 \cdot 2} + 400 \cdot 4 \cdot 10^{-4} = 0,1975 \text{ cm}$$

$$\text{Unda dinamik kuchlanish: } \sigma_g = 200 \left( 1 + \sqrt{1 + \frac{2 \cdot 0,6}{0,1975}} \right) = 732 \frac{\kappa \mathcal{Z}}{\text{cm}^2}$$



2.63 - rasm

**2.94-misol.** N 24 profilli balka ikkita sharnirli tayanchga tayanadi. Yuk balkaning o'rta qismiga 50 sm/sek tezlik bilan kelib zarb ta'sir qiladi. Eng katta kuchlanishni toping.

**echish:** N-24 qo'shtavrli kesimning ayrim geometrik tavsiflarini yozib olamiz.

$$I_x = 3460 \text{ cm}^4; W_x = 289 \text{ cm}^3; A = 34,8 \text{ cm}^2$$

Ctatik kuchlanishni topamiz:

$$\sigma_{cm} = \frac{M}{W_x} = \frac{Ql}{4W} = \frac{1000 \cdot 300}{4 \cdot 289} = 259,5 \frac{\text{kg}}{\text{cm}^2}$$

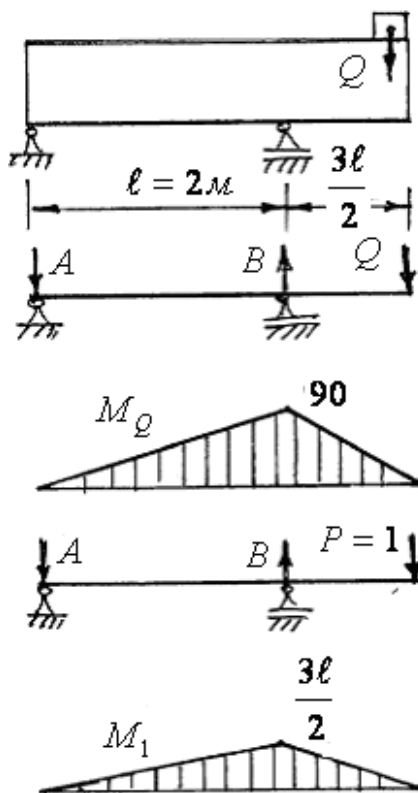
eng katta salqiligini topamiz:

$$f_{cm} = \frac{Ql^3}{48EI} = \frac{1000 \cdot (300)^3}{48 \cdot 2 \cdot 10^6 \cdot 3460} = 0,0813 \text{ cm}$$

Dinamik kuchlanish:

$$\sigma_g = \sigma_{cm} \left( 1 + \sqrt{1 + \frac{V^2}{gf_{cm}}} \right) = 259,5 \left( 1 + \sqrt{1 + \frac{50^2}{981 \cdot 0,0813}} \right) = 1735,4 \frac{\text{kg}}{\text{cm}^2}$$

Dinamik deformatsiya  $f_g = f_{cm} K_g = 0,0813 \cdot 6,69 = 0,544 \text{ cm}$



rasm -2.64

**misol.-2.95.** Bir minutda  $n$  marotaba aylanma harakat qilayotgan, og'irligi  $Q$  bo'lgan dvigatel ikkita qo'shtavrli balkaga o'rnatilgan. Dvigatelning aylanma harakat qilayotgan qismlarini markazdan qochma kuchi  $H = 10 \text{ kH}$ ;  $Q = 30 \text{ kH}$

- 1) erkin tebranish chastotasi –  $\omega_0$
- 2) uyg'otuvchi kuch o'zgarishining chastotasi –  $\omega$
- 3) tebranishning o'sish koeffitsienti –  $\beta$
- 4) dinamik koeffitsient  $K$  va
- 5) eng katta kuchlanish qiymatlari topilsin

Berilgan qo'shtavr N-40

$$n = 200 \frac{\text{ob}}{\text{min}}; I_x = 19062 \cdot 10^{-8} \text{ m}^4,$$

$$E = 2 \cdot 10^8 \frac{\text{kH}}{\text{m}^2}; W_x = 953 \cdot 10^{-6} \text{ m}^3$$

**echish:** Berilgan sxemadan asosiy sxemani tanlab olamiz. Buning uchun  $Q$  yukni o'rniga  $P = 1$  birlik kuchini joylashtiramiz.  $Q$  yuk ta'siridan hosil

bo'lgan eguvchi moment epyurasini quramiz:

$$\sum M_B = Q \frac{3\ell}{2} - A\ell = 0; \quad A = \frac{3Q}{2} = 45\kappa H$$

$$\sum M_A = -B\ell + Q\left(\frac{3\ell}{2} + \ell\right) = 0 \quad B = \frac{5}{2}Q = 75\kappa H$$

b) eguvchi moment  $M_Q$  – ni topamiz  $0 < x_1 < 2\mathcal{M} \quad M_Q = -A \cdot x_1$

$$0 < x_2 < \frac{3\ell}{2} = 3\mathcal{M} \quad M_Q = -Q \cdot x_2$$

Birlik kuch  $R = 1$  ta'siridan hosil bo'lgan eguvchi moment  $M_r$  epyurasini quramiz (*rasm -2.64*)

a) reaksiya kuchini topamiz

$$\sum M_B = P \frac{3\ell}{2} - A\ell = 0 \quad \text{yoki} \quad A = \frac{3}{2}P = 1,5\kappa H \quad \text{va}$$

$$\sum M_A = P \frac{5\ell}{2} - B\ell = 0 \quad \text{yoki} \quad B = \frac{5}{2}P = 2,5\kappa H$$

b) eguvchi moment  $M_p$  - ni topamiz  $0 \leq x_1 \leq \ell \quad M_p = -A \cdot x_1$

$$0 \leq x_1 \leq \frac{3\ell}{2} \quad M_p = -P \cdot x_1$$

$Q$  yuk o'rnatilgan nuqtaning ko'chishini topamiz

$$\Delta = \frac{\omega \cdot M_p^0}{EI} = \frac{\frac{1}{2} \cdot 90 \left( \ell + \frac{3\ell}{2} \right) \frac{3\ell}{2}}{EI} = \frac{1350\ell^2}{8EI} = \frac{1340 \cdot 4}{8 \cdot 2 \cdot 10^8 \cdot 19062 \cdot 16^{-8}} = 0,0177\mathcal{M}$$

$\omega$  - tashqi kuch  $Q$ dan qurilgan eguvchi moment  $M_q$  – ning yuzasi

$M_p^0$  – tashqi kuch  $Q$  ta'siridan qurilgan eguvchi moment  $M_p$  epyurasi yuzasining og'irlik markaziga to'g'ri keluvchi birlik kuch momenti  $M_p$  epyurasining ordinatasi.

Erkin tebranish chastotasini topamiz:

$$\omega_0 = \sqrt{\frac{g}{\Delta}} = \sqrt{\frac{9,81}{0,0177}} = 23,54 \frac{1}{cek}$$

Uyg'otuvchi kuch o'zgarishining chastotasi

$$\omega = 2\pi \frac{n}{60} = \frac{\pi \cdot n}{30} = \frac{3,14 \cdot 200}{30} = 20,9 \frac{1}{cek}$$

Tebranishning o'sish koeffitsienti

$$\beta = \frac{1}{1 - \left( \frac{\omega}{\omega_0} \right)^2} = \frac{1}{1 - \left( \frac{20,9}{23,54} \right)^2} = 4,717$$

$\beta$  – qiymati manfiy ishora bilan chiqsa, keyingi hisoblashlarda  $|\beta|$  olinishi kerak.

Dinamik koeffitsientni topamiz:

$$K_g = 1 + \frac{f_H}{f_a} \beta = 1 + \frac{H}{Q} |\beta| = 1 + \frac{10}{30} 4,717 = 2,57$$

Eng katta normal kuchlanishni topamiz:

$$\sigma_g = K_g \sigma_{CT} = K_g \cdot \frac{M}{W_x} = 2,67 \frac{9}{953 \cdot 10^{-6}} = 0,2427 \cdot 10^6 \frac{\kappa H}{m^2}$$

**misol.-2.96** Mustahkamlik chegarasi  $\sigma_B = 600 \text{ MPa}$ ; oquvchanlik chegarasi  $\sigma_T = 300 \text{ MPa}$ ; po'latdan tayyorlangan, diametri  $d = 50 \text{ mm}$  bo'lgan valni xavfli kesimda  $M_\delta = 320 \text{ Hm}$  burovchi va  $M_g = 320 \text{ Hm}$  eguvchi momentlar ta'sir qiladi. Egilishdagi normal kuchlanishning simmetrik tsikldagi: buralishdagi urinma kuchlanishning tepkili (pulsiruyuvchi) tsikldagi kuchlanishga teng deb qaralib, xavfli kesim uchun extiyotlik koeffitsienti topilsin.

**echish.** Eng katta normal kuchlanish:

$$\sigma_{\max} = \frac{M_g}{W} = \frac{32 M_g}{\pi d^3} = 0,026 \cdot 10^3 \frac{H}{mm^2}$$

Eng katta urinma kuchlanish :

$$\tau_{\max} = \frac{M_\delta}{W} = \frac{16 \cdot M_\delta}{\pi d^3} = 0,013 \cdot 10^3 \frac{H}{mm^2}$$

Buralishda oquvchanlik chegarasi:

$$\tau_{-1} = 0,25 \sigma_T = 0,25 \cdot 300 = 75 \text{ MPa}$$

Chidamlilik (bardosh berish) chegarasi:

$$\text{Buralishda} \quad \sigma_{-1} = 0,25 \sigma_b = 0,25 \cdot 600 = 150 \text{ MPa}$$

$$\text{Egilishda} \quad \sigma_{-1} = 0,43 \sigma_b = 0,43 \cdot 600 = 258 \text{ MPa}$$

Kuchlanishlar kontsentratsiyasi

$$K = 1,2 + 0,2 \frac{\sigma_b - 40}{110} = 1,2 + 0,2 \frac{600 - 40}{110} = 2,2$$

Masshtab koeffitsienti

$$\beta_m = 1,2 + 0,1(d - 3) = 1,2 + 0,1(5 - 0,3) = 1,67$$

$\sigma$  va  $\tau$  bo'yicha extiyotlik koeffitsienti

$$n_\tau = \frac{\tau_{\max}}{2} = \frac{13}{2} = 6,5$$

$$n_\sigma = \frac{\sigma_{-1}}{\sigma_{\max}} = \frac{\sigma_{-1}}{k \beta_m \cdot \sigma_{\max}} = \frac{250}{2,2 \cdot 1,67 \cdot 26} = 2,$$

Charchashdan emirilishdagi va oquvchanlikning boshlanishidagi umumiy extiyotlik koeffitsientlarini topamiz:

$$n_{\tau_0} = \frac{\tau_{-1}}{k \cdot n_\tau + \beta_m n_\tau} = \frac{75}{2,2 \cdot 6,5 + 1,67 \cdot 6,5} = 2,9$$

$$k_{TM} = \beta_m \cdot \kappa = 1,67 \cdot 2,2 = 3,674$$

buralishdagi oquvchanlikka extiyotlik koeffitsienti

$$n_{\tau}' = \frac{\tau_T}{\tau_{\max}} = \frac{75}{13} = 5,77$$

Mustahkamlikning umumiy extiyotlik koeffitsienti

$$n = \frac{n_{\sigma} \cdot n_{\tau}'}{\sqrt{n_{\sigma}^2 + (n_{\tau}')^2}} = \frac{2,7 \cdot 5,77}{\sqrt{(2,7)^2 + (5,77)^2}} = 2,99$$

Charchashdan emirilishga extiyotlik koeffitsienti

$$n = \frac{n_{\sigma} \cdot k_{TM}}{\sqrt{n_{\sigma}^2 + K_{TM}^2}} = \frac{2,7 \cdot 3,674}{\sqrt{(2,7)^2 + (3,674)^2}} = 2,17$$



### III-BOB. MEXANIZM VA MASHINALAR NAZARIYASI

Mexanizm va mashinalar nazariyasi mexanizmlarni tuzilishi, kinematikasi va dinamikasini analiz va sintez etish bilan shug'ullanadi.

**Analiz** - berilgan mexanizmlarning tuzilishi, kinematikasi va dinamikasini tekshirish

**Sintez** - berilgan kinematik va dinamik parametrlar bo'yicha yangi mexanizmlarni loyihalash

Mexanizmlar analizidan, asosan texnologik maqsadlar uchun foydalaniladi, mutaxassis texnologlar uchun mexanizmning ayrim nuqtalari harakat qonunini bilish kifoya. Mutaxassis mashinasozlar uchun sintez muammosi muhim ahamiyatga ega.

Mashinalashtirilgan ishlab chiqarish va ulardan unumli foydalanish uchun mexanizmlarning kinematik sxemasini tuzish, uning tarkibidagi ayrim bo'g'inlarning harakat qonunlarini bilish va undan foydalana olish ikkala mutaxassisga ham taalluqli

Mexanizmning vazifasi ma'lum tartibda harakat qilish yoki harakatni uzatishdan iborat Mexanizmning vazifasi ma'lum tartibda harakat qilish yoki harakatni uzatishdan iborat

Mexanizmdagi ayrim nuqtalarning yurgan yo'li, tezligi, tezlanishi, mexanizm tarkibidagi ayrim bo'g'inlarning burchak tezliklari, burchak tezlanishlari va ularning inertsia kuchlari, inertsia kuchining momentlari va h.k.lar mexanizmdagi mavjud jarayonning harakatini bildiradi.

**Mexanizmlarning tuzilishi.** Mexanizm- etaklovchi va etaklanuvchi bo'g'inlar hamda kinematik juftlardan tashkil topadi.

Bir yoki bir nechta detallarning qo'zg'almas birikmasi bo'g'in deyiladi.

Qo'zg'almas bo'g'in tayanch deb ataladi. Harakati berilgan bo'g'in etaklovchi, qolganlari etaklanuvchi. Harakatlanuvchan bo'g'inlar aylanma, ilgarilanma va murakkab harakatlarni bajarishi mumkin. Mexanizmlar nazariyasini o'rganishda detallar va bo'g'inlarning konstruktiv shaklidan emas, balki ularning kinematik sxemalaridan foydalaniladi

Kinematik juft. Bir-biriga nisbatan harakat qiladigan ikki bo'g'inning birikmasi kinematik juft deyiladi

Quyi va oliy kinematik juftlar mavjud. Oliy kinematik juft - bo'g'in bo'g'in bilan nuqta yoki chiziq buyicha birikma hosil qiladi

Quyi kinematik juft - bo'g'in bo'g'inga sirlari buyicha tegishadi

**Mexanizmni strukturaviy tahlili** deb, mexanizmdagi bo'g'inlar va kinematik juftlarni aniqlash, kinematik juft klassi va mexanizm harakatchanlik darajasini topish, mexanizmning klassi va tartibini belgi-lashga aytiladi.

Strukturaviy sintez deb, mexanizmni strukturaviy loyihalashga aytiladi.

Mexanizm bo'g'inlarining fazoda qo'zg'ala olish xususiyati

harakatlanuvchanlik deb tushuniladi. Harakatchanlik bo'g'inining erkinlik darajasi bilan xarakterlanadi. Mexanizmning erkinlik darajasi mumkin bo'lgan harakatlar soniga qarab beriladi.

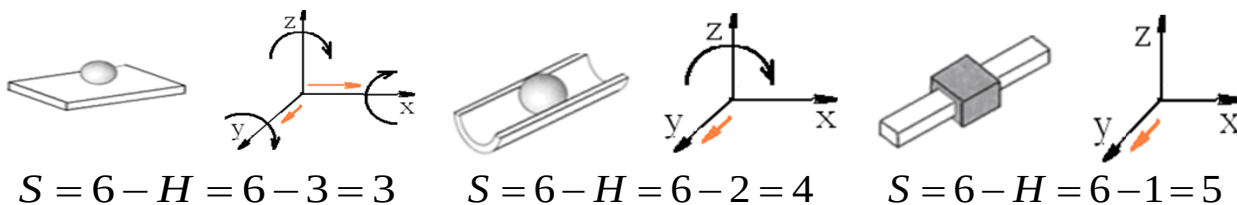
Bir-biriga bog'lanmagan harakatlar soni erkinlik daraja deb ataladi.

Kinematik juft erkinlik darajasi (N) bilan bog'lanishlar sonining (S) yig'indisi mumkin bo'lgan harakatlar soniga teng bo'lishi kerak

$$S + H = 6$$

Dobrovolskiy kinematik juftlar klassini bog'lanishlar soniga teng qilib olgan

$$S = 6 - H$$



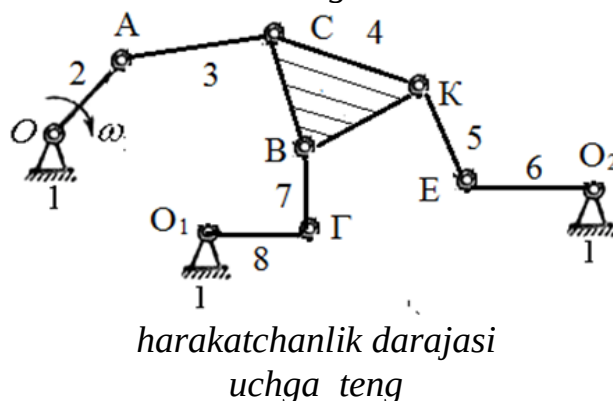
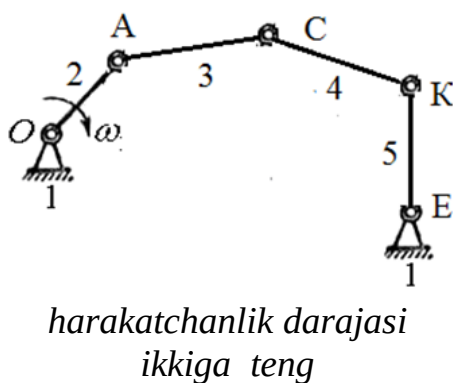
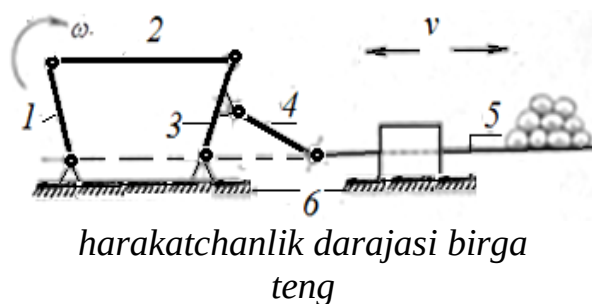
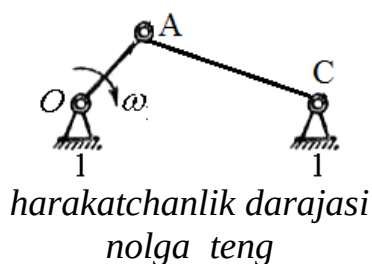
Mexanizmlarning tuzilish formulasini P.L.Chebishev tekis mexanizmlarning harakatchanlik darajasini aniqlovchi formula deb aytadi

$$W = 3n - 2P_K - P_0$$

bu erda:  $n$  - mexanizmdagi harakatlanuvchan bo'g'inlar soni,

$P_K$  - mexanizmdagi quyi kinematik juftlar soni,

$P_0$  - mexanizmdagi oliy kinematik juftlar soni



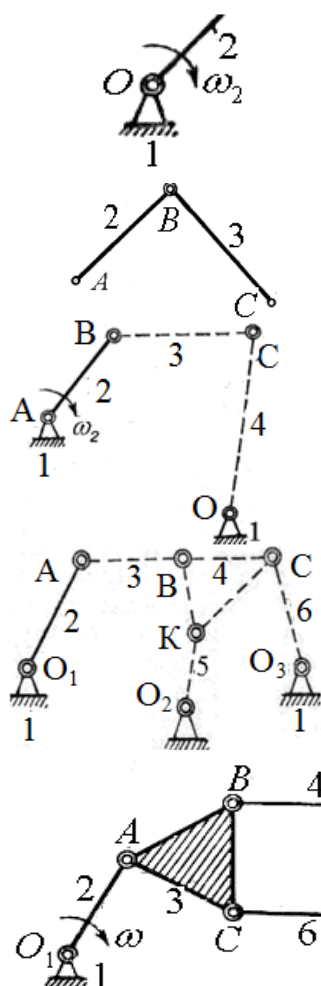
Mexanizmni harakatchanlik darajasi undagi etaklovchi bo'g'in sonini belgilaydi.

**Mexanizmlarni hosil qilishning L.V.Assur –Artobolevskiy printsipi:** Har qanday mexanizm etaklovchi bo'g'in bilan qo'zg'almas bo'g'inga harakatchanlik darajasi nolga teng bo'lgan kinematik zanjirlarni ketma-ket qo'sha borib hosil qilinadi.

Harakatchanlik darajasi nolga teng bo'lgan bo'g'inlar gruppasi Assur gruppasi deyiladi. Mexanizmni Assur gruppasiga ajratish– oxirgi ikkita harakatlanuvchan bo'g'in va uchta beshinchi klass quyi kinematik juftdan iborat bo'g'inlardan boshlanadi. Assur gruppasi strukturaviy gruppasi deyiladi.

Harakatchanlik darajasi nolga teng bo'lgan tekis kinematik zanjirlarning matematik ifodasi  $W = 3n - 2P_K - P_0 = 0$

### Tekislikda harakat qiluvchi mexanizmlar klassifikatsiyasi



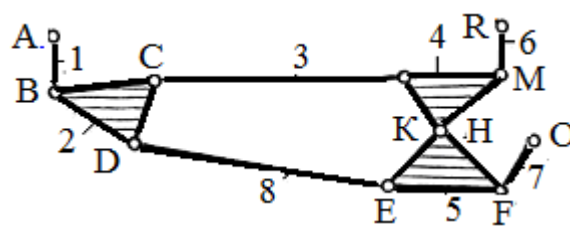
L.V.Assur qo'zg'almas bo'g'in bilan V klass kinematik juft hosil qiluvchi, ya'ni etaklovchi bo'g'in bilan qo'zg'almas bo'g'inni shartli ravishda 1 klass 1-tartibli mexanizm deb atadi

Tarkibiga ikkita bo'g'in va uchta V klass juftli ( $W=0$ ) II klass 2-tartibli gruppalar kirgan mexanizmlar II klass mexanizmlar deyiladi.

Bunday mexanizmlar I klass mexanizmlarga II klass 2-tartibli Assur gruppasini qo'shish bilan hosil qilinadi.

$$W = 3n - 2P_K - P_0 = 3 \cdot 3 - 2 \cdot 4 = 1$$

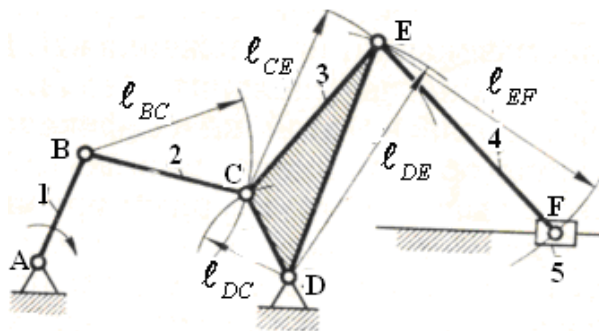
**III-klass.** Tarkibida 3 tomoni yopik va ochik konturli bo'lgan strukturaviy guruh. Guruhdagi asosiy bo'g'in o'zining uchta nuqtasi bilan kinematik juft hosil qiladi



**IV – klass.** Tarkibida 4 tomoni yopik konturli strukturaviy guruh.

**V – klass.** Tarkibida 5 tomoni yopik konturli bo'lgan strukturaviy guruh

III klassdan boshlab yuqori tartibli klassga mansub guruhlar uchun undagi bo'g'inlar soni guruh klassini belgilamaydi, balki klass turlarini belgilaydi. IV klassdan boshlab yuqori klasslarning hammasi guruh tarkibidagi yopik kontur tomonlarining soni guruh klassini belgilaydi lar soniga teng bo'ladi



**misol -3.1.** Tebranuvchi konveyer mexanizmini strukturaliy tahlil qiling?

**echish.** Mexanizm qo'zg'almas bo'g'in O nuqta atrofida aylanma harakat qiladigan bo'g'in 1- krivoship, qo'zg'almas bo'g'in O nuqta atrofida tebranma harakat

etadigan 3-bo'g'in ( koromislo - bazis), aylanma va tebranma harakatda qatnashadigan 2-bo'g'in ( shatun), tebranma va polzunni ilgarilanma-qaytma harakatda qatnashadigan 4-bo'g'in (shatun) va 5-polzundan tashkil topgan.

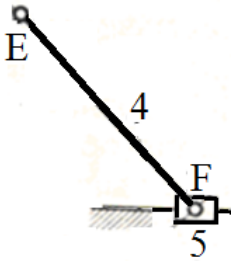
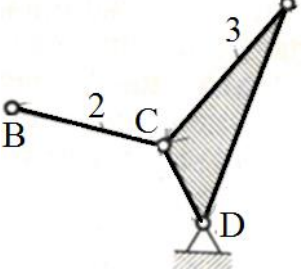
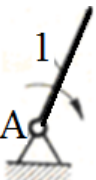
Qo'zg'almas bo'g'in bilan 1-bo'g'inning birikmasi 5-klass quyi kine-matik juft, 1 bo'g'in bilan 2 bo'g'inning birikmasi 5-klass quyi kinematik juft, 2 bo'g'in bilan bazisining birikmasi 5-klass quyi kinematik juft, qo'zg'almas bo'g'in bilan 3-bo'g'inning birikmasi 5-klass quyi kinematik juft, bazis bilan 4-bo'g'inning birikmasi 5-klass quyi kinematik juft, 4 bo'g'in bilan 5 bo'g'inning birikmasi 5-klass quyi kinematik juft. Barcha kinematik juftlar (A,V,D,C,E,F nuqtalar) 5 klassga mansub.

Mexanizmning harakatchanlik darajasi:

$$W = 3n - 2P_K - P_0 = 3 \cdot 5 - 2 \cdot 7 = 1$$

Mexanizmning harakatchanlik darajasi undagi etaklovchi bo'g'inlar sonini ifodalaydi. Ushbu mexanizmning harakatchanlik daraja-si birga teng, shuning uchun mexanizmga bitta etaklovchi bo'g'in bor.

Etaklovchi bo'g'inni aniqlash uchun mexanizmni Assur guruhlariga ajratamiz:

|                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>4-5 bo'g'inlar guruxi <math>n=2</math>, <math>P_K=3</math><br/> <math>W = 3 \cdot 2 - 2 \cdot 3 = 0</math><br/>         Assur guruxi</p> |  <p>2-3 bo'g'inlar guruxi <math>n=2</math>, <math>P_K=3</math><br/> <math>W = 3 \cdot 2 - 2 \cdot 3 = 0</math><br/>         Assur guruxi</p> |  <p><math>n=1</math>, <math>P_K=1</math><br/> <math>W = 3 \cdot 1 - 2 \cdot 1 = 1</math><br/>         qo'zg'almas bo'g'in va 1-bo'g'inning harakatchanlik darajasi mexanizmning harakatchanlik darajasiga teng, 1-bo'g'in etaklovchi. Mazkur bo'g'in mexanizm etaklanuvchi 2,3,4 va 5 bo'g'inlarini harakat bilan ta'minlaydi</p> |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

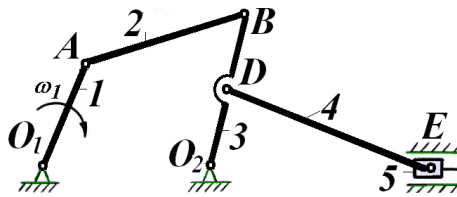
I klass mexanizmga (qo'zg'almas bo'g'in va 2 bo'g'in) II klass 2-tartibli Assur gruppasi qo'shiladi (2,3,4,5 bo'g'inlar), natijada II klass mexanizm hosil bo'ladi

misol-3.2. Mexanizmlarni strukturaviy tahlil qiling.

|   |  |    |  |
|---|--|----|--|
| 1 |  | 6  |  |
| 2 |  | 7  |  |
| 3 |  | 8  |  |
| 4 |  | 9  |  |
| 5 |  | 10 |  |

## Mexanizmning kinematik va vaziyatlar sxemasini chizish

Mexanizmning kinematik sxemasi deb, talab qilingan harakat qonuniyatni ta'minlaydigan ketma - ketlikda va ma'lum masshtabda joylashtirilgan bo'g'inlar birikmasining sxemasiga aytiladi.



rasm-3.1. 1.krivoship; 2 - shatun;  
3 - koromiso; 4 - shatun;  
5 - polzun

**misol-3.2.** Berilgan:

$$\ell_{o_1A} = 80 \text{ мм}; \ell_{o_2B} = 120 \text{ мм}$$

$$\ell_{AB} = 160 \text{ мм}; \ell_{o_1o_2} = 140 \text{ мм}$$

$$\ell_{o_2D} = 60 \text{ мм}; \ell_{DCC} = 180 \text{ мм}$$

$$\omega_1 = 100 \frac{\text{а\ул}}{\text{мин}}$$

Etakchi bo'g'inning vaziyati va unga bog'liq holda boshqa bo'g'inning vaziyatlari tasvirlangan mexanizmning sxemasi vaziyatlar plani deyiladi.

Mexanizm vaziyatining plani deb, tanlangan vaqtdagi bo'g'inlarning o'zaro bog'liq joylashuviga to'g'ri keluvchi grafik ifodalanishiga aytiladi.

Mexanizm bo'g'inlarining vaziyatini chizish uchun uzunlik masshta-bidan foydalanib, bo'g'inlarning chizmadagi uzunliklari aniqlanadi. Mexanizm va mashinalar nazariyasida berilgan o'lchamlarning qiymatlari 1 мм. kesma qanchaga tengligi bilan ifodalanadi. Uzunlik masshtabi koefitsienti quyidagi nisbatga ko'ra olinadi.

$$\mu_\ell = \frac{\ell}{(\ell)} = \frac{\text{хакикий улчам}}{\text{чизмадаги узунлик}} \left( \frac{\text{м}}{\text{мм}} \right)$$

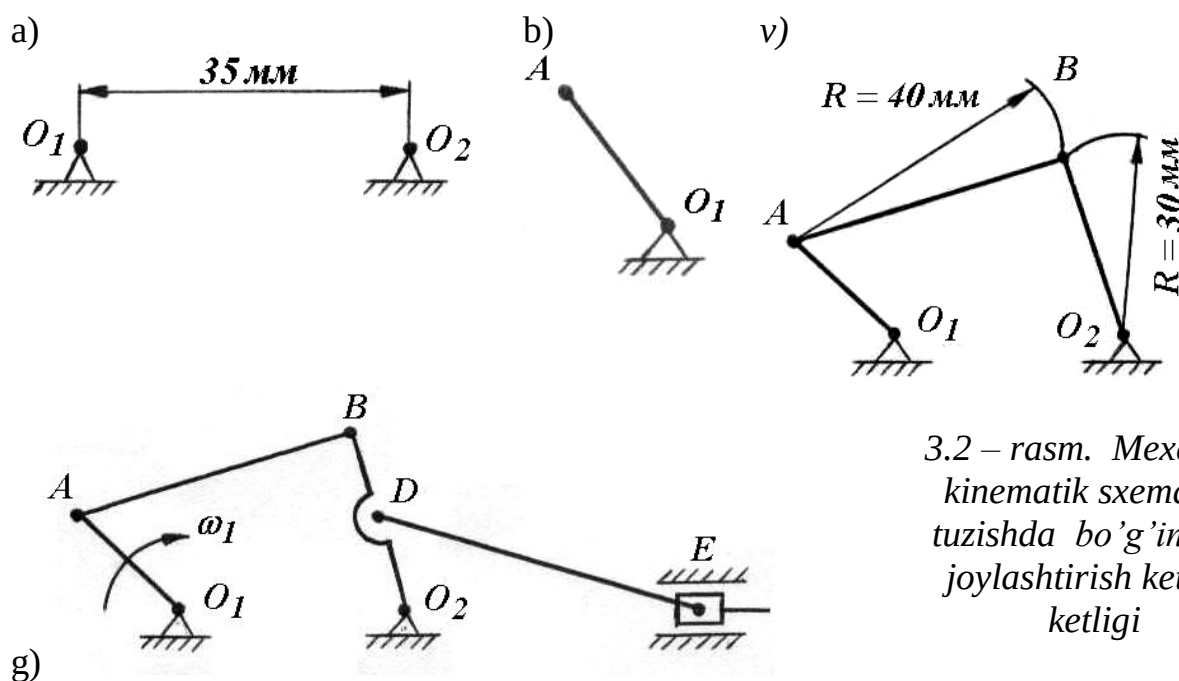
Bo'g'in nuqtalarining traektoriyasini chizishda har bir nuqtaning chizig'ini oldindan bilish kerak. Masalan, bir bo'g'in qo'zg'almas ustun atrofida aylanma harakat qilsa, uning istalgan nuqtasi ma'lum yoy yoki aylana traektoriya chizadi. Agar bo'g'in qo'zg'almas yo'naltiruvchi bo'ylab harakatlansa, uning traektoriyasi to'g'ri chiziqdan iborat bo'ladi.

1.Mexanizm bo'g'inlarining kinematik va vaziyatlar sxemasini chizish uchun uzunlik masshtabidan foydalanamiz (3.2 – rasm).

$$\mu_\ell = \frac{\ell_{AB}}{AB} = \frac{0,16}{40} = 0,004 \left( \frac{\text{м}}{\text{мм}} \right)$$

Mexanizm bo'g'inlarining o'lchamlari (mm):  $O_1O_2 = \frac{\ell_{o_1o_2}}{\mu_\ell}$

$$O_1O_2 = 35 \quad AB = 40 \quad O_1A = 20 \quad O_2B = 30 \quad O_2D = 15 \quad DE = 45$$



3.2 – rasm. Mexanizm kinematik sxemasini tuzishda bo'g'inlarni joylashtirish ketma-ketligi

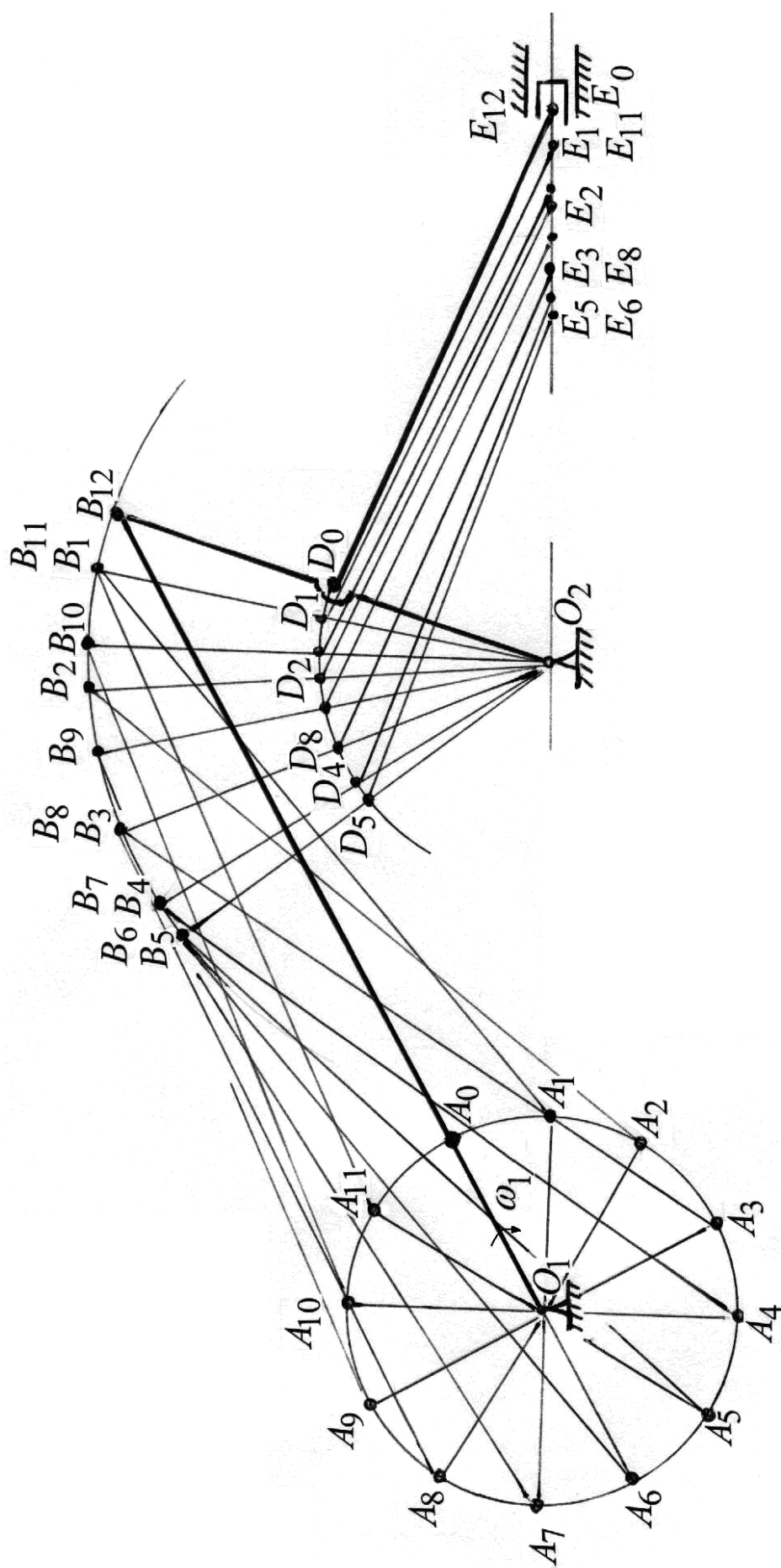
Hisoblangan bo'g'inlar uzunligi bilan mexanizmni xohlagan vaziyatdagi kinematik sxemasini (3.2– rasm) chizish mumkin, masalan:

-  $O_1$  nuqtadan  $R_1 = O_1A + AB = 20 + 40 = 60\text{ mm}$  - radius bilan tsirkul yordamida yoy chizamiz;  $O_2$  nuqtadan  $R_2 = O_2B = 30\text{ mm}$  - radius bilan yoy o'tkazamiz; ikkita yoyni kesishgan nuqtasini mexanizmning  $B_0$  nuqtasi deb belgilaymiz va uni  $O_1$  va  $O_2$  nuqtalar bilan tutashtiramiz. Natijada  $O_1, A$  va  $B_0$  nuqtalar bir to'g'ri chiziqli krivoship va shatun bir chiziqli joylashadi.

-  $O_1$  nuqtadan  $R_3 = O_1A = 20\text{ mm}$  radius bilan to'liq aylana chizamiz, u  $O_1 B_0$  chiziqli  $A_0$  nuqtada kesib o'tadi. Shu nuqtadan boshlab aylanani krivoship burchak tezligining yo'nalishi buyicha 12-ta teng bo'lakka bo'lib chiqamiz va nuqtalarni  $A_0, A_1, A_2, \dots, A_{12}$  deb qabul qilamiz (3.3 – rasm).

-mexanizmni nolinci holati  $O_1A_0B_0$  chiziqli va unga mos ravishda  $\mathcal{D}_0E_0$  chiziqli bilan tasvirlangan.  $A_1, A_2, A_3 \dots A_{12}$  nuqtalarga tegishli  $B_1, B_2, B_3 \dots B_{12}$ ;  $\mathcal{D}_1, \mathcal{D}_2, \mathcal{D}_3 \dots \mathcal{D}_{12}$  va  $E_1, E_2, E_3 \dots E_{12}$  nuqtalarni vaziyatlari belgilanadi

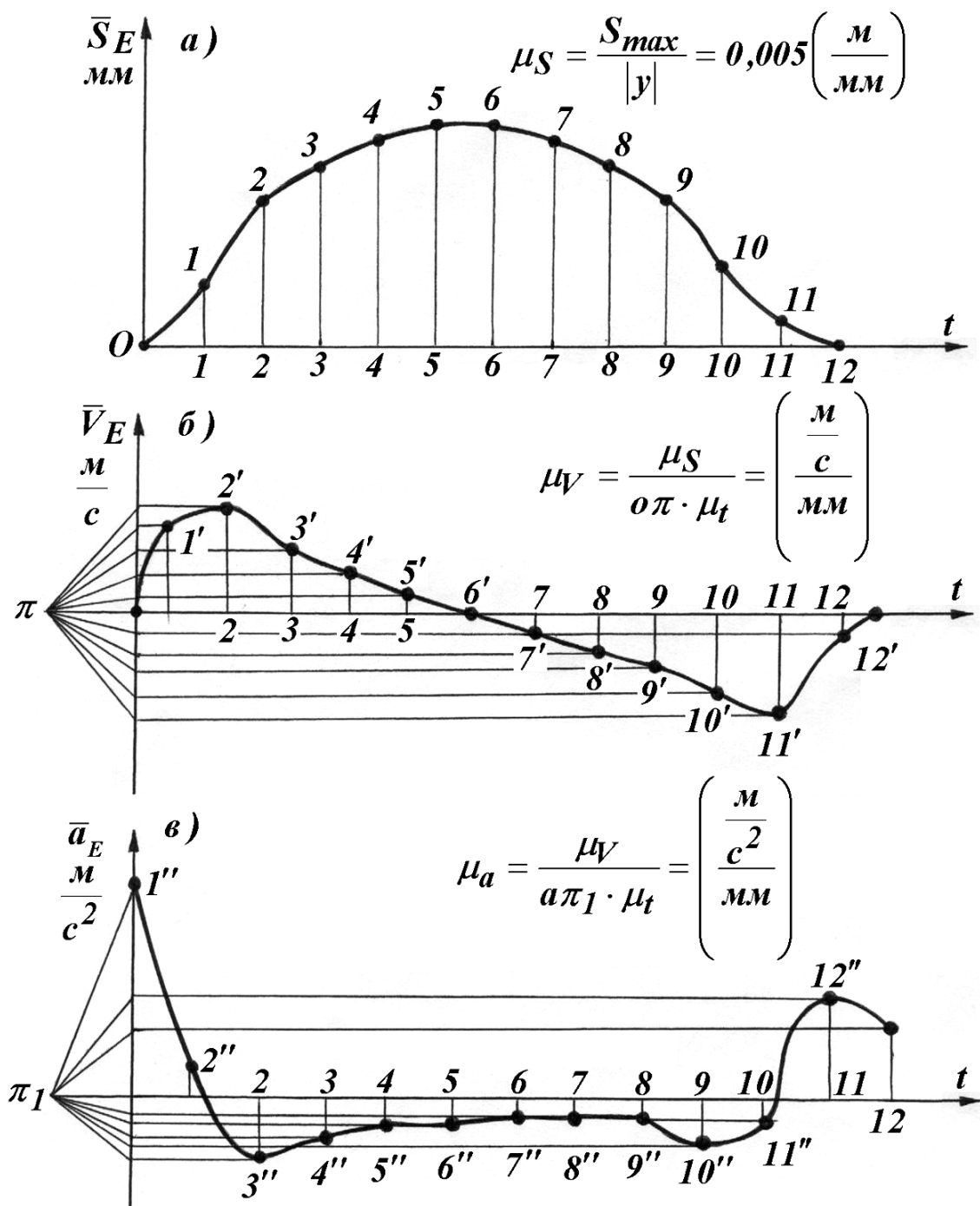




3.3— rasm. Mexanizmning vaziyatlar sxemasi (plani)



**Siljish diagrammasini qurish.** Bo'g'in nuqtasining siljish diagrammasini qurish uchun mexanizm bo'g'inlarining vaziyatlar chizmasidan foydalanamiz. Buning uchun siljish diagrammasini masshtabini belgilaymiz:



3.4 – rasm. Kinematik diagrammalar

$$\mu_S = \frac{S_{\max}}{|y|} = \frac{E_o E_6}{80} = \frac{0,040}{80} = 0,0005 \frac{\text{m}}{\text{mm}}$$

buerda:  $S_{\max}$  – nuqtasiljishiningengkattahaqiqiyqiymati;

$|y|$  – nuqta siljishining chizmadagi qiymati.

Mexanizmning vaziyatlar sxemasidan etaklovchi bo'g'in E

nuqtasini krivoshipning bir marotaba aylanishiga to'g'ri keluvchi bosib o'tgan masofasini o'lchab olamiz:

$$E_o E_1 = 0,01 \text{ m}, E_o E_2 = 0,026 \text{ m}, E_o E_3 = 0,034 \text{ m}, E_o E_4 = 0,037 \text{ m} \\ E_o E_5 = 0,039 \text{ m}, E_o E_6 = 0,040 \text{ m}, E_o E_7 = 0,037 \text{ m}, E_o E_8 = 0,032 \text{ m} \\ E_o E_9 = 0,025 \text{ m}, E_o E_{10} = 0,015 \text{ m}, E_o E_{11} = 0,006 \text{ m}, E_o E_{12} = 0$$

Belgilangan masshtabda krivoshipni har bir vaziyatiga to'g'ri keluvchi  $E$  nuqta bosib o'tgan masofani  $y = \frac{E_o E_n}{\mu_s}$  mexanizmning vaziyatlar sxemasidan aniqlaymiz

$$y_1 = 20 \text{ mm}, y_2 = 52 \text{ mm}, y_3 = 68 \text{ mm}, y_4 = 74 \text{ mm}, y_5 = 78 \text{ mm}, y_6 = 80 \text{ mm} \\ y_7 = 74 \text{ mm}, y_8 = 64 \text{ mm}, y_9 = 50 \text{ mm}, y_{10} = 30 \text{ mm}, y_{11} = 12 \text{ mm}$$

Nuqtaning vaqtga bog'liq diagrammasini qurish uchun qabul qilingan  $S - t$  koordinata sistemasining abtsissa o'qida kesma ajratib, uni teng o'n ikkibo'lakka ajratamiz. Har bir bo'lak oraligi davrning  $1/12$  bo'lagini yoki krivoshipning  $30^\circ$  ga buralishini ko'rsatadi. Har bir belgilangan nuqtadan tik chiziqlar o'tkazib, shu chiziqlarga nuqtaning dastlabki holatiga nisbatan bosib o'tgan yo'li  $y_1, y_2, y_3, \dots$  masofalarni keltirib qo'yamiz. Ylchamlarning oxirlari ravon egri chiziqlar bilan lekalo yordamida tutashtirilib siljish diagrammasi hosil kilinadi.

Siljish diagrammasini differentsiallab, **tezlik diagrammasini** quyidagi tartibda chizamiz.

1. Siljish grafigida 0-1, 1-2, 2-3, ... 10-11 vatar chiziqlar o'tkazamiz
2.  $V - t$  koordinatalar boshining chap tomonida  $\pi$  nuqtani belgilaymiz
3.  $\pi$  nuqtadan ordinata o'qi bilan kesishguncha 0-1, 1-2, 2-2, ... vatar chiziqlarga parallel chiziqlar o'tkazamiz (3.4 – rasm).
4. Ordinatalar o'qidagi kesishuv nuqtadan abtsissalar o'qiga parallel qilib 0-1, 1-2, 2-3, ... oraliqlarning o'rtasigacha gorizonttal chiziqlar o'tkazamiz.
5. Belgilangan 1, 2, 3, ... nuqtalarni birlashtirib, tezlik grafigining egri chizig'ini hosil qilamiz.

Tezlik grafikining masshtabi

$$\mu_v = \frac{\mu_s}{O\pi \cdot \mu_t} = \frac{0,0005}{30 \cdot 0,2617} = 69 \cdot 10^{-10} \left( \frac{\text{m} / \text{s}}{\text{mm}} \right)$$

$$\text{Bu erda } \mu_t = \frac{60}{240 \cdot n} = \frac{60}{240 \cdot 955} = 0,2617 \left( \frac{\text{s}}{\text{mm}} \right) - \text{vaqt}$$

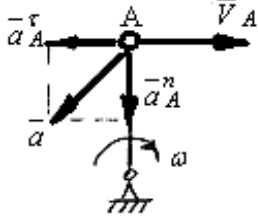
masshtabi.

**Tezlanish grafigini** chizish uchun tezlik grafigini yuqoridagi tartibda differentsiallash kifoya.

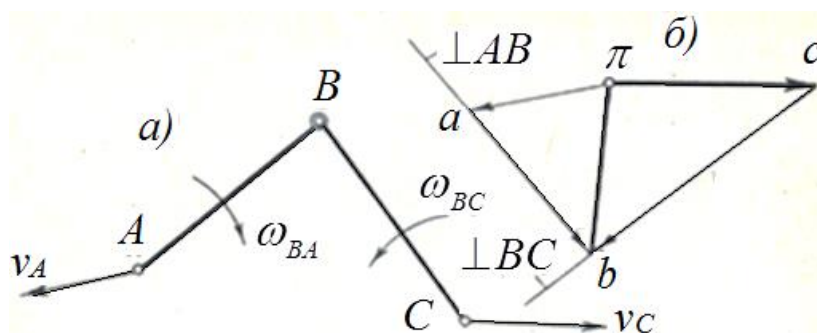
$$\text{Tezlanish grafigining masshtabi: } \mu_a = \frac{\mu_v}{\pi \cdot \mu_t} \frac{\text{m} / \text{s}^2}{\text{mm}}$$

Qutb oraligi qancha katta bo'lsa, tezlanish grafigining ordinatasi shuncha oshadi. Grafikning eng tik bo'lgan vatar chizig'iga parallel chiziq o'tkazib, grafikning maksimal ordinatasini belgilaymiz vaqutb oraligi  $\pi_1 O$  ni tanlaymiz.

### Mexanizm kinematikasini tezlik va tezlanish planlari yordamida tekshirish

|                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  |
|--------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <p>Quyidagi hol-larga e'tibor beramiz:</p>                | <p>1. Harakatdagi nuqtaning qo'zg'almas bo'g'indagi nuqtaga nisbatan aniqlanadigan tezligi va tezlanishi absolyut va harakatdagi nuqtaga nisbatan esa nisbiy tezlik va tezlanish deyiladi.</p> <p>2. Ilgarilanma harakatlanuvchi bo'g'indagi nuqtalar tezliklarining yo'nalishlari o'zaro parallel bo'lib, qiymatlari bir xil bo'ladi. Bu hol tezlanishga ham taalluqli</p> <p>3. Qo'zg'almas o'q atrofida aylanma harakat qiluvchi bo'g'inga tegishli A nuqtaning absolyut tezligi shu nuqtani aylanish o'qi bilan tutashtiruvchi to'g'ri chiziqqa tik yo'naladi</p> |  |
| <p>A nuqtaning tezligi</p> $V_A = \omega \cdot \ell_{OA}, \frac{M}{c}$ <p>va tezlanishi</p> $a_A = \ell_{OA} \sqrt{\omega^2 + \epsilon^2}$ | $a_A^n = \omega^2 \cdot \ell_{OA} = \frac{V_A^2}{\ell_{OA}}; \frac{M}{c^2}$<br>$a_A^\tau = \epsilon \cdot \ell_{OA}, \quad \frac{M}{c^2}$                                                                                                                                                                                                                                                                                                                                                                                                                             |  |
|                                                                                                                                            | <p>Bo'g'inga tegishli nuqtaning normal tezlanishi aylanish markaziga yo'nalgan</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |  |
|                                                                                                                                            | <p>Bo'g'inga tegishli nuqtaning urinma tezlanishi nuqtani aylanish o'qi bilan tutash-tiruvchi to'g'ri chiziqqa tik yo'naladi</p>                                                                                                                                                                                                                                                                                                                                                                                                                                      |  |

**Tezlik planini qurish.** Tezliklar biror markazdan ixtiyoriy masshtab kesmada qo'yilgan va ularning uchlari tutashtirishdan hosil bo'lgan shakl tezliklar plani deyiladi.



3.5-rasm.  
2 klass Assur  
gruppasi (a) uchun  
tezliklar plani (b).

2 klass Assur gruppasidagi (3.5-rasm) A va C nuqtalarning tezliklari berilgan deb V sharnirning tezligini topamiz. A nuqtaning tezligi  $V_A$  va C nuqtaning tezligi  $V_C$  berilganligi uchun, tezlik planida ularni tegishli  $\pi a$  va  $\pi c$  ixtiyoriy vektor kesmalar bilan ifodalaymiz, u holda, haqiqiy tezlikni tanlab

olingan kesmaga bo'lib, tezliklar masshtabini topamiz.

$$\mu_v = \frac{V_A}{\pi a}; \quad \left( \frac{m/c}{mm} \right)$$

Demak,  $\pi a$  va  $\pi c$  kesmalar  $\mu_v$  masshtabda A va C nuqtalarning tezliklarini bildiradi.

Tezliklar planini qurish uchun tezligi noma'lum bo'lgan V nuqta tezligining vektor tenglamasini tuzamiz.

$$\left. \begin{aligned} \bar{V}_B &= \bar{V}_A + \bar{V}_{BA} \\ \bar{V}_B &= \bar{V}_C + \bar{V}_{BC} \end{aligned} \right\}$$

Tezlik planini qurish tartibi:

1. Ixtiyoriy  $\pi$  qutb nuqtasini tanlaymiz.
2. A va C nuqtalarning tezliklarining  $\pi a$  va  $\pi c$  vektor kesmalarini  $\pi$  qutb nuqtadan  $V_A$  va  $V_C$  ga parallel qilib qo'yamiz

3.  $V_A$  vektorning uchidan (tezlik planidagi a nuqtadan) AB bo'g'inga tik chiziq ( $\perp AB$ ) o'tkazamiz.  $V_C$  vektorning uchidan (tezlik planidagi c nuqtadan) BC bo'g'inga tik chiziq ( $\perp BC$ ) o'tkazamiz. ( $\perp AB$ ) va ( $\perp BC$ ) chiziqlar kesishgan nuqtasi b nuqtani beradi.

4. b nuqtani tutashtirib  $\pi b$  kesmani hosil qilamiz. Bu kesma  $\mu_v$  masshtabda V nuqtaning absolyut tezligini beradi:

$$V_B = \mu_v \cdot \pi b$$

Tezliklar planidan quyidagilarni olamiz:

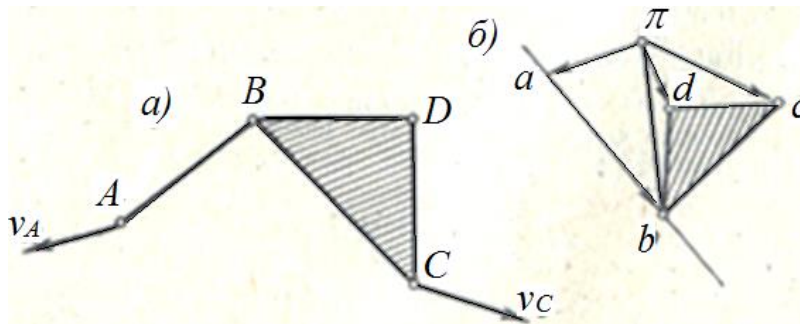
1.  $V_B = \mu_v \cdot \pi b$  - V nuqtaning absolyut tezligi
2.  $V_{BA} = \mu_v \cdot ab$  - V nuqtaning A nuqtaga nisbatan tezligi
3.  $V_{BC} = \mu_v \cdot bc$  - V nuqtaning S nuqtaga nisbatan tezligi
4.  $\omega_{BA} = \frac{V_{BA}}{l_{BA}}$  - AB bo'g'inining burchak tezligi, soat strelkasi yurgan tomonga yo'naladi
5.  $\omega_{BC} = \frac{V_{BC}}{l_{BC}}$  - BC bo'g'inining burchak tezligi, soat strelkasi yurgan tomonga teskari yo'naladi
6. Tezliklar planining qutbidan o'tuvchi vektorlar absolyut tezliklarni ifodalaydi

7. Tezliklar planining qutbidan o'tmaydigan vektorlar nisbiy tezliklarni ifodalaydi

8. Qutbda yotuvchi nuqtalarning tezliklari nolga teng.

**Teorema.** Mexanizm bo'g'inining tezliklar planidagi nisbiy tezliklar manzarasi mexanizmdagi bo'g'in shakliga o'xshash, ammo shu shaklga nisbatan burchak tezligi aylanish tomonga qarab  $90^\circ$  burilgan bo'ladi

Bir bo'g'ini bazisli bo'lgan Assur gruppasini o'rganamiz (3.6- rasm). Bu gruppadagi B va D sharnirlarning tezliklarini topamiz.



3.6- rasm.  
II klass Assur  
gruppasi (a) si- ning  
tezliklar plani (b)

ABCD Assur gruppasi A va C nuqtalarning tezliklari berilgan, ular  $V_A$  va  $V_C$ . Masalani echish uchun V nuqta tezligining vektor tenglamasini tuzamiz:

$$\left. \begin{aligned} \bar{V}_B &= \bar{V}_A + \bar{V}_{BA} \\ \bar{V}_B &= \bar{V}_C + \bar{V}_{BC} \end{aligned} \right\}$$

Bu tenglamani echish uchun  $\pi a$  va  $\pi c$  vektorlarning a va c nuqtalaridan AB va BC bo'g'inlarga tik chiziqlar o'tkazamiz

ularning kesishuv nuqtalari b ni beradi

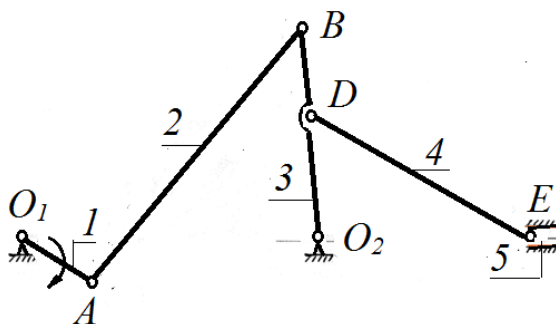
D nuqtaning tezligini topish uchun, uni B va C nuqtalar bilan bog'laydigan vektor tenglamani tuzamiz:

$$\left. \begin{aligned} \bar{V}_D &= \bar{V}_B + \bar{V}_{DB} \\ \bar{V}_D &= \bar{V}_C + \bar{V}_{DC} \end{aligned} \right\}$$

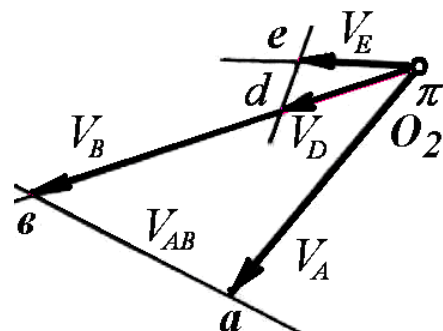
Bu tenglamani echish uchun  $\pi b$  vektorning b uchidan DB ga tik chiziq,  $\pi c$  vektor kesmaning C uchidan DC ga tik chiziq

o'tkazamiz. O'tkazilgan tik chiziqlarning kesishuv nuqtasi d bo'ladi

**misol-3.3.** Besh bo'g'inli mexanizm etaklanuvchi bo'g'in E nuqtasining tezligini tezliklar planini qurish usuli bilan topilsin



rasm-3.7. Tebranuvchi konveyer mexanizmi. 1-krivoship; 2 - shatun; 3 - koromislo; 4 - shatun; 5 - polzun



rasm-3.8. Mexanizmning berilgan vaziyati uchun tezlik plani

Tezlik planining masshtabini tanlaymiz:

$$\mu_v = \frac{V_A}{\pi \cdot a} = \frac{8}{40} = 0,2 \left( \frac{m/c}{mm} \right)$$

$$V_A = \omega_1 \cdot \ell_{oA} = 100 \cdot 0,08 = 8 \frac{m}{c} - \text{mexanizm } A \text{ nuqtasining absolyut tezligi;}$$

Mexanizmni II holati (*rasm-3.7*). uchun tezliklar planini quramiz

$B$  nuqta tezligini vektor tenglamadan topamiz:

$$\left. \begin{aligned} \bar{V}_B &= \bar{V}_A + \bar{V}_{BA} \\ \bar{V}_B &= \bar{V}_{O_2} + \bar{V}_{BO_2} \end{aligned} \right\} \text{Tenglamada } A \text{ nuqtaning } V_A \text{ tezlik vektori } OA$$

bo'g'inga nisbatan  $\omega_1$  burchak tezligini berilgan tomoniga perpendikulyar yo'nalgan.  $AV$  bo'g'ining nisbiy tezlik vektori  $V_{BA}$  – shu bo'g'inga perpendikulyar yo'nalgan. Tayanch  $O_2$  nuqtaning tezligi nolga teng.  $O_2B$  bo'g'inining nisbiy tezlik vektori shu bo'g'inga perpendikulyar yo'nalgan. Tezlik planini qurish uchun  $\pi$  qutb nuqtasini tanlaymiz. Qutbdan  $OA$  bo'g'inga nisbatan perpendikulyar chiziq o'tkazamiz va unda  $\pi \cdot a = 40mm$  masofani o'lchab  $a$  nuqtani belgilaymiz.  $AB$  bo'g'inga nisbatan perpendikulyar chiziq o'tkazamiz (*3.8-rasm*). Qutb –  $\pi$  nuqtadan  $O_2B$  bo'g'inga perpendikulyar chiziq o'tkazamiz.  $AB$  va  $O_2B$  bo'g'inlarga o'tkazilgan perpendikulyarlar kesishgan nuqtani –  $b$  harfi bilan belgilaymiz.  $D$  nuqtaning tezliklar planidagi o'rnini quyidagi proporsiya orqali belgilaymiz.

$$\frac{O_2D}{AB} = \frac{\pi d}{ab} \quad \text{va} \quad \pi d = ab \cdot \frac{O_2D}{AB} = 31 \cdot \frac{0,06}{0,18} = 10,3mm$$

$\pi d = 10,3mm$  kesma uzunligi tezliklar planida  $D$  nuqta tezligini aniqlaydi, u  $\pi b$  chiziqda –  $\pi$  qutb nuqtasidan boshlab  $b$  – nuqta tomon yo'naladi. Mexanizm  $E$  nuqtasining tezligini vektor tenglamadan topamiz

$$\left. \begin{aligned} \bar{V}_B &= \bar{V}_D + \bar{V}_{ED} \\ \bar{V}_E &= \bar{V}_X + \bar{V}_{EX} \end{aligned} \right\} \begin{aligned} &\text{Tenglamada } D \text{ nuqtaning } \bar{V}_D \text{ tezlik vektori} \\ &B_2O_2 \text{ bo'g'inga perpendikulyar joylashadi va} \\ &\text{tezliklar planida u } \pi b \text{ chiziqda } - \pi \text{ qutb} \\ &\text{nuqtasidan boshlab } b - \text{ nuqta tomon yo'naladi.} \end{aligned}$$

$$\bar{V}_D = \pi d \cdot \mu_v - \text{mexanizm } D \text{ nuqtasining absolyut tezligi}$$

$V_{ED}$  - bo'g'inning nisbiy tezlik vektori

$\bar{V}_{ED}$  – shu bo'g'inga perpendikulyar yo'naladi. Perpendikulyar chiziq tezlik planidagi  $D$  nuqtadan o'tkaziladi. Polzun yo'nalti-ruvchisi, ya'ni tayanch nuqtasining  $\bar{V}_x$  tezligini nolga teng deb olamiz. Tezliklar planida  $\bar{V}_x = 0$  tezlik qutb nuqtada joylashadi. Polzunning  $\bar{V}_{EX}$  yo'naltiruvchiga nisbatan tezligi  $X - X$  o'qiga parallel joylashadi.

Mexanizmni ikkinchi holati uchun qurilgan tezlik planidan tegishli nuqtalarning tezliklarini topamiz:

$$\bar{V}_{BA} = ab \cdot \mu_v; \quad \bar{V}_B = \pi \cdot b \cdot \mu_v; \quad \bar{V}_c = \pi \cdot d \cdot \mu_v;$$

$$\bar{V}_{ED} = ce \cdot \mu_v; \quad \bar{V}_E = \pi \cdot e \cdot \mu_v$$

Bo'g'inlarning burchak tezliklari:

$$\omega_2 = \frac{\bar{V}_{BA}}{\ell_{BA}}; \quad \omega_3 = \frac{\bar{V}_{BO_2}}{\ell_{BO_2}}; \quad \omega_4 = \frac{\bar{V}_{EX}}{\ell_{EX}}$$

**Tezlanishlar planini qurish.** Tezlanishlar planini qurishda mexanizm etaklovchi bo'g'inning burchak tezligi yoki aylanishlar chastotasi o'zgarmas kattalik deb qabul qilinadi:

$$\omega = \frac{\pi \cdot n}{30} = const$$

Etaklovchi bo'g'inning burchak tezlanishi burchak tezligidan

vaqt bo'yicha olingan hosilasiga teng:  $\varepsilon = \frac{d\omega}{dt} = 0$

Shuning uchun A nuqtaning tangentsial tezlanishi ham nolga teng, ya'ni  $a_A^\tau = 0$  bo'ladi. Unda krivoship nuqtasining to'la tezlanishi faqat normal

tezlanishdan iborat bo'ladi:  $\vec{a}_A = \vec{a}_A^n + \vec{a}_A^\tau = \vec{a}_A^n$

$a_A^n$ -tezlanish, etaklovchi bo'g'inning o'qi bo'ylab A nuqtadan O nuqta tomon yo'nalgan bo'ladi. Shuning uchun,  $a_A^n$  tezlanishni markazga intiluvchi tezlanish deb ham ataladi va qiymati quyidagicha topiladi:

$$a_A^n = \frac{V_A^2}{l_{OA}} = \frac{(\omega \cdot l_{OA})^2}{l_{OA}} = \omega^2 l_{OA}$$

Tezlanish masshtabini topish uchun  $a_A^n$  tezlanish ixtiyoriy

$\pi_1 a_1$  kesmaga bo'linadi:  $\mu_a = \frac{a_A^n}{\pi_1 a_1}$

Tezliklar plani ma'lum masshtabda qurilib, tegishli nuqtalarning tezliklari aniqlangach, tezlanishlar plani quriladi.

**Tezlanish planini** qurish uchun masshtab tanlaymiz:

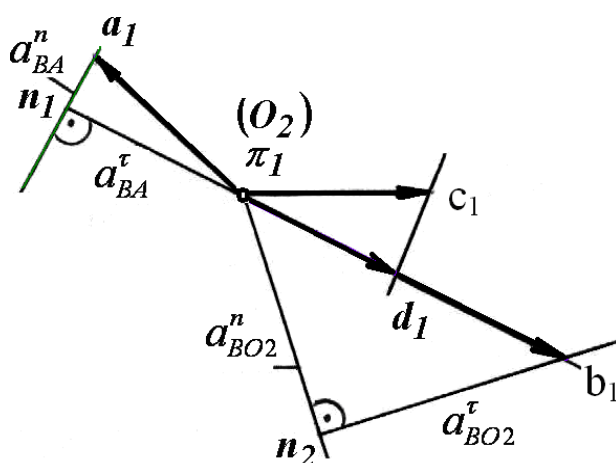
$$\mu_a = \frac{a_A}{\pi_1 a_1} = \frac{800}{32} = 25 \frac{\frac{M}{c^2}}{MM}$$

buerda,  $a_A = \omega_1^2 \cdot \ell_{OA} = (100)^2 \cdot 0,08 = 800 \left[ \frac{M}{c^2} \right]$  mexanizm A nuqtasining absolyut tezlanishi

V nuqta tezlanishini aniqlash uchun quyidagi vektor tenglamalarni tuzamiz:

$$\left. \begin{aligned} \vec{a}_B &= \vec{a}_A + \vec{a}_{BA}^n + \vec{a}_{BA}^\tau \\ \vec{a}_B &= \vec{a}_{O_2} + \vec{a}_{BO_2}^n + \vec{a}_{BO_2}^\tau \end{aligned} \right\}$$

Tenglamadagi  $\vec{a}_A$  tezlanish vektori  $O_1A$  bo'g'in bo'ylab  $A$  nuqtadan etaklovchi bo'g'inning aylanish markazi  $O_1$  nuqta tomon yo'nalgan.  $\vec{a}_{BA}^n$  tezlanish  $BA$  bo'g'inga parallel chiziq bo'ylab tezlanishi noma'lum  $B$  nuqtadan tezlanishi ma'lum  $A$  nuqta tomon yo'nalgan.



3.9– rasm. Tezlanish plani

$BA$  bo'g'inning tangentsial  $\vec{a}_{BA}^\tau$  tezlanish vektori  $BA$  bo'g'inga perpendikulyar yo'naladi. Tayanch  $O_2$  nuqtaning tezlanishi nolga teng  $BO_2$  bo'g'inning normal  $\vec{a}_{BO_2}^n$  tezlanishi  $BO_2$  bo'g'inga parallel, tangentsial  $\vec{a}_{BO_2}^\tau$  tezlanish esa perpendikulyar joylashadi Tezlanishlar planini qurish uchun  $\pi_1$  qutb

nuqtasini tanlaymiz. Qutbdan  $O_1A$  bo'g'inga parallel chiziq o'tkazamiz va unda  $\pi_1 a_1 = 32 \text{ mm}$  masofada  $a_1$  nuqtani belgilaymiz (3.9– rasm).  $a_1$  nuqtadan  $BA$  bo'g'inga parallel chiziq o'tkazib, unda  $\vec{a}_{BA}^n$  tezlanishni aniqlovchi  $a_1 n_1 = \frac{a_{BA}^n}{\mu_a}$  kesma uzunligini noma'lum  $B$  nuqtadan ma'lum  $A$  nuqta tomon

$$\text{o'lchab qo'yamiz. } a_{BA}^n = \frac{V_{BA}^2}{\ell_{BA}} = \frac{(ab \cdot \mu_v)^2}{\ell_{BA}} = \frac{(31 \cdot 0,2)^2}{0,18} = 213,6 \frac{\text{m}}{\text{c}^2};$$

$$a_1 n_1 = \frac{213,6}{25} = 8,5 \text{ mm}$$

$n_1$  nuqtadan  $\vec{a}_{BA}^\tau$  tezlanish vektorini  $BA$  bo'g'inga perpendikulyar yo'naltiramiz. Qutbdan  $\vec{a}_{BO_2}^n$  tezlanish vektorini  $BO_2$  bo'g'inga parallel chiziq bo'ylab  $\pi_2 n_2 = \frac{a_{BO_2}^n}{\mu_a}$  kesma uzunligi bilan belgilaymiz.



Bu erda,  $\bar{a}_{BO_2}^n = \frac{\bar{V}_{BO_2}^2}{\ell_{BO_2}} = \frac{(\pi \cdot b \cdot \mu_v)^2}{\ell_{BO_2}}$  yoki  $\bar{a}_{BO_2}^n = \frac{(57 \cdot 0,2)^2}{0,12} = 1083 \frac{m}{c^2}$ ;

$\pi_2 n_2 = \frac{1083}{25} = 43,3 mm$ . Vektor  $\bar{a}_{BO_2}^n$  - uchi  $n_2$  nuqtadan  $BO_2$  bo'g'inga

perpendikulyar o'tkazamiz.  $n_1$  va  $n_2$  nuqtalardan o'tkazilgan perpendikulyarlar kesishgan nuqtasida  $b_1$  nuqta hosil bo'ladi. Unda  $\pi_1 b_1$  kesma uzunligi  $a_B$  tezlanish vektorini belgilaydi, ya'ni  $a_B = \pi_1 b_1 \cdot \mu_a$ .  $D$  nuqtaning tezlanishining plandagi o'rni quyidagi proporsiyadan topiladi:

$$\frac{O_2 D}{AB} = \frac{\pi d_1}{a_1 b_1} \quad \text{va} \quad \pi d_1 = a_1 b_2 \frac{O_2 D}{AB} = 90 \cdot \frac{0,96}{0,18} = 30 mm$$

$E$  nuqtaning tezlanishini topish uchun vektor tenglama tuzamiz:

$$\begin{cases} \bar{a}_B = \bar{a}_D + \bar{a}_{DE}^n + \bar{a}_{DE}^t \\ \bar{a}_E = \bar{a}_X + \bar{a}_{XE} \end{cases}$$

bu erda:  $\bar{a}_D$  - mexanizm  $D$  nuqtasining tezlanish vektori, tezlanish planida  $\pi_1 b_1$  chiziqda  $\pi_1 d_1$  kesma uzunligi bilan belgilanadi va quyidagicha hisoblanadi.  $\bar{a}_D = \pi_1 d_1 \cdot \mu_a$

$\bar{a}_{DE}^n$  - mexanizm  $DE$  bo'g'inining normal tezlanishi,  $DE$  bo'g'inga parallel chiziq bo'ylab tezlanishi noma'lum  $E$  nuqtadan tezlanishi ma'lum  $D$  nuqta tomon yo'nalgan.

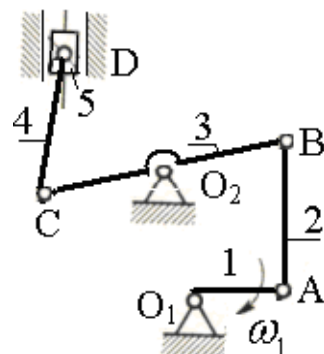
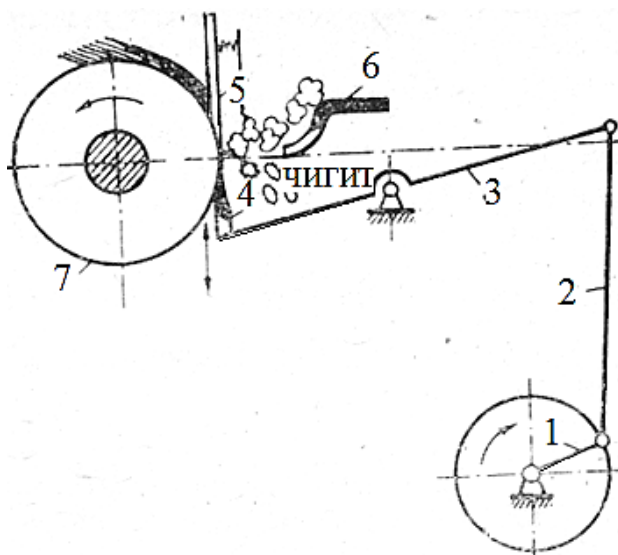
$DE$  bo'g'inining tangentsial  $\bar{a}_{DE}^t$  tezlanish vektori  $DE$  bo'g'inga perpendikulyar joylashadi. Polzun yo'naltiruvchisining tezlanishi nolga teng. Polzunning tezlanishi  $\bar{a}_{XE}$  vektori, uning  $X-X$  o'qiga parallel yo'nalgan. Tezlanishlar planida  $d_1$  nuqtadan  $DE$  bo'g'inga parallel chiziq o'tkazib, unda  $d_1 n_3$  kesma uzunligi bilan  $\bar{a}_{DE}^n$  tezlanish vektorini joylashtiramiz.

$$d_1 n_3 = \frac{a_{DE}^n}{\mu_a} = \frac{(V_{DE})^2}{\ell_{DE} \cdot \mu_a} = \frac{(de \cdot \mu_v)^2}{\ell_{DE} \cdot \mu_a} = \frac{(8 \cdot 0,2)^2}{0,18 \cdot 25} = 0,57 mm$$

$d_1 n_3$  - masofa kichik miqdor bo'lganligi uchun,  $n_3$  nuqta  $d_1$  nuqta bilan ustma - ust joylashadi.

$n_3$  nuqtadan  $DE$  bug'inga perpendikulyar va qutbdan  $x-x$  o'qiga parallel o'tkazamiz. Perpendikulyar va parallel chiziqlarni kesishish nuqtasi qutbdan  $\pi_1 e_1$  masofada joylashadi va u polzun tezlanishini belgilaydi.

**misol-3.4.** Charmli val (7) aylanadi. Valga qo'zg'almas pichoq (5) maxsus kuch bilan taqab qo'yiladi. Val aylanganda paxta tolasi (4) qo'zg'almas pichoq bilan val elementlari orasidan o'tadi, chigit esa bu oraliqq kirolmay qoladi. Shu chigitlarni tebranib turuvchi pichoq (3) toladan ajratib yuboradi va o'z tolasidan ajralgan chigitlar (4) kolosniklar (6) orasidan tushib ketadi.

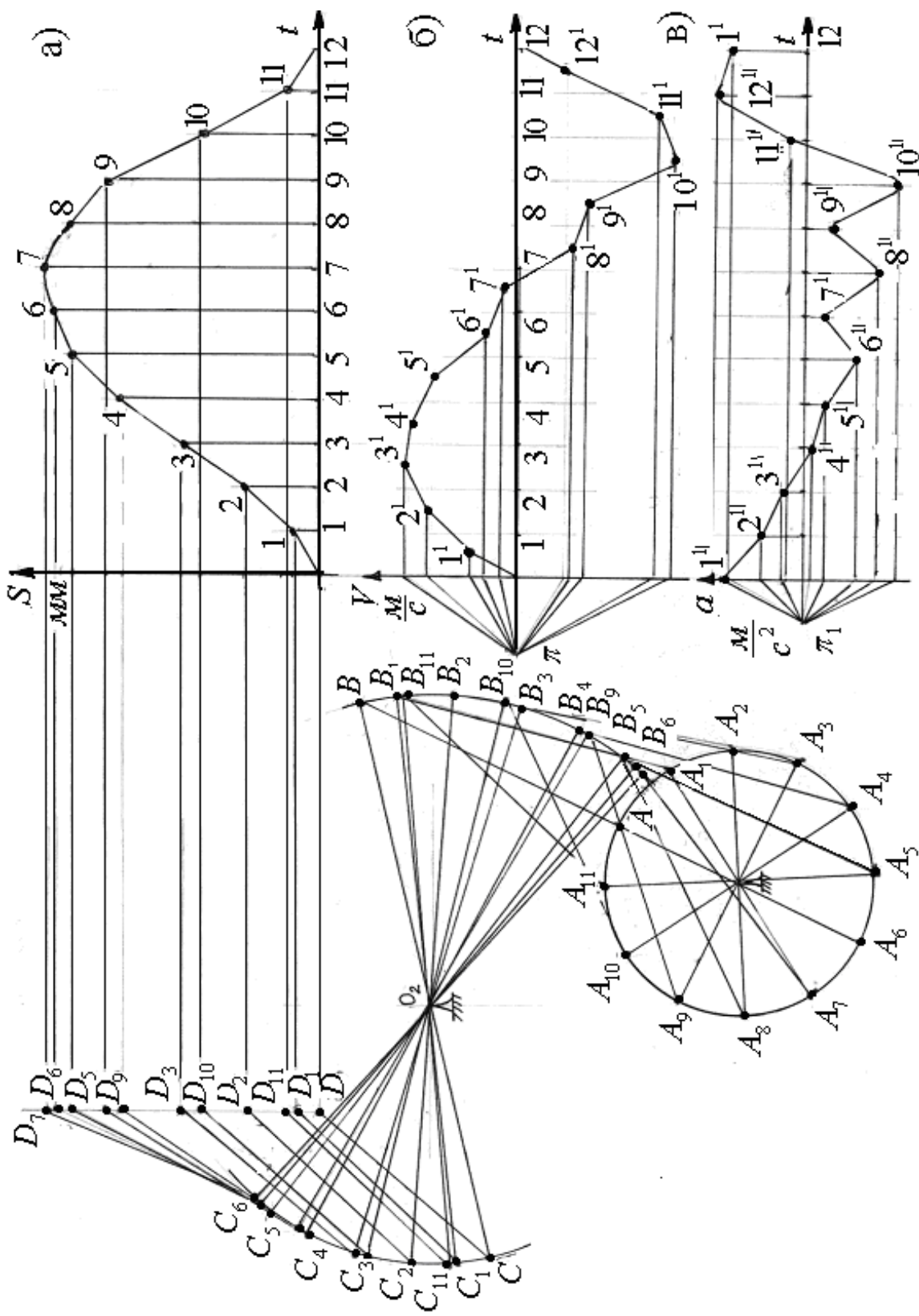


3.10-rasm. Valikli tola ajratuv mashinasi asosiy mexanizmining kinematik sxemasi

**Vaziyatlar planini qurish.** Mexanizm vaziyatlar planiga asosan uning bo'g'in va nuqtalarining harakatini kuzatish mumkin. Misol tariqasida besh bo'g'inli tebranuvchi konveyer mexanizmini (3.10-rasm) tahlil qilamiz. Mexanizm krivoship -1, richag – 2, koromyislo -3, shatun -4 va polzun – 5 dan tashkil topgan. Bo'g'inlar vaziyatlar plani krivoship va richag bitta to'g'ri chiziqda yotadigan mexanizmning boshlang'ich vaziyatini tanlashdan boshlanadi.

Bu chiziq quyidagicha topiladi: ( $O_1$  va  $O_2$ ) kinematik juftlarning markazlaridan tsirkul bilan  $OA + AB = R_1$  va  $O_2B = R_2$  radiuslar o'tkazamiz, ularning kesishuv nuqtasi  $B$  juftni aniqlaydi.  $B$  nuqtani  $O_1$  va  $O_2$  nuqtalar bilan tutashtirib 1 va 2 bo'g'inlar vaziyatlarini aniqlaymiz.  $C$  va  $D$  nuqtalarning vaziyatlari boshlang'ich vaziyatga nisbatan topamiz. Keyin  $O_1A = R_3$  radius bilan  $O_1$  markazda aylana chizamiz. Hosil bo'lgan aylanani boshlang'ich vaziyatga nisbatan teng 12 qismga bo'lamiz. Aylanadagi  $A, A_1, A_2, \dots, A_{12}$  nuqtalarni  $O_1$  markaz bilan tutashtirib  $O_1A; O_1A_1; O_1A_2, \dots, O_1A_{12}$  to'g'ri chiziqlarni hosil qilamiz. Ushbu chiziqlar krivoshipning 12 vaziyatini va unga tegishli 2 bo'g'inning  $AB; A_1B_1; A_2B_2, \dots, A_{12}B_{12}$  12 vaziyatini belgilaydi. Mexanizm boshqa bo'g'inlarining vaziyatlari 3.11 – rasmda ko'rsatilgan.

**Bo'g'inlarning tezlik va tezlanishlarini aniqlash.** Mexanizm etaklanuvchi bo'g'inlarining tezlik va tezlanishlari kinematik diagramma va planlar usullari bilan aniqlanishi mumkin. Ushbu barcha hollarda etakchi bo'g'inning vaziyatiga bog'liq bo'lgan mexanizmning sxemasi, uning tezlik va tezlanishi beriladi



3.11-rasm. Mexanizm kinmatikasasini dianramma usulda tekshirish

**Kinematik diagramma metodi.** Biror aniq vaqtda tezlik va tezlanish qonuniyatini o'rnatish lozim bo'lsa grafik differentsiallashga asoslangan kinematik diagrammalar usuli tadbiiq etiladi. Etaklanuvchi  $D$  bo'g'inining  $S = S(t)$  vaqtda ko'chish grafigidan foydalanib (3.11-rasm) bosib yo'lni vaqt bo'yicha birinchi tartibli hosilasi sifatida tezlik topiladi,  $V = \frac{ds}{dt}$ .

Etaklanuvchi  $D$  bo'g'inining ko'chish grafigini qurish uchun, uning krivoshipni qo'zg'olmas  $O_1$  nuqta atrofida to'liq bir marotaba aylanishida bosib o'tgan masofasini aniqlaymiz. Etaklanuvchi 1- bo'g'innining to'liq bir aylanish tsikli krivoshipni 12 vaziyatini belgilaydi. Abstissa o'qida  $\mu_t$  masshtabda vaqt belgilanadi. Tanlangan  $\ell$  uzunlikdagi abstissada  $\mu_t = \frac{60}{\ell \cdot n} \cdot \left( \frac{c}{mm} \right)$  masshtabda to'liq bir tsiklni aniqlaydi. Etaklanuvchi bo'g'inining bosib o'tgan masofasi  $D_0D_1, D_0D_2, D_0D_3, \dots, D_0D_{12}$  ordinata o'qida  $\mu_s = \frac{S_{\max}}{|y|} = \frac{D_0D_7}{80} \cdot \left( \frac{m}{mm} \right)$  masshtabda belgilanadi.

buerda,  $S_{\max}$  –  $D$  (m) nuqtani bir tomonlama harakatidagi bosib o'tgan eng katta masofasi;

Mexanizmning turli vaziyatlari orasida  $D$  ni bosib o'tgan masofasi tanlangan masshtabda quyidagicha topiladi:

$$y_1 = \frac{D_0D_1}{\mu_s}, mm; \quad y_2 = \frac{D_0D_2}{\mu_s}, mm; \quad y_3 = \frac{D_0D_3}{\mu_s}, mm; \dots; \quad y_{11} = \frac{D_0D_{11}}{\mu_s}, mm$$

Ushbu masofalarni  $SOt$  koordinata sistemasida joylashtirib (3.11-rasm) 1-1, 2-2, 3-3, ..., 12-12 nuqtalarni hosil qilamiz va ularni o'zaro silliq tutashtirib  $D$  nuqtaning siljish diagrammasini olamiz. Bu  $S = S(t)$  diagramma etaklanuvchi bo'g'inining to'liq bitta tsiklda bosib o'tgan masofasini ifodalaydi. Siljish diagrammasining har bir ordinatasini vaqtga nisbati etaklanuvchi bo'g'in tezligini aniqlaydi.

Tezlik diagrammasini qurish uchun  $vO_1t$  koordinata sistemasini olamiz va uning boshlang'ich  $O_1$  nuqtasiningn chap tomonidan abstissa o'qida qutb  $\pi$  nuqtasini belgilaymiz.  $O_1\pi$  masofa kattalashsa tezlik diagrammasining ordinatasi ham ortadi.

Siljish diagrammasining 0-1, 1-2, 2-3, 3-4 va h.k. vatarlarlarini to'g'ri chiziq deb qabul qilib nur sifatida  $vO_1t$  koordinata (3.11-rasm, b) sistemasining qutb nuqtasiga parallel ko'chiramiz. Ushbu nurlarni  $v$  o'qi bilan kesishgan nuqtasidan abstissaga parallel chiziq o'tkazamiz va uni abstissa o'qidagi 0-1 1-2, 2-3, 3-4 va h.k. masofalarning yarmidan chiqarilgan vertikal chiziqlar bilan kesishguncha davom etdiramiz. Barcha gorizontal va vertikal chiziqlarni

kesishgan nuqtalarini lekala bilan tutashtirib etaklanuvchi bo'g'in tezlik diagrammasini hosil qilamiz.

$$\text{Tezlik diagrammasining masshtabi: } \mu_v = \frac{\mu_s}{O\pi \cdot \mu_t}, \left( \frac{m/c}{mm} \right)$$

Tezlik diagrammasini differentsiallab tezlanish diagrammasini hosil qilamiz.

Buning uchun  $aO_2t$  koordinata sistemasining chap tomonidan  $\pi_1$  qutb nuqtasini tanlaymiz va tezlik diagrammasini qurish usulidan foydalanami (3.11-rasm, v).

$$\text{Tezlanish diagrammasining masshtabi } \mu_a = \frac{\mu_v}{\pi \cdot \mu_t} \frac{m./c^2}{mm}$$

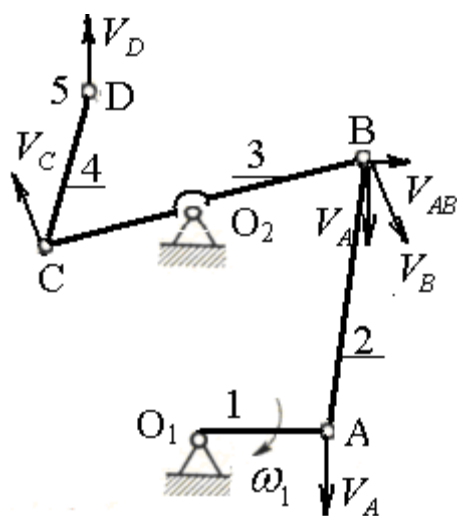
**Planlar usuli.** Tezlik va tezlanish planlarini qurish, etaklovchi bo'g'indan boshlab ketma-ket barcha guruhlar uchun vektor tenglamalarni tuzish asosida olib boriladi.

Xohlagan bo'g'in tezligi to'g'risida tasavvur hosil qilish uchun, ushbu bo'g'in ikkita nuqtasining chiziqli tezligini yoki bitta nuqtasining chiziqli tezligi va bo'g'inning burchakli tezligini bilish etarli va zarurdir.

Vektor tenglamani tuzishda ko'chirma tezlikka ega nuqtani aniqlash zarur. Agar, guruhdagi bo'g'in ilgarilanma harakatdagi kinematik juftlikni tashkil etsa, yo'naltiruvchi bo'g'in nuqtasini aniqlashtirish lozim. Misol tariqasida ikkinchi klass, ikkinchi tartibli guruh uchun tezlik va tezlanish planlarini o'rganamiz.

**Tezlik plani.** Mexanzmdagi etaklovchi bo'g'inning tezligi geometrik va kinematik parametrlar asosida topiladi:

$$V_A = \omega_1 \cdot \ell_{O_1A}, \quad \frac{m}{c}$$



rasm-3.12. Nuqtalar tezliklarining yo'nalishi

A nuqta tezligining vektorining yo'nalishi etaklovchi bo'g'inning o'qiga tik va aylanish yo'nalishiga mos. Ikkinchi bo'g'in tezligini aniqlash uchun 2 va 3 bo'g'inlar uchun umumiy bolgan  $B$  nuqta tezligini bilishimiz kerak. 2 bo'g'inning 1 bo'g'ingan nisbatan harakatini o'rganamiz. Bu bo'g'inlar aylanuvchi kinematik juftlikni tashkil etadi. Shuning uchun  $B$  nuqtaning murakkab harakatdagi tezligi  $V_B$  - bo'g'inning ko'chirma va 2 bo'g'inni  $A$  nuqta atrofidagi nisbiy  $V_{BA}$ -tezligidan tashkil topadi:

$$V_B = V_A + V_{BA} \quad (a)$$

$V_{BA}$  -  $B$  nuqtani  $A$  nuqtaga nisbatan tezligi, 2 bo'g'in o'qiga perpendikulyar joylashgan. Nisbiy tezlik 2 bo'g'in burchak tezligi bilan ifodalanadi:

$$V_{BA} = \omega_2 \cdot \ell_{AB}$$

Endi  $B$  nuqta tezligini 3 bo'g'inga bog'lab topamiz. 2 bo'g'in bilan 3 bo'g'in ilgariylanma xarakatdagi juftlikni tashkil etadi, shuning uchun  $B$  nuqta tezligini ikkita tezliklar yig'indisidan iborat deb qabul qilish mumkin:

qo'g'almas  $O_2$  nuqtaning tezligi va  $B$  nuqtani  $O_2$  nuqtaga nisbatan 2 bo'g'inni 3 bo'g'in atrofidagi ilgariylanma harakatining tezligi, ya'ni

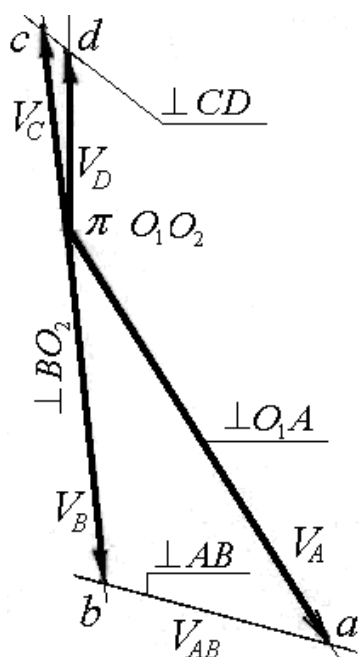
$$V_B = V_{O_2} + V_{BO_2} \quad (b)$$

Tenglamalar sistemasi 
$$\begin{cases} V_B = V_A + V_{BA} \\ V_B = V_{O_2} + V_{BO_2} \end{cases}$$
 -ni  $\mu_v = \frac{V_A}{\pi \cdot a}$ ,  $\left( \frac{\frac{M}{C}}{\frac{MM}{MM}} \right)$  masshtabda

tezliklar planida grafik usulda echamiz.

Tanlangan  $\pi$  qutb nuqtasidan  $A$  tezlik vektoriga parallel  $\pi \cdot a$  (mm)kesmani joylashtiramiz, ushbu kesmaning oxiridan 2 bo'g'in o'qiga tik yo'nalgan  $V_{AB}$  tezlik vektoriga parallel chiziq o'tkazamiz.

$O_1$  ( $V_{O_2} = 0$ ) qutb nuqtasidan  $BO_2$  chiziqqa perpendikulyar chiziq o'tkazamiz, bu chiziq  $V_{AB}$  tezlik vektori chiziqi bilan kesishadi, bu nuqtani  $\epsilon$  bilan belgilaymiz. Unda  $\pi \cdot \epsilon$  kesma  $\mu_v$  -masshtabda  $B$  nuqta tezligi  $V_B = \pi \cdot \epsilon \cdot \mu_v$  ni aniqlaydi.



Rasm-3.13. Tezlik plani

3-bo'g'in  $O_2$  nuqta atrofiga tebranma harakat qiladi. Unda  $B$  nuqtaning traektoriyasi  $R = BO_2$  radius bilan chizilgan yoy boladi,  $C$  nuqtada esa  $O_2C$  radiusdagi yoy bo'ladi.  $B$  va  $C$  nuqtalar bir-biriga qarama-qarshi tomonga parallel tekisliklarda harakatlanadi. Shuning uchun  $C$  nuqta tezlik vektori  $B$  nuqta tezlik vektoriga qarama-qarshi tomonlarga yo'naladi. Unda  $C$  nuqta tezligi quyidagi proportsiyadan topiladi:

$$\frac{O_2B}{\pi \cdot \epsilon} = \frac{O_2C}{\pi \cdot c}.$$

Tezlik planidan

$V_C = \pi \cdot c \cdot \mu_v$  nuqtaning tezligi

$$\begin{cases} V_D = V_C + V_{CD} \\ V_C = V_y + V_{Dy} \end{cases} \text{vektor tenglamadan topiladi.}$$

buerda,  $V_{DC}$  -  $D$  ning  $C$  nuqtaga nisbatan tezligi bo'lib 4-bo'g'in shqiga perpendikulyar joylashgan.  $V_y$  - qo'zg'almas  $D$  nuqtaning tezligi  $V_y = 0$ .

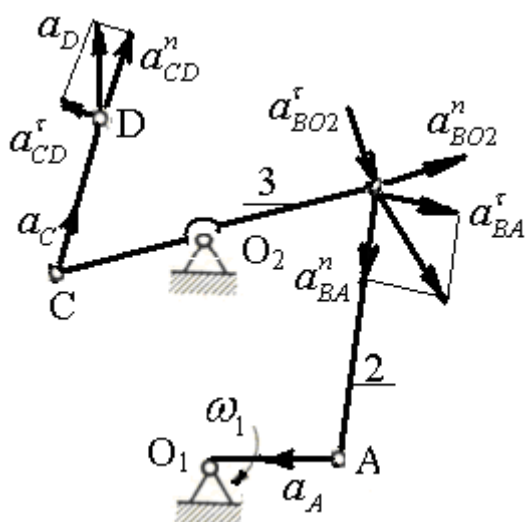
Tezlik planida  $C$  nuqta tezlik vektorining oxiridan 4-bo'g'in o'qiga perpendikulyar o'tkazamiz. Qutb nuqtasidan  $Y$  o'qida joylashgan  $D$  nuqta traektoriyasiga parallel o'tkazamiz. Unda nisbiy tezliklar kesishadi. Bu nuqtani  $d$  - bilan belgilaymiz.  $D$  nuqtaning absolyut tezligi  $V_D = \pi \cdot d \cdot \mu_v$  tenglik bilan topiladi 3 va 4 bo'g'inlarning burchak tezliklari quyidagicha topiladi:

$$\omega_3 = \frac{V_{O_2B}}{\ell_{BO_2}} = \frac{(\pi \cdot e) \cdot \mu_v}{(BO_2) \cdot \mu_\ell} \quad \text{va} \quad \omega_4 = \frac{V_{DC}}{\ell_{DC}} = \frac{(cd) \cdot \mu_v}{(DC) \cdot \mu_\ell}$$

**Tezlanish plani.** Tezlanish planini qurish uchun mexanizm bo'g'inlarining vaziyati, etakchi bo'g'in tezlik va tezlanishlari ma'lum bo'lishi kerak. Tezlanish planini qurishda tezlik planini qurish tartibidan foydalanish mumkin.  $B$  nuqta tezlanishini topishda  $A$  nuqtaning tezlanishi va 3-bo'g'in biror nuqtasining tezlanishi aniqlanishi kerak.  $A$  nuqtaning tezlanishi quyidagicha topiladi:

$$a_A = \omega_1^2 \cdot \ell_{O_1A}, \left( \frac{M}{c^2} \right)$$

1-bo'g'in aylanma va 2-bo'g'in tekis parallel harakatlanishini e'tiborga olib vektor tenglamani yozamiz:



rasm-3.14. Nuqtalar tezlanishlarining yo'nalishi

$$\left. \begin{aligned} \vec{a}_B &= \vec{a}_A + \vec{a}_{BA}^n + \vec{a}_{BA}^\tau \\ \vec{a}_B &= \vec{a}_{O_2} + \vec{a}_{BO_2}^n + \vec{a}_{BO_2}^\tau \end{aligned} \right\}$$

$a_{BA}^n, a_{BA}^\tau$  - tegishlicha,  $B$  nuqtani  $A$  nuqtaga nisbatan normal va tangentsial tezlanishlari;

$a_{O_2}$  - Qo'g'almas  $O_2$  nuqtaning tezlanishi

$a_{BO_2}^n, a_{BO_2}^\tau$  - tegishlicha,  $B$  nuqtani  $O_2$  nuqtaga nisbatan normal va tangentsial tezlanishlari.

Tenglamalar sistemasini grafik echish uchun tezlanishlar

planini qurish masshtabini tanlaymiz:  $\mu_a = \frac{a_A}{\pi_1 a_1}, \left( \frac{\frac{M}{c^2}}{MM} \right)$

$$a_{BA}^n = \frac{V_{BA}^2}{\ell_{BA}} = \frac{(av \cdot \mu_v)^2}{\ell_{BA}}, \left( \frac{M}{c^2} \right).$$

$n_1$  nuqtani hosil qilamiz.

$$a_{BO2}^n = \frac{V_{BO2}^2}{\ell_{BO2}} = \frac{(\pi \cdot \mathcal{B} \cdot \mu_V)^2}{\ell_{BO2}}, \left( \frac{M}{c^2} \right).$$
$$a_{BO2}^n \quad \text{tezlanishni} \quad \pi_1 n_2 = \frac{a_{BO2}^n}{\mu_a}$$

hosil qilamiz.  $n_1$  nuqta-dan  $a_{BA}^\tau$  - tangentsial tezlanish ta'sir chiziqiga, ya'ni  $a_1 n_1$  kesmaga perpendikulyar o'tkazamiz;

$n_2$  nuqtadan  $a_{BO2}^\tau$  tangentsial  
tezlanish ta'sir chiziqiga perpendi-  
kulyar o'tkazamiz.  $a_{BA}^\tau$  va  $a_{BO2}^\tau$

180



$$a_{BA}^{\tau} = \mu_a \cdot n_1 \theta_1 \text{ va } a_{BO2}^{\tau} = \mu_a \cdot n_2 \theta_1.$$

$C$  nuqta tezlanish vektorini  $\pi_1 C_1$  kesma aniqlaydi, uning uzunligini quyidagicha topamiz:

$$\pi_1 C_1 = \pi_1 \theta_1 \frac{O_2 C}{O_2 B}, \text{ va qiymatm } a_C = \mu_a \cdot \pi_1 C_1$$

4-bo'g'inni tekisparallel va 5-bo'g'inni ilgarilanma harakatini e'tiborga olib  $D$  nuqta tezlanishining vektor tenglamasini yozamiz:

$$\begin{cases} \bar{a}_D = \bar{a}_C + \bar{a}_{DC}^n + \bar{a}_{DC}^{\tau} & a_{DC}^n, a_{DC}^{\tau} - \text{tegishli}, D \text{ nuqtaning } C \text{ nuqtaga} \\ & \text{nisbatan normal va tangentsial tezlanishlari;} \\ \bar{a}_D = \bar{a}_y + \bar{a}_{yD} \end{cases}$$

$a_y$  - qo'zg'almas yo'naltiruvchining tezlanishi, nolga teng.

$a_{yD}$ , -  $D$  nuqtani qo'zg'almas yo'naltiruvchiga nisbatan tezlanishi.

$D$  nuqtaning  $C$  nuqtaga nisbatan normal tezlanish vektori 4-bo'g'inning o'qi bo'ylab  $D$  nuqtadan  $C$  nuqta tomon yo'naladi, tezlanish planida

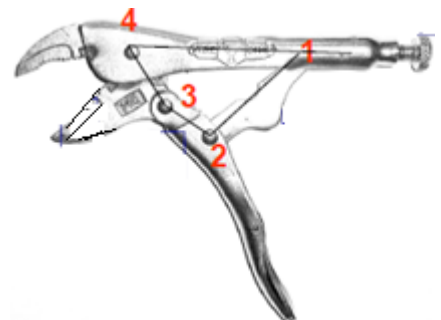
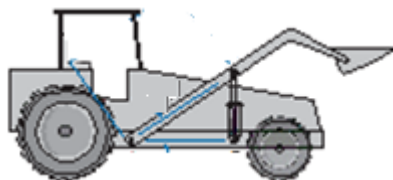
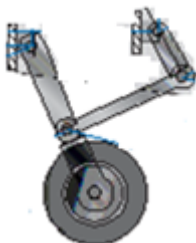
$c_1 n_3 = \frac{a_{DC}^n}{\mu_a}$  kesma uzunligi bilan belgilaymiz va qiymatini

$$a_{DC}^n = \frac{V_{DC}^2}{\ell_{DC}} = \frac{(cd \cdot \mu_V)^2}{\ell_{DC}} \text{ formuladan topamiz.}$$

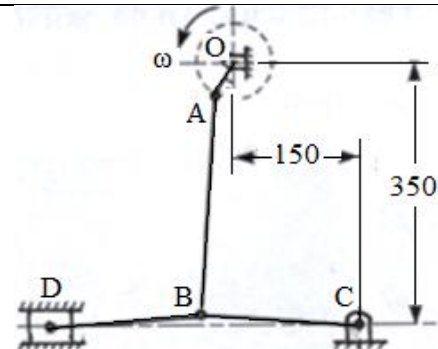
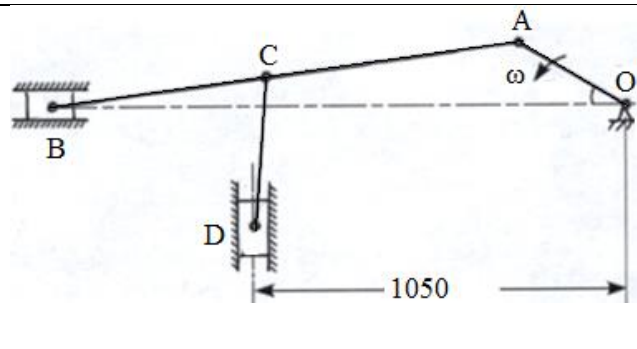
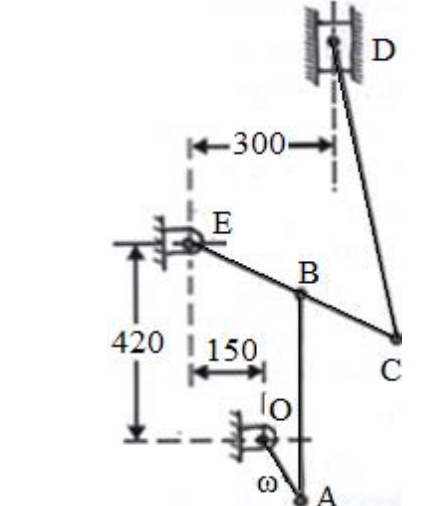
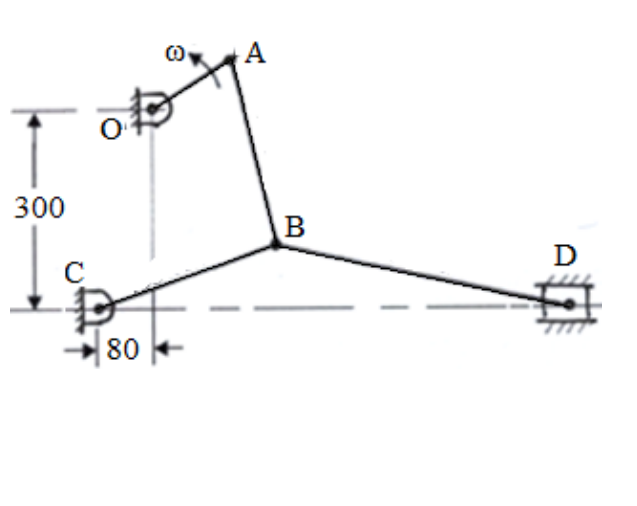
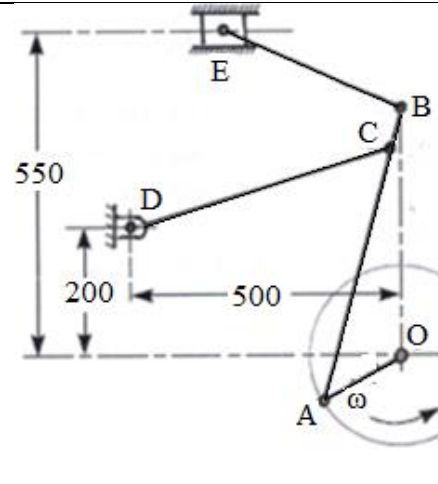
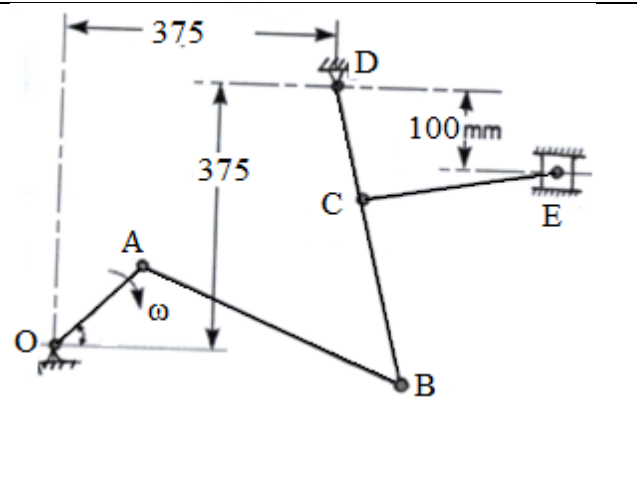
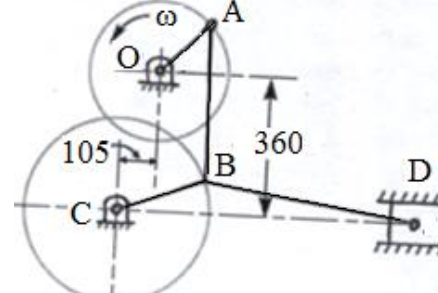
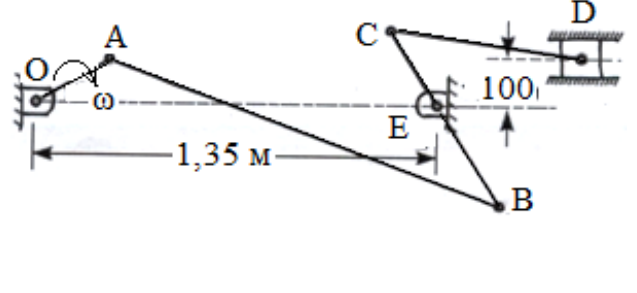
$n_3$  nuqtadan  $c_1 n_3$  kesmaga  $a_{DC}^{\tau}$  tangentsial tezlanish ta'sir chiziqini perpendikulyar o'tkazamiz.  $\pi_1$  nuqtadan 5-bo'g'in harakat yo'nalishiga parallel chiziq o'tkazamiz, u  $a_{DC}^{\tau}$  tezlanish ta'sir chiziqi bilan kesishadi. Ushbu nuqtani  $d_1$  bilan belgilaymiz.  $\pi_1 d_1$  kesma berilgan tezlanish plani masshtabida 5-bo'g'in tezlanishi  $a_D$  -ni ifodalaydi.

$$\text{Tezlanish planidan } a_D = \mu_a \cdot n_3 d_1 \text{ va } a_{DC}^{\tau} = \mu_a \cdot n_3 d_1$$

Berilgan konstruktsiyalar uchun mexanizmni kinematik sxemasini chizing



**misol-3.5.** Berilgan mexanizmlar uchun vaziyatlar sxemasini chizing va etaklanuvchi nuqta tezlik va tezlanishini planlar usulida tahlil qiling.

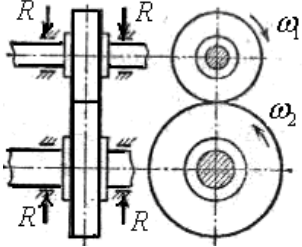
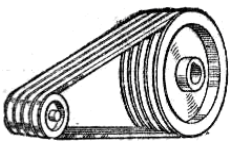
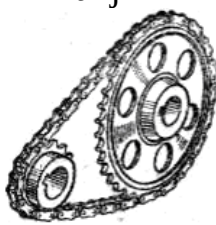
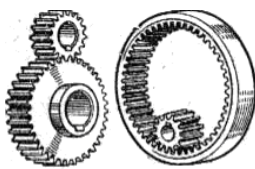
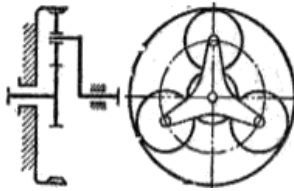
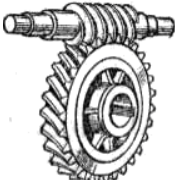
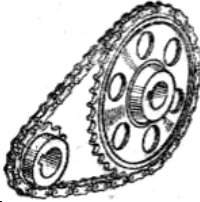
|   |                                                                                     |    |                                                                                      |
|---|-------------------------------------------------------------------------------------|----|--------------------------------------------------------------------------------------|
| 1 |    | 9  |    |
| 2 |   | 10 |   |
| 3 |  | 11 |  |
| 4 |  | 12 |  |

|   |  |        |  |
|---|--|--------|--|
| 5 |  | 1<br>3 |  |
| 6 |  | 1<br>4 |  |
| 7 |  | 1<br>5 |  |
| 8 |  | 1<br>6 |  |
|   |  | 1<br>7 |  |

## IV-BOB. MASHINA DETALLARI

Texnik mexanikaning mashina detallari qismida mexanik uzatmalarni tanlash va hisoblash usullari o'rganiladi.

### Mexanik uzatmalarning klassifikatsiyasi

| Ta'sirlashuvga ko'ra                                                                                     | Bo'g'inlarning joylashuviga ko'ra                                                                         |                                                                                                  |                                                                                                     |                                                                                                   |
|----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|
|                                                                                                          | Tegishib harakat uzatadi                                                                                  |                                                                                                  | Elastik bog'lanishli                                                                                |                                                                                                   |
| Ishqalanish uzatishlari                                                                                  | friksion<br>             |                                                                                                  | tasmali<br>      | zanjirli<br>   |
|                                                                                                          | Ilashib uzatish                                                                                           |                                                                                                  |                                                                                                     |                                                                                                   |
| tsilindrik tishli<br> | konussi-mon tishli<br> | planetar<br> | chervyakli<br> | zanjirli<br> |

### Bir pog'onali maxanik uzatmalarning asosiy parametrlari [26]

| Uzatmaning turi                                               | Uzatishlar soni                            | Taxminiy quvvat, kVt                                    | FIK ( KPD)                                        |
|---------------------------------------------------------------|--------------------------------------------|---------------------------------------------------------|---------------------------------------------------|
| Tishli:<br>tsilindrik<br>konussimon<br>planetar<br>chervyakli | 6,3 gacha<br>5 gacha<br>15 gacha<br>8...80 | Chegaralanmagan<br>4000 gacha<br>5000 gacha<br>60 gacha | 0,97...0,98<br>0,97<br>0,95...0,99<br>0,70...0,92 |
| Zanjirli                                                      | 8 gacha                                    | 120 gacha                                               | 0,92...0,96                                       |
| Tasmali                                                       | 6 gacha                                    | 50 gacha                                                | 0,94...0,96                                       |
| Friksion                                                      | 7 gacha                                    | 20 gacha                                                | 0,85...0,95                                       |

$i_{12} > 1$ ,  $\omega_1 > \omega_2$  bo'lsa, uzatma sekinlatuvchi, u reduktor deyiladi.

$i_{12} < 1$ ,  $\omega_1 < \omega_2$  bo'lsa, uzatma tezlatuvchi, u multiplikator deyiladi.

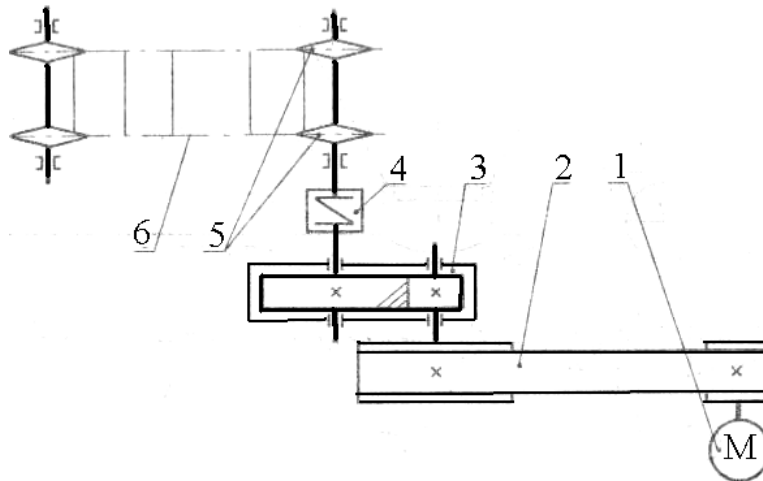
Mexanik uzatmalar yuritmaning tarkibiga kiradi. Shuning uchun yuritmaning ayrim parametrlarni hisoblaymiz

## Yuritmani kinematik va kuch munosabatlarini hisoblash tartibi

jadval -4.1

| Nima qilish kerak                                                                  | Nimadan foydalanish lozim                                                                                                                                                                                             |                                                      |                                 |
|------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|---------------------------------|
| 1.Yuritmani kinematik sxemasi tanlanadi                                            | Loyihaga texnik topshiriqda beriladi.                                                                                                                                                                                 |                                                      |                                 |
| 2. Konveyer uchun talab etilgan quvvat va barabanining burchak tezligi aniqlanadi. | a) Konveyer lentasining yoki zanjirining tortish kuchi $F$ va harakat tezligi texnik topshiriqda beriladi                                                                                                             |                                                      |                                 |
|                                                                                    | b) konveyerni ishlashi uchun kerak bo'lgan quvvat aniqlanadi<br>$N_{\epsilon.M} = F \cdot V$ yoki $N_{\epsilon.M} = M \cdot \omega_{\epsilon.M}$                                                                      |                                                      |                                 |
|                                                                                    | v) konveyer barabani valining aylanishlari soni va burchak tezligi :<br>lentali konveyer $n_{\epsilon.M} = \frac{60 \cdot 10^3 v}{\pi \cdot D}$<br>zanjirli konveyer $n_{\delta} = \frac{60 \cdot 10^3 v}{z \cdot t}$ |                                                      |                                 |
| 3.Yuritmaning (uzatmaning) FIK tanlanadi                                           | I-1 ilovadan qarang                                                                                                                                                                                                   |                                                      |                                 |
| 4. Talab etilgan quvvat topiladi                                                   | $P_{mp} = \frac{N_{\delta}}{\eta_{ym}}$ , kVt .                                                                                                                                                                       |                                                      |                                 |
| 5.Elektrodvigatel tanlanadi.                                                       | $P_{\delta\epsilon} \geq P_{mp}$ shartidan foydalanamiz<br>I-2 va I-29 ilovalardan qarang                                                                                                                             |                                                      |                                 |
| 6. Uzatmaning uzatishlari tanlanadi<br>$i = \frac{n_{HOM}}{n_{\epsilon.M}}$        | Tishli uzatma $i = 2 \dots 6$<br>Chervyakli uzatma $i = 8 \dots 80$<br>Ochiq tishli uzatma $i = 3 \dots 7$<br>Zanjirli uzatma $i = 2 \dots 7$<br>Tasmali uzatma $i = 2 \dots 4$                                       |                                                      |                                 |
| 7. Yuritmaning kinematik va kuch munosabyuatlari                                   | Aylanish chastotasi                                                                                                                                                                                                   | Burchak tezlik                                       | Aylantiruvchi moment            |
|                                                                                    | $n_1 = n_{\delta\epsilon}$                                                                                                                                                                                            | $\omega_1 = \frac{\pi \cdot n_{\delta\epsilon}}{30}$ | $M_1 = \frac{P_{mp}}{\omega_1}$ |
|                                                                                    | $n_2 = \frac{n_1}{i_{12}}$                                                                                                                                                                                            | $\omega_2 = \frac{\omega_1}{i_{12}}$                 | $M_2 = M_1 \cdot i_{12}$        |
|                                                                                    | $n_{\epsilon.M}$                                                                                                                                                                                                      | $\omega_3 = \frac{\omega_2}{i_{23}}$                 | $M_3 = M_2 \cdot i_{23}$        |

## Yuritmaning kinematik va kuch munosabatlariga oid misolla echish. Elektrodvigatelni tanlash



**misol–4.1.** Zanjirli konveyer uchun yuritma bir pog'onali gorizotal tsilindrik reduktor va tasmali uzatmadan tashkil topgan yuritma.

*rasm-4.1. 1- dvigatel, 2- tekis tasmali uzatma, 3-tsilindrik reduktor, 4- elastik mufta, 5-konveyerning etaklovchi yulduzchasi, 6- tortish zanjiri*

**Berilgan:** Tortish kuchi  $F = 4,8 \cdot \kappa H$  va zanjirning tezligi  $v = 0,65 \cdot \frac{M}{c}$ , yulduzcha tishlarining qadami  $t = 80 \text{ mm}$  va soni  $z = 7$

**echish.** Yuritmaning vallaridagi burchak tezliklar va aylantiruvchi momentlar hisoblansin.

Barabanning validagi quvvat va burchak tezlikni topamiz:

$$N_{\delta} = F \cdot v = 4,8 \cdot 0,60 = 2,88 \kappa \text{em} \quad \text{va}$$

$$n_{\delta} = \frac{60 \cdot 10^3 v}{z \cdot t} = \frac{60 \cdot 10^3 \cdot 0,65}{7 \cdot 80} = 69,28 \frac{\text{ayl}}{\text{min}},$$

Reduktor uzoq muddat foydalaniladi, ishlash bir smenali, vallar dumalash podshipniklariga o'rnatilgan. Qo'yilgan vazifalarni bajarish – yuritmaga nisbatan belgilangan talablar asosida tanlangan elektrodvigatelni xarakteristikalariga bog'liq

**Elektrodvigatelni tanlash va yuritmaning kinematikasini hisoblash.**

Dvigatel mashina agregatining asosiy elementi hisoblanadi. Ishchi mashina va yuritmaning konstruktiv va ekspluatatsion xarakteristikalarini dvigatelning turi, quvvati, valining aylanish chastotasiga bog'liq.

Yuritmaning foydali ish koeffitsienti (FIK) tsilindrik tishli g'ildirak uchun  $\eta_1 = 0,98$ ; bir juft dumalash podshipnikalar uchun  $\eta_2 = 0,99$ ; ochiq tekis tasmali uzatma uchun FIK.  $\eta_3 = 0,97$  va konveyer barabanining tayanchlaridagi FIK  $\eta = 0,99$  - larning ko'paytmalariga teng ( I-1. jadval )

$$\eta_{ym} = \eta_1 \cdot \eta_2^2 \cdot \eta_3 \cdot \eta_4 = 0,98 \cdot 0,99^2 \cdot 0,97 \cdot 0,99 = 0,922$$

Elektrodvigatelni talab etilgan quvvati:

$$P_{mp} = \frac{N_{\delta}}{\eta_{ym}} = \frac{2,88}{0,922} = 3,12 \text{ kBm}$$

$P_{\delta} \geq P_{mp}$ , ya'ni tanlangan elektrodvigatelning quvvati talab etilgan quvvatdan kichik bo'lmashligi shartidan foydalanib AOP2 seriyali quvvati 4 kvv bo'lgan uch fazali, asinxron dvigatelli, shamollatib sovutiladigan elektrodvigatelni tanlaymiz [7.1-29].

Elektrodvigatellar katalogining standart qatorida bir xil quvvatli, valining aylanish chastotasi bir necha xil -  $n_c = 3000 - 1500 - 1000 - 750 \frac{\text{a\ddot{u}l}}{\text{min}}$  belgilangan.

Dvigatelning optimal turi, uzatmaning turi, ishchi mashinaning kinematik xarakteristikasiga, yuritma va pog'onalari uzatishlarining nisbatini aniqlashga bog'liq. Keltirilgan elektrodvigatellardan samarali bo'lganini tanlashimiz lozim.

Katta tezlikda ishlaydigan konveyer uchun yuqori aylanish chastotasiga ega bo'lgan elektrodvigatel, yoki aksincha past tezlikda ishlaydigan konveyer uchun kichik aylanish chastotasiga ega bo'lgan elektrodvigatel tanlanadi. Yuqori

chastotali aylanishlar sonida ( $n_{\delta} = 3000 \frac{\text{a\ddot{u}l}}{\text{min}}$ ) dvigatel kam resursli va kichik

chastotali aylanishlar sonida ( $n_{\delta} = 750 \frac{\text{a\ddot{u}l}}{\text{min}}$ ) dvigatellarda metall sarfi ko'p bo'ladi, shuning uchun zarurat bo'lmasa bunday kam quvvatli dvigatellar qo'llanilmaydi.

Ushbu holatdan kelib chiqib  $P_{mp} = 4 \text{ kBm}$  quvvatli elektrodvigatelning ikkita turini ko'rib chiqamiz.

1-variant AOP2 -41-4 markali elektrodvigatel valining nominal aylanishlari chastotasi  $n_{\delta} = 1440 \frac{\text{a\ddot{u}l}}{\text{min}}$

2-variant AOP2 -42-6 markali elektrodvigatel valining nominal aylanishlari chastotasi  $n_{\delta} = 955 \frac{\text{a\ddot{u}l}}{\text{min}}$

2 ta elektrodvigateldan qaysi birini tanlash konveyer ishlashining kinematik va energetik talabiga bog'liq.

**Yuritmnining uzatishlari nisbati**—dvigatel valining nominal aylanishlari chastotasi ( $n_{\text{HOM}}$ ) ni ishchi mashina harakatlantiruvchi valining aylanishlari

chastotasi ( $n_{\text{BM}}$ ) ga nisbatiga teng:  $i = \frac{n_{\text{HOM}}}{n_{\text{BM}}}$

$$n_{\text{BM}} = \frac{60 \cdot 10^3 v}{\pi \cdot D} - \text{yuritmaning etaklanuvchi valining aylanishlari soni}$$

lentali konveyer uchun

buerda,  $V$  - konveyer tezligi;  $D$  -baraban diametri;

Yuritmnining uzatishlari nisbati tanlangan elktrodvigatel valining aylanish chastotasiga bog'liq:

$$1\text{-variant } i = \frac{n_{\partial\epsilon}}{n_{\delta}} = \frac{1440}{69,28} = 20,78$$

$$2\text{-variant } i = \frac{n_{\partial\epsilon}}{n_{\delta}} = \frac{955}{69,28} = 13,78$$

Yuritmaning umumiy uzatishlari nisbati tasmali va tsilindrik tishli reduktor uzatishlari sonlari standart qiymatlarining ko'paytmalariga teng:

$$i = i_{LP} \cdot i_{TV}$$

Tasmali uzatma uzatishlari soni  $i_{TV} = 2..4$  va tsilindrik tishli reduktor uzatishlari soni  $i_{LP} = 3..6$  oraliqda o'zgaradi.

| Yuritmnning uzatishlari nisbati<br>$i = \frac{n_{\partial\epsilon}}{n_{\delta}}$ | Uzatmalarning uzatishlari soni           |                                               |
|----------------------------------------------------------------------------------|------------------------------------------|-----------------------------------------------|
|                                                                                  | Tsilindrik reduktor uchun tanlab olinadi | Tasmali uzatma<br>$i_{TV} = \frac{i}{i_{LP}}$ |
| $i = 20,78$                                                                      | $i_{up} = 6$                             | $i_{TV} = \frac{20,78}{6} = 3,46$             |
| $i = 13,78$                                                                      | $i_{up} = 6$                             | $i_{TV} = \frac{13,78}{6} \approx 2,3$        |

Tsilindrik reduktor uzatishlari soni o'zgarmagan holda yuritmaning uzatishlari nisbati ortib borsa tasmali uzatma uzatishlari soni xam kattalashib boradi. Bu esa tasmali uzatma etaklanuvchi shkivining diametrini ortishiga va natijada yuritmaning gabarit o'lchamlarini kattalashishiga olib keladi.

Alohida uzatmalar uzatishlari sonlarining kichikroq qiymatlari qabul qilinsa, yuritmaning va uzatmaning geometrik o'lchamlari kichikroq bo'ladi. Shuning uchun reduktor etaklovchi valining nominal aylanishlari chastotasi  $n_{\partial\epsilon} = 955 \frac{\text{a\ddot{u}l}}{\text{min}}$  bo'lgan AOP2 -42-6 markali elektrodvigatelni qabul qilamiz ( $i = 13,71$ ,  $i_{up} = 6$  va  $i_{TV} = 2,3$ ).

**Yuritmaning kinematik va kuch munosabatlari.** Valning kinematik munosabatlari vallarning aylanish chastotasi va burchak tezligi bilan xarakterlansa, kuch munosabatlarini vallardagi aylantiruvchi momentlar tashkil etadi.

$$1\text{-val. aylanish chastotasi} - n_1 = n_{\partial\epsilon} = 955 \frac{\text{a\ddot{u}l}}{\text{min}}$$

$$\text{burchak tezligi, } \omega_1 = \frac{\pi \cdot n_{\partial\epsilon}}{30} = \frac{\pi \cdot 955}{30} = 99,96 \text{ } c^{-1}$$

$$\text{aylantiruvchi moment } M_1 = \frac{P_{mp}}{\omega_1} = \frac{3,12 \cdot 10^3}{99,96} = 31,2 \cdot 10^3 \text{ } H \cdot \text{mm}$$



$$\text{2-val. aylanish chastotasi} - n_2 = \frac{n_1}{i_{TY}} = \frac{955}{2,3} = 415,22 \frac{\text{a\ddot{y}l}}{\text{min}}$$

$$\text{burchak tezligi,} - \omega_2 = \frac{\omega_1}{i_{TY}} = \frac{99,96}{2,3} = 43,46 \text{ } c^{-1}$$

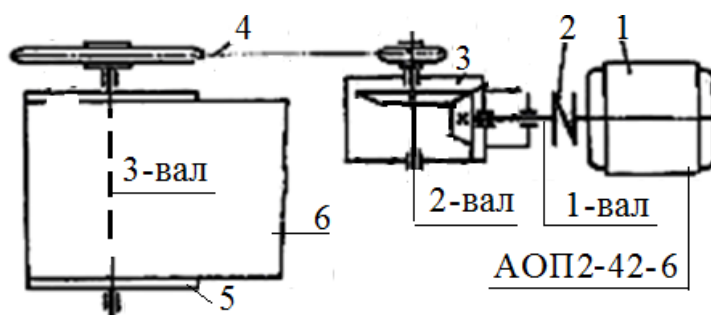
$$\text{aylantiruvchi moment} \quad M_2 = M_1 \cdot i_{TY} = 31,2 \cdot 10^3 \cdot 2,3 = 71,76 \cdot 10^3 \text{ H} \cdot \text{mm}$$

$$\text{3-val. aylanish chastotasi} - n_3 = \frac{n_2}{i_{LP}} = \frac{415,2}{6} = 69,20 \frac{\text{a\ddot{y}l}}{\text{min}}$$

$$\text{burchak tezligi,} - \omega_3 = \frac{\omega_2}{i_{LP}} = \frac{43,46}{6} = 7,29 \text{ } c^{-1}$$

$$\text{aylantiruvchi moment} \quad M_3 = M_2 \cdot i_{LP} = 71,76 \cdot 10^3 \cdot 6 = 430,6 \cdot 10^3 \text{ H} \cdot \text{mm}$$

**misol –4. 2.** Lentali konveyer uchun zanjirli uzatma va bir pog'onali konussimon reduktordan tashkil topgan yuritma berilgan. Yuritma uchun bir pog'onali konussimon reduktor loyihalansin.



rasm-4.2. 1. Elektrodvigatel, 2. Mufta, 3. Konussimon reduktor. 4. Zanjirli uzatma. 5. Xarakatlan-tiruvchi baraban. 6. Lenta.

Lentali konveyerni talab etgan quvvati  $N_3 = 3,12 \text{ kBm}$ , konveyer barabanining burchak tezligi  $\omega_6 = 5,6 \text{ } c^{-1}$ , reduktor bir smena ishlaydi, vallar dumalash podshipniklariga o'rnatilgan.

**echish.** 1. Berilgan yuritma uchun elektrodvigatelni tanlash

Yuritmani foydali ish koeffitsientini aniqlaymiz [7.I-1]:

$$\eta_{ym} = \eta_1 \cdot \eta_2 \cdot \eta_3 \cdot \eta_4 = 0,97 \cdot 0,92 \cdot 0,99^2 \cdot 0,99 = 0,866$$

buerda:  $\eta_1 = 0,97$  - konussimon g'ildiraklarning f.i.k.;  
 $\eta_2 = 0,99$  – dumalash podshipniklarning f.i.k.;  
 $\eta_3 = 0,92$  – ochiq zanjirli uzatmaning f.i.k.  
 $\eta_4 = 0,99$  – konveyer barabani uchun f.i.k.

$$\text{Elektrodvigatelni talab qilgan quvvati.} \quad N_{TP} = \frac{N_3}{\eta_{ym}} = \frac{3,12}{0,866} = 3,6 \text{ kBm}$$

Quvvati  $N_{og} = 4 \text{ kVt}$  bo'lgan AOP2-42-6 elektrodvigatelni tanlaymiz:

AOP2-42-6 elektrodvigateli  $n_{\delta\epsilon} = 955 \frac{\text{aйл}}{\text{мин}}$   $d_{\delta\epsilon} = 32 \text{ мм}$

Elektrodvigatel valining burchak tezligi

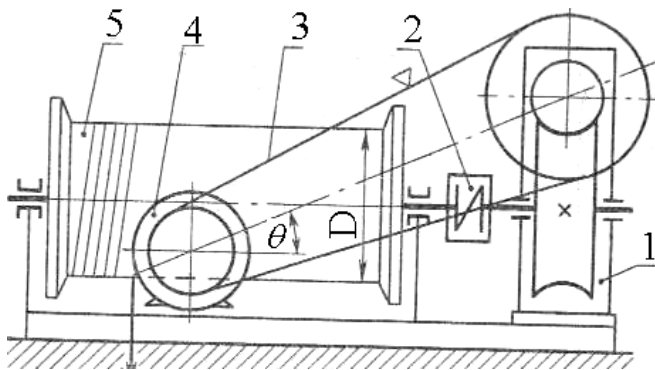
$$\omega_{\delta\epsilon} = \omega_1 = \frac{\pi \cdot n_{\delta\epsilon}}{30} = \frac{3,14 \cdot 955}{30} = 99,96 \frac{\text{p}}{\text{c}}$$

Yuritmaning umumiy uzatishlari nisbati.  $i = \frac{\omega_{\delta\epsilon}}{\omega_{\delta}} = \frac{99,96}{5,6} = 17,85$

Reduktor uchun uzatishlar sonini  $i_p = i_1 = 3,15$  qabul qilamiz va zanjirli uzatmaning uzatishlar sonini aniqlaymiz:  $i_s = \frac{i}{i_p} = \frac{17,85}{3,15} = 5,67$

Yuritmaning vallarida kinematika va kuch munosabatlari:

| Val   | Burchak tezlik                                                                   | Aylantiruvchi moment                                                                     |
|-------|----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| 1-val | $\omega_1 = 99,96 \text{ c}^{-1}$                                                | $M_1 = \frac{N_1}{\omega_1} = \frac{3,59 \cdot 10^3}{99,96} = 36 \cdot 10^3 \text{ Hмм}$ |
| 2-val | $\omega_2 = \frac{\omega_1}{i_{my}} = \frac{99,96}{3,15} = 31,73 \text{ c}^{-1}$ | $M_2 = M_1 \cdot i_p = 36 \cdot 10^3 \text{ Hмм}$                                        |
| 3-val |                                                                                  | $M_3 = M_2 \cdot i_s = 643 \cdot 10^3 \text{ Hмм}$                                       |



rasm -4.3.

**misol –4. 3.** Elektrik lebedka uchun bir pog'onali chervyakli reduktor va ponasimon tasmali uzatmadan tashkil topgan yuritma hisoblansin.

Elektrik lebedka yuritmasi

1- chervyakli reduktor,

2- elastik mufta,

3.ponasimon tasmali uzatma, 4- dvigatel, 5- lebedka barabani

Lebedkaning yuk ko'tarish qobiliyati  $F = 5 \kappa H$  va tezligi

$v = 0,8 \frac{\text{m}}{\text{c}}$ , baraban diametri  $D = 500 \text{ мм}$ , tasmali uzatmaning qiyalik

burchagi  $45^\circ$ . Etaklanuvchi valdagi quvvat  $N_3 = F \cdot v = 5 \cdot 0,8 = 4 \kappa \text{ вт}$  va

aylanishlar chastotasi  $n_3 = \frac{60 \cdot v}{\pi \cdot D} = \frac{60 \cdot 0,8}{3,14 \cdot 0,5} = 30,57 \frac{\text{aйл}}{\text{мин}}$

**echish.** 1. Yuritmaning umumiy foydali ish koeffitsienti

$$\eta_{ym} = \eta_{my} \cdot \eta_{\text{чп}} \cdot \eta_{\text{нод}} \cdot \eta_{\delta} = 0,96 \cdot 0,82 \cdot 0,99^2 \cdot 0,99 = 0,764$$

buerda,  $\eta_{my} = 0,96$  - tasmali uzatmaning f.i.k.;

$\eta_{nod} = 0,99$  – dumalanuvchi podshipniklarning f.i.k.;

$\eta_{\text{чр}} = 0,82$  – chervyakli reduktorning f.i.k. ( $z_1 = 2$ ),

$\eta_4 = 0,99$  – lebedka barabani uchun f.i.k. [7.I-1]

### **Elektrodvigatelni tanlash va kinematik hisoblash**

- elektrodvigatelni talab qilgan quvvati

$$N_{Tp} = \frac{N_3}{\eta} = \frac{4}{0,764} = 5,236 \text{ kBm}$$

AOP2–42 -4 markali asinxron elektrodvigatelni tanlaymiz [22]:

quvvati  $N_{\text{дв}} = 5,5 \text{ kBm}$ , valni aylanish chastotasi  $n_{\text{дв}} = 1440 \frac{\text{айл}}{\text{мин}}$ ,

val diametri  $d_{\text{дв}} = 32 \text{ мм}$ .

$$\text{Yuritmani uzatishlar soni } i = \frac{n_{\text{дв}}}{n_3} = \frac{1440}{30,57} = 47,1$$

Chervyakli reduktor uzatishlari sonini  $i_{\text{чр}} = 20$  qabul qilamiz

$$\text{Tasmali uzatma uzatishlarining soni } i_{my} = \frac{i}{i_{\text{чр}}} = \frac{47,1}{20} = 2,355$$

### **Yuritmanig kinematik va kuch munosabatlari**

|        |                                                                                        |                                                                                     |
|--------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| 1 -val | $n_1 = n_{\text{дв}} = 1440 \frac{\text{айл}}{\text{мин}}$                             | $\omega_1 = \omega_{\text{дв}} = \frac{\pi \cdot 1440}{30} = 150,72 \text{ c}^{-1}$ |
| 2 -val | $n_2 = \frac{n_1}{i_{my}} = \frac{1440}{2,355} = 611,46 \frac{\text{айл}}{\text{мин}}$ | $\omega_2 = \frac{\omega_1}{i_{my}} = \frac{150,72}{2,355} = 64 \text{ c}^{-1}$     |
| 3 -val | $n_3 = 30,57 \frac{\text{айл}}{\text{мин}}$                                            | $\omega_3 = 3,2 \text{ c}^{-1}$                                                     |

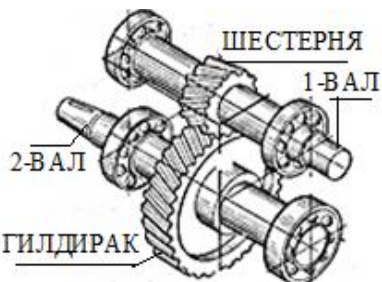
Aylantiruvchi momentlarni hisoblaymi:

$$1\text{-val. } M_1 = \frac{N_1}{\omega_1} = \frac{5,236 \cdot 10^3}{150,72} = 34,74 \text{ Hм} = 34,74 \cdot 10^3 \text{ H} \cdot \text{мм}$$

$$2\text{-val. } M_2 = M_1 \cdot i_{my} = 34,74 \cdot 10^3 \cdot 2,355 = 81,81 \cdot 10^3 \text{ H} \cdot \text{мм}$$

$$3\text{-val. } M_3 = M_2 \cdot i_{\text{чр}} = 81,81 \cdot 10^3 \cdot 20 = 1636,2 \cdot 10^3 \text{ H} \cdot \text{мм}$$

## Tsilindrik to'g'ri tishli uzatmani hisoblash ketma-ketligi

| Nima qilish kerak                                                                                                                                                                                             | Nimadan foydalanish lozim                                                                                                                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Tez yurar valning burchak tezligi va uzatishlari sonidan sekin yurar valning burchak tezligini aniqlash.<br>Uzatmaning gabarit o'lchamlarini kattalashib ketmasligi uchun $i = 6$ dan katta olmaslik kerak | $\omega_2 = \frac{\omega_1}{i_2}$ yoki $n_2 = \frac{n_1}{i_2}$<br>Agar, tez yurar val elektrodvigatel vali bilan biriktirilsa $\omega_1 = \omega_{\partial\theta}$<br>va $n_1 = n_{\partial\theta}$ $i = 2 \dots 6$ |
| 2. Shesternya va g'ildirak uchun material tanlash.                                                                                                                                                            | I-5. jadvalni qarang                                                                                                                                                                                                |
| 3. G'ildirak uchun ruxsat etilgan kontaktli kulanishni aniqlash                                                                                                                                               | $[\sigma]_H = 2,75HB$ [21]                                                                                                                                                                                          |
| 4. G'ildirak gardishining eni koefitsientini tanlaymiz                                                                                                                                                        | $\psi_b = \frac{b}{a_w}$ , $\psi_b = 0,125 \dots 0,4$                                                                                                                                                               |
| 5. Yuklanish koefitsientini tanlaymiz<br>$K_H = K_{H\alpha} \cdot K_{H\beta} \cdot K_{HV}$ –                                                                                                                  | I-3, I-6, I-7 jadvallarni qarang                                                                                                                                                                                    |
| 6. Shesternya validagi hisobiy momentni aniqlaymiz                                                                                                                                                            | $M_1 = \frac{N_1}{\omega_1}$ , Nmm.                                                                                                                                                                                 |
| 7. O'qlararo masofani aniqlaymiz                                                                                                                                                                              | $a_w = (i+1)^3 \sqrt{\left(\frac{310}{[\sigma]_H \cdot i}\right)^2 \cdot \frac{M_2 K_H}{\Psi_b}}$                                                                                                                   |
| 8. Tishli g'ildiraklar gardishining enini aniqlaymiz                                                                                                                                                          | $b = \psi \cdot a_w$                                                                                                                                                                                                |
| 9. Tish modulini qabul qilamiz                                                                                                                                                                                | $m = (0,01 \dots 0,02) a_w$ –                                                                                                                                                                                       |
| 10. Tishlar sonini aniqlaymiz:<br>shesternya ( $z_1$ ) va g'ildirak ( $z_2$ )                                                                                                                                 | $z_\Sigma = \frac{2a_w}{m}$ , $z_1 = \frac{z_\Sigma}{i+1}$ , $z_2 = i \cdot z_1$                                                                                                                                    |
| 11. O'qlararo masofani aniqlash-tiramiz                                                                                                                                                                       | $a_w = \frac{z_1 + z_2}{2} m$                                                                                                                                                                                       |
| 12. Tishli uzatmani kontaktli kuchlanishga mustahkamligini tekshiramiz                                                                                                                                        | $\sigma_H = \frac{310}{a_w} \sqrt{\frac{K_H M_2 (u+1)^3}{b \cdot u^2}} \leq [\sigma]_H$                                                                                                                             |
| 13. Shesternya va g'ildirakning asosiy o'lchamlari:<br><br>                                                                | tishning balandligi $h = 2,25m_t$                                                                                                                                                                                   |
|                                                                                                                                                                                                               | tish uchining balandligi $h_a = m_t$                                                                                                                                                                                |
|                                                                                                                                                                                                               | tish tubining balandligi $h_f = 1,25m_t$                                                                                                                                                                            |
|                                                                                                                                                                                                               | bo'luvchi aylana diametri $d = m_t \cdot z$                                                                                                                                                                         |
|                                                                                                                                                                                                               | tish uchi va tubi aylanalarining diametri<br>$d_f = m_t(z - 2,5)$<br>$d_a = m_t(z + 2)$                                                                                                                             |

## Tsilindrik qiyshiq tishli uzatmani hisoblash tartibi

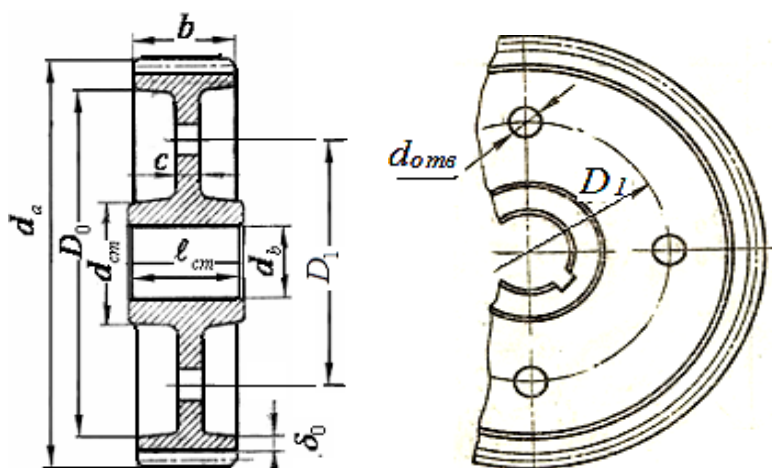
jadval -4.3

| Nima qilish kerak                                                                            | Nimadan foydalanish lozim                                                                               |
|----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| 1, 2,3,4,5,6 ,7,8,9 va 13 bandlar to'g'ri tishli uzatmalarni hisoblash tartibi bilan bir xil |                                                                                                         |
| 7. O'qlararo masofani aniqlaymiz                                                             | $a_w = (i+1)^3 \sqrt{\left(\frac{270}{[\sigma]_H \cdot i}\right)^2 \cdot \frac{M_2 \cdot K_H}{\Psi_b}}$ |
| 10. Tishlar sonini aniqlaymiz                                                                | $z_\Sigma = \frac{2a_w}{m} \cos \beta_{\min}$                                                           |
| Shesternya tishlarining soni                                                                 | $z_1 = \frac{2a_w \cos \beta}{(i+1)m_n}$                                                                |
| Tishning qiyalik burchagini taqriban qabul qilish                                            | $\beta = 8 \dots 15^\circ$ , birlamchi hisoblashda<br>$\beta = 10^\circ$ qabul qilinadi                 |
| 11. O'qlararo masofani aniqlash-tiramiz                                                      | $a_w = \frac{z_1 + z_2}{2 \cos \beta} m$                                                                |
| Tishning qiyalik burchagini aniqlashtirish                                                   | $\cos \beta = \frac{(z_1 + z_2)m_n}{2a_w}$                                                              |
| Bo'luvchi aylana diametri                                                                    | $d = \frac{m_n \cdot z}{\cos \beta}$                                                                    |
| 12.Tishli uzatmani kontaktli kuchlanishga mustahkamligini tekshiramiz                        | $\sigma_H = \frac{270}{a_w} \sqrt{\frac{K_H M_2 (u+1)^3}{b \cdot u^2}} \leq [\sigma]_H$                 |

## Tishli g'ildirak o'lchamlari

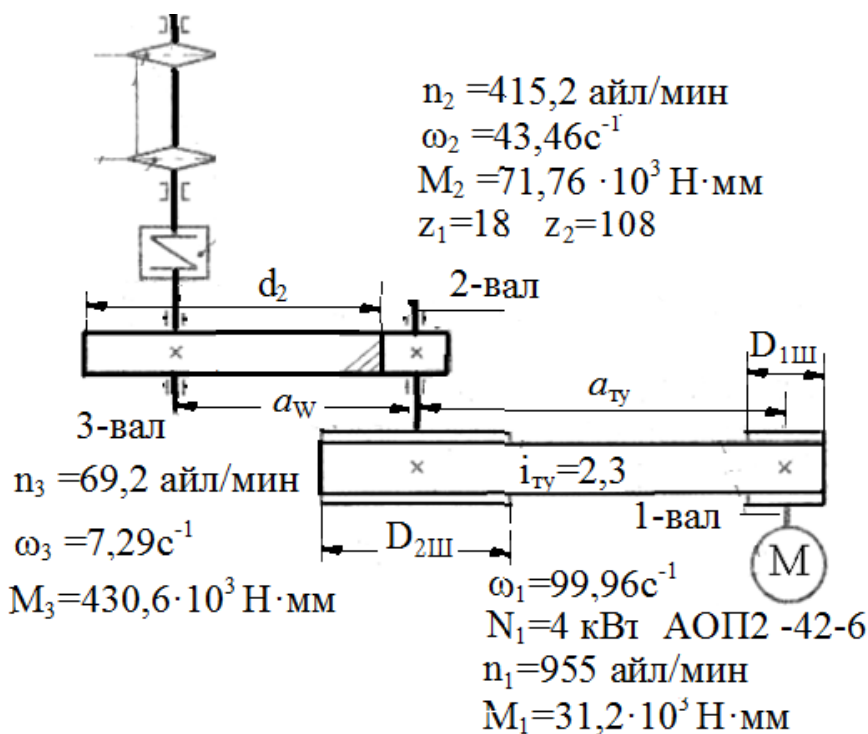
jadval -4.4

| № | Tishli g'ildirak elementlari                               | hisoblash formulasi                                             |
|---|------------------------------------------------------------|-----------------------------------------------------------------|
| 1 | diskni engillashtiruvchi teshiklar diametri                | $d_{om} = \frac{D_0 - d_{cm}}{4}$                               |
| 2 | stupitsa: diametri va uzunligi                             | $d_{cm} = 1,6d_b \quad \text{va} \quad \ell_{cm} = 1,1b$        |
| 3 | obod: qalinligi va diametri                                | $\delta_0 = (2,5 \dots 4,0)m, \quad d_{ob} = d_a - 8,5 \cdot m$ |
| 4 | tish uzunligi                                              | $b = (6 \dots 8)m$                                              |
| 5 | disk qalinligi                                             | $c = (0,2 \dots 0,3)b$                                          |
| 6 | val uchun teshik diametri                                  | $d_b = 0,2 \cdot d_a$                                           |
| 7 | diskni engillashtiruvchi teshiklar markazlarining diametri | $D_1 = 0,5 \cdot (D_o + d_{cm})$                                |
| 8 | Obod tub qismi aylanasi diametri                           | $D_0 = d_a - 2(h + \delta_0)$                                   |



4.4- rasm. Tsilindrik  
tishli g'ildirak  
( quyma )  $d_a < 600 \text{ мм}$

**Bir pog'onali tsilindrik uzatama tishli g'ildiraklarini hisoblash.**



**misol-4.4.** Yuritma  
vallarining ayla-nishlari  
chastotasi, burchak  
tezliklari va aylanti-  
ruvchi momentlari  
ko'rsatilgan sxemasi  
(rasm-4.5).

$a_w, a_{TU}$  – tegishli  
reduktor va tasmali  
uzatmaning o'qlararo  
masofasi;

$D_{1ш}, D_{2ш}$  – tasmali  
uzatma kata va kichik  
shkivlarining  
diametrlari

**Uzatma tishli g'ildiraklarini hisoblash.** G'ildirak va shesternya uchun material sifatida, o'rtacha mexanik xarakteristikali legirlangan 40X markali po'latni tanlaymiz. Tanlangan material termik ishlanganda quyidagi ko'rsatkichlarga erishiladi deb olinadi: g'ildirak tishlari uchun HB- 200; shesternya uchun HB - 230.

Ruxsat etilgan kontakt kuchlanishi. 
$$[\sigma_H] = \frac{\sigma_H K_{HL}}{[n_H]}$$

buerda,  $\sigma_H = 2HB + 70$  kontaktli kuchlanishga chidamlilik chegarasi

$K_{HL} = 1,15$  qabul qilamiz.

$[n_h] = 1,1 \dots 1,2$  - xavfsizlik koeffitsienti, o'rtacha qiymatini qabul qilamiz.

Mustahkamlikka hisoblashda ruxsat etilgan kontaktli kuchla-nish shesternya va g'ildirak uchun alohida – alohida aniqlanadi

$$\text{shesternya uchun } [\sigma_{H1}] = \frac{(2HB + 70)K_{H1}}{[n_h]} = \frac{(2 \cdot 230 + 70) \cdot 1,15}{1,15} = 530 \frac{H}{\text{mm}^2}$$

$$\text{g'ildirak } [\sigma_{H2}] = \frac{(2HB_2 + 70)K_{H2}}{[n_h]} = \frac{(2 \cdot 200 + 70) \cdot 1,15}{1,15} = 470 \frac{H}{\text{mm}^2}$$

Unda hisobiy ruxsat etilgan kuchlanish.

$$[\sigma_H] = 0,45(530 + 470) = 450 \frac{H}{\text{mm}^2}$$

Qiya tishli g'ildirak enining koeffitsienti  $\varphi_b = 0,4$

Yuklanish koeffitsienti  $K_{H\beta}$ -ni tanlashda, tasmali uzatmani reduktorning etaklovchi valiga bosim kuchining ( $Q$ ) ta'sirini va tishlarni kontaktlashishining yomonlashuvini e'tiborga olamiz. ( $Q$ )-kuchga nisbatan shesternya nosimmetrik, ya'ni ( $Q$ ) kuch konsol ko'rinishida joylashgani uchun  $K_{H\beta} = 1,25$  qabul qilamiz [7.I-3].

Qiya tishli juft uchun o'qlararo masofa:

$$a_w \geq (i+1) \cdot \sqrt[3]{\left(\frac{270}{[\sigma_H]}\right)^2 \frac{M_3 \cdot 10^3 K_{H\beta}}{\psi_b \cdot i^2}} = (6+1) \cdot \sqrt[3]{\left(\frac{270}{450}\right)^2 \frac{430 \cdot 10^3 \cdot 1,25}{0,4 \cdot 6^2}} = 166,6 \text{ mm}$$

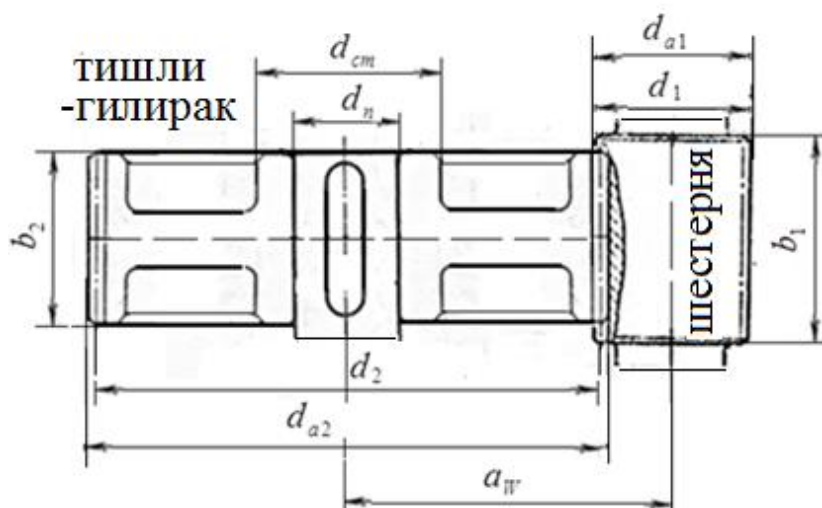
Yqlararo masofani standart qatordan  $a_w = 160 \text{ mm}$  qabul qilamiz.

Ilashmaning normal moduli

$$m_n = (0,01 \div 0,02) \cdot a_w = (0,01 \dots 0,02) 160 = (1,6 \dots 3,2) \text{ mm}$$

Ikkita o'zaro ilashadigan g'ildiraklarning moduli bir xil tanlanadi

$m_n = 2,5 \text{ mm}$  qabul qilamiz [22,23].



Tishlarning qiyalik burchagi  $\beta = 8 \dots 15^\circ$  oraliqda o'zgaradi. Birlamchi hisob-lashda  $\beta = 10^\circ$  qabul qilamiz.

rasm-4.6

Shesternya va tishli g'ildirakning geometrik o'lchamlari ko'rsatilgan sxema

Shesternya tishlarining sonini aniqlaymiz.

$$Z_1 = \frac{2\alpha_w \cos \beta}{(i+1) \cdot m_n} = \frac{2 \cdot 160 \cdot 0,985}{(6+1) \cdot 2,5} = 18$$

G'ildirakning tishlari soni  $Z_2 = Z_1 \cdot i = 18 \cdot 6 = 108$

Tishlarning qiyalik burchagini aniqlashtiramiz:

$$\cos \beta = \frac{(Z_1 + Z_2) \cdot m_n}{2a_w} = \frac{(18 + 108) \cdot 2,5}{2 \cdot 160} = 0,984 \quad \text{va} \quad \beta = 10^\circ$$

G'ildirak va shesternyaning geometrik o'lchamlari hisoblanadi  
Bo'luvchi diametr:

$$\text{shesternya } d_1 = \frac{m_n}{\cos \beta} \cdot Z_1 = \frac{2,5}{0,984} \cdot 18 = 45,73 \text{ мм}$$

$$\text{va g'ildirak } d_2 = \frac{m_n}{\cos \beta} \cdot Z_2 = \frac{2,5}{0,984} \cdot 108 = 274,27 \text{ мм}$$

O'qlararo masofani tekshirish.

$$\alpha_w = \frac{d_1 + d_2}{2} = \frac{45,73 + 274,27}{2} = 160 \text{ мм}$$

Tishlar uchining diametrlari:

$$\text{shesternya } d_{a1} = d_1 + 2m_n = 45,73 + 2 \cdot 2,5 = 50,73 \text{ мм}$$

$$\text{va g'ildirak } d_{a2} = d_2 + 2m_n = 274,27 + 2 \cdot 2,5 = 279,27 \text{ мм}$$

$$\text{G'ildirak gardishining eni. } \epsilon_2 = \Psi_\epsilon \cdot a_w = 0,47 \cdot 160 = 75 \text{ мм}$$

Reduktorlarni loyihalashda  $\Psi_\epsilon$  ning qiymati to'g'ri tishli uzatma uchun  $\Psi_\epsilon = 0,125 \dots 0,25$  va qiyshiq tishli  $\Psi_\epsilon = 0,25 \dots 0,40$  olinadi.  $\Psi_{\epsilon d}$  koefitsient yukni tishning gardishida notekis taqsimlanishini e'tiborga oluvchi  $K_{H\beta}$  koefitsientni aniqlash uchun kerak.

$$\Psi_{\epsilon d} = \frac{b}{d_1} = \frac{b \cdot (i+1)}{2a_w} = 0,5 \cdot \psi_b \cdot (i+1)$$

$$\psi_\epsilon = \frac{\epsilon_1}{d_1} = \frac{80}{45,73} = 1,75 \quad \text{bo'lganda} \quad K_{H\beta} = 1,11$$

$$\text{Shesternya eni } \epsilon_1 = \epsilon_2 + (5 \div 10) = 75 + 5 = 80 \text{ мм}$$

$K_{H\alpha}$  – tishlar orasida yukni notekis tasimlanishini hisobga oluvchi koefitsient. To'g'ri tishli g'ildirak uchun  $K_{H\alpha} = 1,0$ . Qiyshiq tishli g'ildirak uchun, tezlik 10 m/s gacha bo'lsa  $K_{H\alpha} = 1,05 \dots 1,1$  va tezlik  $v = 10 \dots 20 \frac{\text{m}}{\text{s}}$  bo'lsa  $K_{H\alpha} = 1,0 \dots 1,1$  olinadi.

$$\text{Qiyshiq tishli uzatma uchun } K_{H\alpha} = 1,13 \text{ [22]}$$

$$\text{Dairaviy tezlik } v = \frac{\omega_2 \cdot d_1}{2} = \frac{43,46 \cdot 45,73}{2} = 0,994 \frac{\text{m}}{\text{s}}$$



tezdik  $v = 5 \frac{M}{c}$  gacha bo'lganda  $K_{HV} = 1,0$  [22, I-8]

$K_H = K_{H\alpha} \cdot K_{H\beta} \cdot K_{HV} = 1,13 \cdot 1,11 \cdot 1 = 1,254$  yuklanish koefitsienti:

Kontaktli kuchlanishni tekshirish

$$\sigma_H = \frac{270}{a_w} \cdot \sqrt{\frac{K_H M_2 (i+1)^3}{b_2 \cdot i^2}} = \frac{270}{160} \cdot \sqrt{\frac{1,254 \cdot 430 \cdot 10^3 (6+1)^3}{75 \cdot 6^2}} = 441,7 \leq [\sigma]_H$$

Loyihaviy hisoblangan kontaktli kuchlanishning qiymati ruxsat etilgan kontaktli kuchlanishdan 5 % katta bo'lsa qoniqarsiz hisoblanadi, va hisoblangan kuchlanish ruxsat etilgan qiymatidan 15 % dan kam bo'lmasligi kerak.

#### Ilashmadagi kuchlar:

Doiraviy

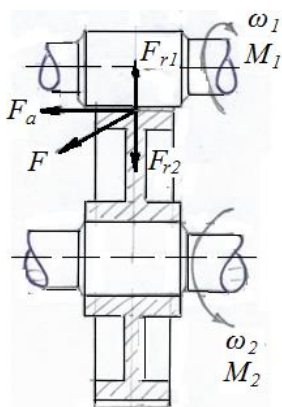
$$F = \frac{2M_2}{d_1} = \frac{2 \cdot 71,76 \cdot 10^3}{45,73} = 3138,4H$$

Radial

$$F_r = F \cdot \frac{\tan \alpha}{\cos \beta} = 3138,4 \cdot \frac{\tan 20^\circ}{\cos 10^\circ} = 1160,9H$$

Bo'ylama

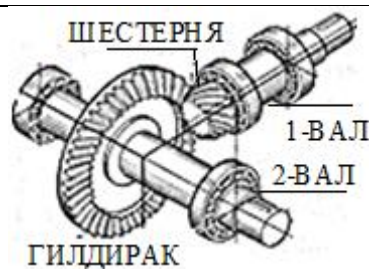
$$F_a = F \cdot \tan \beta = 3138,4 \cdot \tan 10^\circ = 553,3H$$



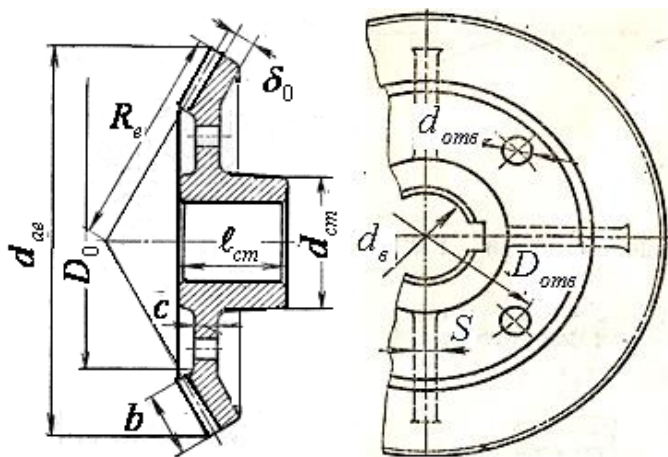
#### Konussimon tishli uzatmani hisoblash tartibi

jadval-4.5

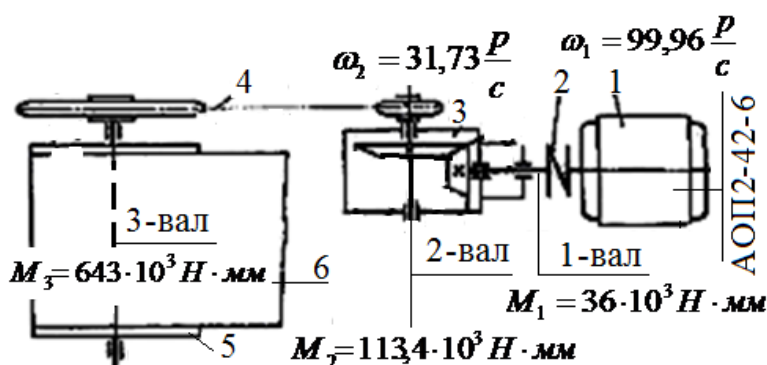
| № | Tishli g'ildirak elementlari                                           | hisoblash formulasi                                                 |
|---|------------------------------------------------------------------------|---------------------------------------------------------------------|
| 1 | Tezyurar valdagi quvvat $N_1$ valni aylanishlari soni $n_1$ aniqlanadi | $N_1 = N_{\text{dв}}$<br>va<br>$n_1 = n_{\text{dв}}$                |
| 2 | Uzatma uchun uzatishlar sonini $i$ qabul qilamiz                       | $i = 2 \dots 6$                                                     |
| 3 | Birinchi va ikkitnchi vallaridagi burchak tezliklarini topamiz         | $\omega_1 = \omega_{\text{dв}} \quad \omega_2 = \frac{\omega_1}{i}$ |
| 4 | Shesternya tishlari soni                                               | $z = 18 \dots 30$                                                   |
| 5 | G'ildirak tishlari soni                                                | $Z_2 = Z_1 \cdot i_p$                                               |
| 6 | Shesternya validagi aylantiruvchi moment                               | $M_1 = \frac{N_1}{\omega_1}, H \cdot \text{мм}$                     |
| 7 | G'ildirakning validagi aylantiruvchi moment                            | $M_2 = M_1 \cdot i, H \cdot \text{мм}$                              |
| 8 | Tish enining koefitsientini tanlaymiz                                  | $\psi_{\text{вRe}} = 0,285$                                         |



|    |                                                                                       |               |                                                                                                                                                                             |
|----|---------------------------------------------------------------------------------------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 9  | Shesternya va g'ildirak uchun material tanlaymiz                                      |               | I 5 jadvalni qarang                                                                                                                                                         |
| 10 | Ruxsat etilgan kontaktli kulanish ni aniqlash<br>$K_{hl}=1$ va $[n]_H=1,10\cdots 1,2$ |               | $[\sigma]_H = \frac{\sigma_{H\lim} \cdot K_{hl}}{[n]_H} \quad \sigma_{H\lim} = 2HB + 70$                                                                                    |
| 11 | Tashqi bo'luvchi diametrni aniqlaymiz, $K_{H\beta}=1,35$                              |               | $d_{e2} = 2 \cdot \sqrt[3]{\left(\frac{335}{\sigma_H}\right)^2 \frac{M_2 \cdot K_{H\beta} \cdot i_p}{(1 - 0,5 \cdot \Psi_{\epsilon R\ell})^2 \cdot \Psi_{\epsilon R\ell}}}$ |
| 12 | Ilashma modulini aniqlaymiz                                                           |               | $m_e = \frac{d_{e2}}{Z_2}$                                                                                                                                                  |
| 13 | boshlang'ich konus burchaklari                                                        |               | $\operatorname{ctg} \delta_1 = i$ va $\delta_2 = 90^\circ - \delta_1$                                                                                                       |
| 14 | Shesternya tashqi konus masofasi                                                      |               | $R_\ell = 0,5m_\ell \sqrt{Z_1^2 + Z_2^2}$                                                                                                                                   |
| 15 | Shesternya tishining uzunligini                                                       |               | $\epsilon = \Psi_{\epsilon R\ell} \cdot R_\ell$                                                                                                                             |
| 16 | Shesternyaning tashqi bo'luvchi diametri                                              |               | $d_{e1} = m_\ell \cdot Z_1$                                                                                                                                                 |
| 17 | Shesternyaning o'rtacha bo'luvchi diametri                                            |               | $d_1 = 2(R_e - 0,5b) \sin \delta_1$                                                                                                                                         |
| 18 | Shesternya va g'ildirakning tashqi diametrlari                                        |               | $d_{a1} = d_{e1} + 2m_\ell \cos \delta_1$<br>$d_{a2} = d_{e2} + 2m_\ell \cos \delta_2$                                                                                      |
| 19 | Mustahkamlik kontakli kuchlanish bo'yicha tekshiriladi                                |               | $\sigma_H = \frac{335}{R_e - 0,5b} \sqrt{\frac{M_2 \cdot K_H \sqrt{(i^2 + 1)^3}}{b \cdot i^2}}$                                                                             |
| 20 | tish uchi aylanasing diametri                                                         |               | $d_a = d + 2m_t \cos \alpha$                                                                                                                                                |
| 21 | tishli g'ildirak ishchi kengligi                                                      |               | $b = (6 \cdots 8) \cdot m_t$                                                                                                                                                |
| 22 | val uchun teshik diametri                                                             |               | $d_b = 0,2 \cdot d_a$                                                                                                                                                       |
| 23 | tish uchining balandligi                                                              |               | $h_a = m_t$                                                                                                                                                                 |
| 24 | tish tubining balandligi                                                              |               | $h_f = 1,25m_t$                                                                                                                                                             |
| 25 | tishning balandligi                                                                   |               | $h = 2,25m_t$                                                                                                                                                               |
| 26 | disk qalinligi                                                                        |               | $c = (0,1 \cdots 0,2)R_e$                                                                                                                                                   |
| 27 | obod qalinligi                                                                        |               | $\delta_0 = (3,8 \cdots 4,0) \cdot m$                                                                                                                                       |
| 28 | stupitsa diametri                                                                     |               | $d_{cm} = (1,6 \cdots 2) \cdot d_b$                                                                                                                                         |
| 29 | stupitsa uzunligi                                                                     |               | $\ell_{cm} = 1,5d_b$                                                                                                                                                        |
| 30 | Ilashmadagi kuchlarni aniqlaymiz                                                      | Doiraviy kuch | $F = \frac{2M_1}{d_1}$                                                                                                                                                      |
|    |                                                                                       | Radial kuch   | $F_{r_1} = F_{a2} = F \cdot \operatorname{tg} \alpha \cdot \cos \delta_1$                                                                                                   |
|    |                                                                                       | Bo'ylama kuch | $F_{a_1} = F_{r_2} = F \cdot \operatorname{tg} \alpha \cdot \sin \delta_1$                                                                                                  |



rasm-4.7. Konussimon tishli  
g'ildirak  $d_{ae} < 500 \text{ mm}$ .



rasm-4.8.

Bir pog'onali konussimon  
reduktor tishli g'ildiragini  
hisoblash.

**misol-4.5.** G'ildirak va  
shesternya uchun material  
tanlaymiz. G'ildirak uchun  
qattiqligi NV 270 va  
shesternya uchun NV 245 40X  
markali po'lotni tanlaymiz.

$$\text{Ruxsat etilgan kuchlanish: } [\sigma]_H = \frac{\sigma_{H\lim} \cdot K_{Hl}}{[n]_H} = \frac{560 \cdot 1}{1,15} = 485 \frac{\text{H}}{\text{mm}^2}$$

$$\text{buerda shesternya uchun } \sigma_{H\lim} = 2HB + 70 = 2 \cdot 245 + 70 = 560 \frac{\text{H}}{\text{mm}^2}$$

$K_{Hl} = 1$  – uzoq ekspluatatsiya etishda xizmat muddatining koeffitsienti;

$[n]_H = 1,15$  – mustahkamlik koeffitsienti;

$K_{H\beta} = 1,35$  shesternyaning vali konsol ko'rinishda o'rnatilga yuklanish koeffitsienti,

Tish enining tashqi konus masofasiga nisbatan koeffitsienti  $\psi_{eRe} = 0,285$ .

$$d_{e2} = 2 \cdot \sqrt[3]{\left(\frac{335}{\sigma_H}\right)^2 \frac{M_2 \cdot K_{H\beta} \cdot i_p}{(1 - 0,5 \cdot \Psi_{eRe})^2 \cdot \Psi_{eRe}}} = 2 \cdot \sqrt[3]{\left(\frac{335}{485}\right)^2 \frac{113,1 \cdot 10^3 \cdot 1,35 \cdot 3,15}{(1 - 0,5 \cdot 0,285)^2 \cdot 0,285}} = 206 \text{ mm}$$

$d_{e2} = 200 \text{ mm}$  kabul qilamiz.

Shesternya tishlarining sonini  $Z_1 = 25$  qabul qilamiz.

G'ildirak tishlarining soni  $Z_2 = Z_1 \cdot i_p = 25 \cdot 3,15 = 78,75$

$Z_2 = 79$  qabul qilamiz va  $i_p$  ni aniqlaymiz.  $i_p = u = \frac{Z_2}{Z_1} = \frac{79}{25} = 3,16$

Uzatishlar soni orasidagi farq  $\frac{3,16 - 3,15}{3,15} \cdot 100 = 0,3 \%$

Tashqi aylana modulini aniqlaymiz.  $m_e = \frac{d_{e2}}{Z_2} = \frac{200}{79} = 2,5316 \text{ мм}$

Tashqi aylana modulini yaxlitlamaymiz

Uzatish sonidan foydalanib, boshlang'ich konus burchaklarini topamiz:  $\text{ctg} \delta_1 = i_P = 3,16 \quad \delta_1 = 17^\circ 34'$  va

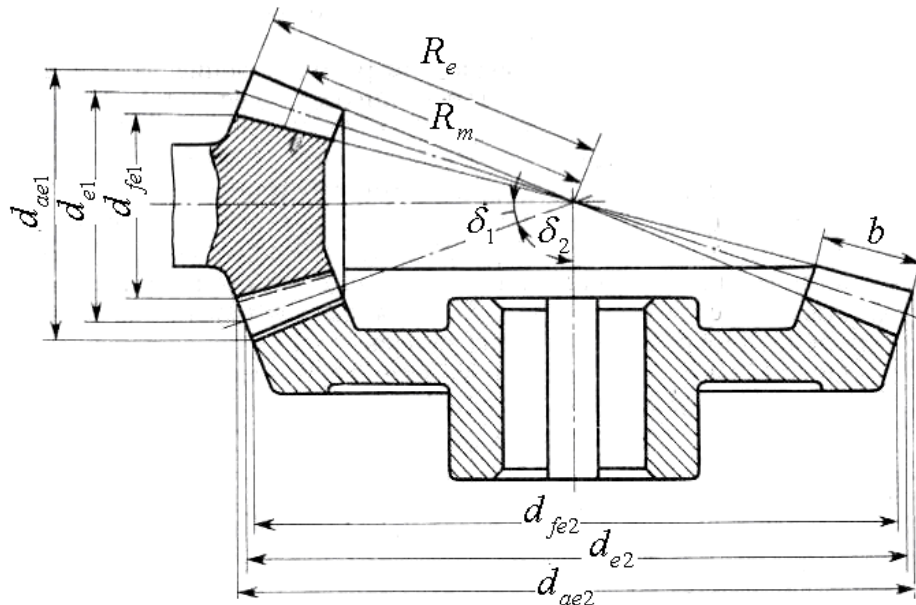
$$\delta_2 = 90^\circ - \delta_1 = 90^\circ - 17^\circ 34' = 72^\circ 26'$$

Shesternya tashqi konus masofasini va tishni uzunligini hisoblaymiz.

$$R_\ell = 0,5m_\ell \sqrt{Z_1^2 + Z_2^2} = 0,5 \cdot 2,5316 \sqrt{25^2 + 79^2} = 105 \text{ мм}$$

$$\epsilon = \Psi_{\epsilon R_\ell} \cdot R_\ell = 0,285 \cdot 105 \approx 30 \text{ мм}$$

$$R_m = R_e - 0,5b = 105 - 0,5 \cdot 30 = 90 \text{ мм}$$



rasm-4.9. Konussimon tishli uzatmaning geometrik o'lchamlari

Shesternyaning tashqi bo'luvchi diametri.

$$d_{e1} = m_\ell \cdot Z_1 = 2,5316 \cdot 25 = 63,25 \text{ мм}$$

Shesternyaning o'rtacha bo'luvchi diametri

$$d_1 = 2(R_e - 0,5b) \sin \delta_1 = 2(105 - 0,5 \cdot 30) \sin 17^\circ 34' = 54,43 \text{ мм}$$

Shesternya va g'ildirakning tashqi diametrlari:

$$d_{ae1} = d_{e1} + 2m_\ell \cos \delta_1 = 63,25 + 2 \cdot 2,5316 \cos 17^\circ 34' = 68 \text{ мм}$$

$$d_{ae2} = d_{e2} + 2m_\ell \cos \delta_2 = 200 + 2 \cdot 2,5316 \cdot \cos 72^\circ 26' = 201,53 \text{ мм}$$

O'rtacha doiraviy modul  $m = \frac{d_1}{Z_1} = \frac{54,43}{25} = 2,18 \text{ мм}$

O'rtacha diametr bo'yicha shesternya enining koeffitsienti

$$\psi_{bd} = \frac{b}{d_1} = \frac{30}{54,43} = 0,55$$

O'rtacha doiraviy tezlik 
$$v = \frac{\omega_1 d_1}{2} = \frac{99,96 \cdot 54,43}{2} = 2,72 \frac{m}{c}$$

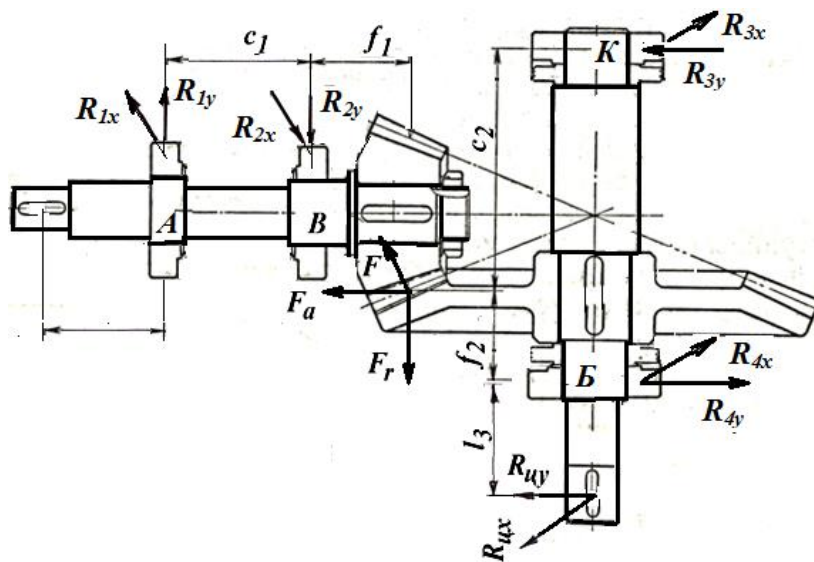
Kontaktli kuchlanishga tekshirish uchun yuklanish koeffitsientini topamiz:

$$K_H = K_{H\beta} K_{H\alpha} K_{HV}$$

I-7 jadvaldan  $\psi_{bd} = 0,55$ , g'ildirakning konsol ko'rinishda joylashuvi va  $\prec HB 350$  qattqlikda, tishning uzunligi bo'yicha yukni taqsimlanish koeffitsienti  $K_{H\beta} = 1,05$  qabul qilamiz. Tishlar orasida yukni taqsimlanish koeffitsienti  $K_{H\alpha} = 1,0$ . Dinamik koeffitsient  $v \prec 5 \frac{m}{c}$  bo'lsa,  $K_{HV} = 1,05$

Unda  $K_H = 1,05 \cdot 1,0 \cdot 1,05 = 1,1$

$$\begin{aligned} \sigma_H &= \frac{335}{R_e - 0,5b} \sqrt{\frac{M_2 \cdot K_H \sqrt{(i^2 + 1)^3}}{b \cdot i^2}} = \\ &= \frac{335}{105 - 0,5 \cdot 30} \sqrt{\frac{113,1 \cdot 10^3 \cdot 1,1 \cdot \sqrt{(3,15^2 + 1)^3}}{30 \cdot 3,15^2}} = 456,9 \frac{H}{mm^2} \end{aligned}$$



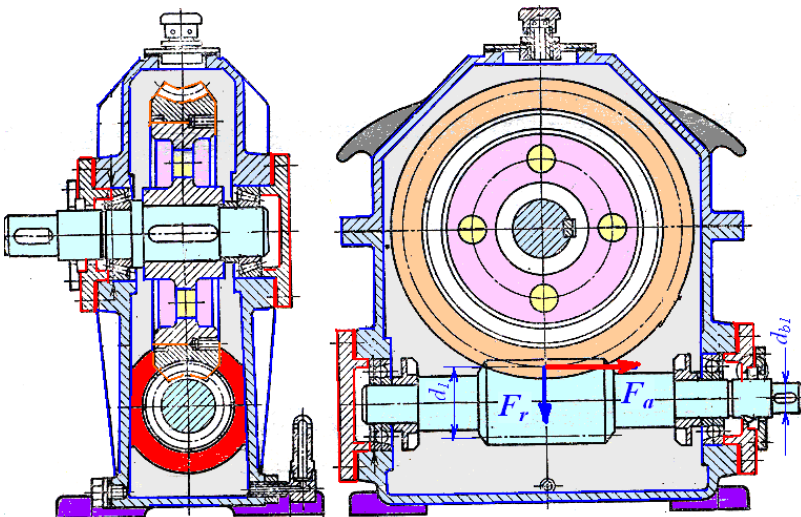
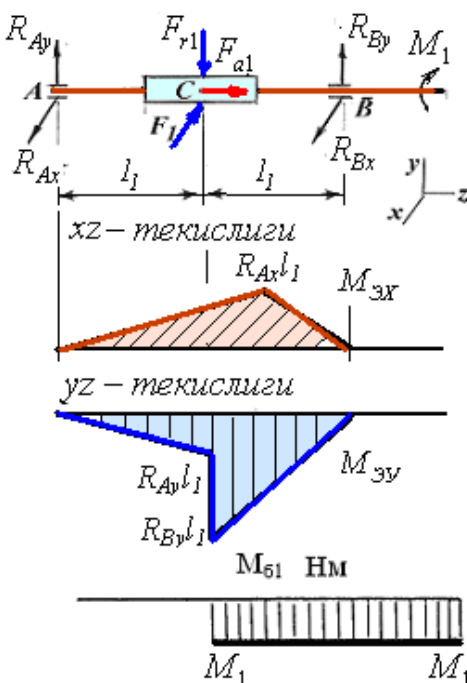
rasm.4.10.  
Konussimon  
ilashmadagi  
kuchlar va  
tayanchlardagi  
reaktsiya  
kuchlari.

Ilashmadagi kuchlarni aniqlaymiz :

Doiraviy kuch 
$$F = \frac{2M_1}{d_1} = \frac{2 \cdot 36 \cdot 10^3}{54,43} = 1322,8H$$

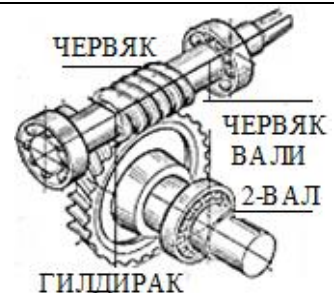
Radial kuch  $F_{r_1} = F_{a_2} = F \cdot \operatorname{tg} \alpha \cdot \cos \delta_1 = 1322,8 \cdot \operatorname{tg} 20^\circ \cdot \cos 17^\circ 34' = 460 H$

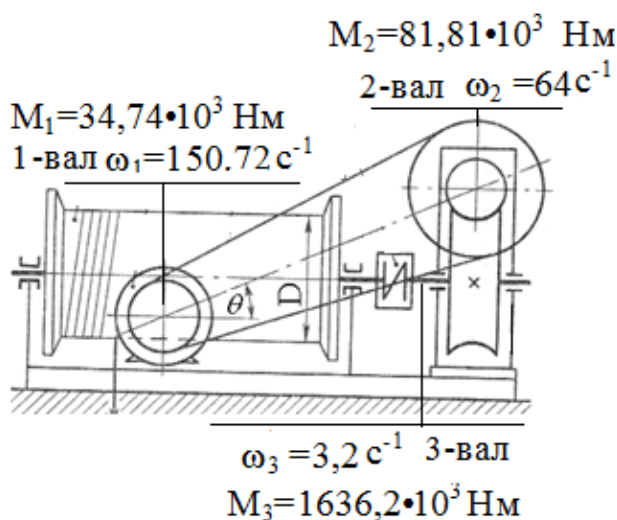
Bo'ylama kuch.  $F_{a_1} = F_{r_2} = F \cdot \operatorname{tg} \alpha \cdot \sin \delta_1 = 1322,8 \cdot \operatorname{tg} 20^\circ \cdot \sin 17^\circ 34' = 146 H$

| ChERVYAKLI UZATMANI HISOBLASH.                                                                                                                                                                                    |                                            |                                                                                    | jadval-4.6.                                                         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| real ob`ekt                                                                                                                                                                                                       |                                            | - chervyakli uzatma, detalning nomi - chervyak vali                                |                                                                     |
| vazifasi                                                                                                                                                                                                          |                                            | – aylanma harakatni elektrodvigatel validan chervyak g'ildiragiga uzatish          |                                                                     |
| turlari                                                                                                                                                                                                           |                                            |  |                                                                     |
| chervyakni shakliga ko'ra                                                                                                                                                                                         |                                            |                                                                                    |                                                                     |
| tsilindrik      globoid                                                                                                                                                                                           |                                            |                                                                                    |                                                                     |
| o'ramlar soniga ko'ra                                                                                                                                                                                             |                                            |                                                                                    |                                                                     |
| $z_1 = 1,2$ $z_1 = 4$                                                                                                                                                                                             |                                            |                                                                                    |                                                                     |
| chervyakni g'ildirakga nisbatan joylashishiga ko'ra                                                                                                                                                               |                                            |                                                                                    |                                                                     |
| past      yonbosh      yukori                                                                                                                                                                                     |                                            |                                                                                    |                                                                     |
| kinematikasi                                                                                                                                                                                                      |                                            |                                                                                    |                                                                     |
| aylanish chastotasi                                                                                                                                                                                               | burchak tezlik                             |                                                                                    |                                                                     |
| $n_1 = n_{\partial\partial}$                                                                                                                                                                                      | $\omega_1 = \frac{\pi \cdot n_1}{30}$      |                                                                                    |                                                                     |
| material                                                                                                                                                                                                          |                                            | geometriyasi - asosiy diametrlar va tish balandligi                                |                                                                     |
| – o'rta uglerodli po'lot turlari (St.45,50) va legirlangan po'lotlardan tayyorlanadi                                                                                                                              |                                            | bo'luvchi aylana $d_1 = m \cdot q$                                                 | $h = h_{a1} + h_{f1} = 2,2m$                                        |
|                                                                                                                                                                                                                   |                                            | tish uchining $d_{a1} = m (q + 2)$                                                 | $h_a = m, h_f = 1,2m$                                               |
|                                                                                                                                                                                                                   |                                            | tish tubining $d_{f1} = m (q - 2,4)$                                               |                                                                     |
| ilashma moduli                                                                                                                                                                                                    |                                            | chervyak diametrining koeffitsienti                                                |                                                                     |
| $m = \frac{(1,4...1,7)a_w}{z_2}$                                                                                                                                                                                  |                                            | $q_{\min} = 0,212 \cdot z_2$                                                       |                                                                     |
| kuch munosabatlari                                                                                                                                                                                                |                                            |                                                                                    |                                                                     |
| doiraviy                                                                                                                                                                                                          | radial                                     | bo'ylama                                                                           |                                                                     |
| $F_t = \frac{2M_1}{d_1}$                                                                                                                                                                                          | $F_r = F_a \cdot tg\alpha$                 | $F_a = \frac{2M_2}{d_2}$                                                           |                                                                     |
| chervyak validagi ay-lantiruvchi moment                                                                                                                                                                           |                                            | chervyak g'ildiragining validagi moment                                            |                                                                     |
| $M_1 = \frac{N_1}{\omega_1}$                                                                                                                                                                                      |                                            | $M_2 = M_1 \cdot \eta \cdot i$                                                     |                                                                     |
| dastlab-ki hisob-lash                                                                                                                                                                                             | val kirish qismi ning diametri             | podshipnik o'rni diametri                                                          |                                                                     |
|                                                                                                                                                                                                                   | $d_{e1} = \sqrt[3]{\frac{M_1}{0,2[\tau]}}$ | $d_{n1} = d_{e1} + 10$                                                             |                                                                     |
|                                                                                                                               |                                            |                                                                                    |                                                                     |
| eskizli sxema chiziladi, konstruksiyasi belgilanadi, eguvchi va burovchi momentlarning epyurlari quriladi, valni xavfli kesimi tanlanadi, mustahkamlik tekshiriladi                                               |                                            |                                                                                    |                                                                     |
| $\sigma_{\partial\partial} = \sqrt{(\sigma_F + \sigma_C)^2 + 3\tau_{\delta}^2} \leq [\sigma_{-1f}]$<br>$M_{\partial} = 0,25\sqrt{(F_2 \cdot \ell + F_a d_1)^2 + (F_t \ell)^2}$<br>xavfli kesimdagi eguvchi moment |                                            | egilish kuchlanishi<br>$\sigma_F = \frac{M_{\partial}}{0,1d_t^3}$                  | siquvchi uchlanishi<br>$\sigma_C = \frac{4F_a}{\pi \cdot d_{f1}^2}$ |
|                                                                                                                                                                                                                   |                                            | buralish kuchlanishi<br>$\tau_{\delta} = \frac{M_1}{0,2d_f^3}$                     |                                                                     |



### Chervyakli uzatmani hisoblash [21]

| Nima qilish kerak                                                                                                                                                                                                                   | Nimadan foydalanish lozim                                                                                         |     |                                                                                       |                           |       |    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|-----|---------------------------------------------------------------------------------------|---------------------------|-------|----|
| 1.uzatishlar soni $i$ asosida chervyakni kirimlar soni $z_1$ ni tanlaymiz                                                                                                                                                           | $i$                                                                                                               | 7-8 | 9-13                                                                                  | 14-27                     | 28-55 | 36 |
|                                                                                                                                                                                                                                     | $z_1$                                                                                                             | 4   | 3-4                                                                                   | 2-3                       | 1-2   | 1  |
| 2.g'ildirak tishlari sonini aniqlaymiz                                                                                                                                                                                              | $z_2 = i \cdot z_1$                                                                                               |     |                                                                                       |                           |       |    |
| 3.Chervyak g'ildiragining burchak tezligini topamiz                                                                                                                                                                                 | $\omega_2 = \frac{\omega_1}{i}$                                                                                   |     |                                                                                       |                           |       |    |
| 4.Uzatmani ishlash sharoiti asosida chervyak va chervyak g'ildi-ragi uchun material tanlaymiz                                                                                                                                       | I-11 va I-16 jadvallar asosida                                                                                    |     |                                                                                       |                           |       |    |
| 5.Ruxsat etilgan kontaktli va $[\sigma]_K$ va egilish $[\sigma]_9$ kuchlanish-shini aniqlaymiz                                                                                                                                      | I-11 va I-16 jadvallarga qarang                                                                                   |     |                                                                                       |                           |       |    |
| 6. G'ildirakdagi momentni topamiz                                                                                                                                                                                                   | $M_{KX} = M_K K = \frac{N_2}{\omega_2} K, \quad K = 1,05 \dots 1,4$                                               |     |                                                                                       |                           |       |    |
| 7. Kontaktli mustahkamlik asosida uzatma o'qlararo masofa-sini topamiz. Chervyak diametri koefitsienti : $q = \frac{d_1}{m} = 8 \dots 12$                                                                                           | $a_w = 30,7 \left( \frac{z_2}{q} + 1 \right)^3 \sqrt{\frac{M_{KX}}{\left( \frac{z_2}{q} \right)^2 [\sigma]_K^2}}$ |     |                                                                                       |                           |       |    |
| 8. Ilashma moduli topiladi.                                                                                                                                                                                                         | $m = \frac{2 \cdot a_w}{z_2 + q}$                                                                                 |     |  |                           |       |    |
| 9.O'ram chiziqligining ko'tarilish burchagi topiladi                                                                                                                                                                                | $\gamma = \arctg \frac{z_1}{q}$                                                                                   |     |                                                                                       |                           |       |    |
| O'qlararo masofa tekshiriladi                                                                                                                                                                                                       | $a_w = \frac{m(z_2 + q)}{2}$                                                                                      |     |                                                                                       |                           |       |    |
| Chervyak va chervyak g'ildiragi o'lchamlari hisoblanadi:<br>- bo'luvchi diametr<br>- o'ram uchi diametri<br>- o'ram tubi diametri<br>- g'ildirakni katta diametri<br>chervyak o'rami kesilgan uzunlik<br>g'ildirak gardishining eni | chervyak                                                                                                          |     |                                                                                       | g'ildirak                 |       |    |
|                                                                                                                                                                                                                                     | $d_1 = mq$                                                                                                        |     |                                                                                       | $d_2 = mz_2$              |       |    |
|                                                                                                                                                                                                                                     | $d_{a1} = d_1 + 2m$                                                                                               |     |                                                                                       | $d_{a2} = d_2 + 2m$       |       |    |
|                                                                                                                                                                                                                                     | $d_{f1} = d_1 - 2,4m$                                                                                             |     |                                                                                       | $d_{f2} = d_2 - 2,4m$     |       |    |
|                                                                                                                                                                                                                                     | -                                                                                                                 |     |                                                                                       | $d_{aM2} = d_{a2} + 1,5m$ |       |    |
|                                                                                                                                                                                                                                     | $b_1 = (11 + 0,06z_2)m$                                                                                           |     |                                                                                       | $b_1 = (11 + 0,06z_2)m$   |       |    |
|                                                                                                                                                                                                                                     |                                                                                                                   |     |                                                                                       | $b_2 \leq 0,75d_{a1}$     |       |    |
| Ilashmadagi doiraviy, bo'ylama va radial kuchlar topiladi                                                                                                                                                                           | $F = \frac{2M_K}{d_2} \quad F_a = \frac{2M_1}{d_1} \quad F_r = F \cdot tg\alpha$                                  |     |                                                                                       |                           |       |    |



rasm-4.11

## Bir pog'onali chervyakli uzatmani hisoblash

**misol-4.6.** Uzatmani hisoblashni chervyak vali va g'ildiragi gardishining materialini tanlashdan boshlaymiz. Chervyak vali uchun qattiqligi *HRC* 45 gacha toblangan po'latni 45 markasini; chervyak g'ildiragining gardishi uchun *B<sub>r</sub>*. AJg – 4L bronza. Chervyak g'ildiragi tishlarining soni

$$z_2 = i \cdot z_1 = 20 \cdot 2 = 40$$

$$\text{O'qlararo masofa: } a_w = \left( \frac{z_2}{q} + 1 \right) \cdot \sqrt[3]{\left( \frac{170}{\frac{z_2}{q} \cdot 155} \right)^2} \cdot M_2 \cdot K_H$$

$$a_w = \left( \frac{40}{10} + 1 \right) \cdot \sqrt[3]{\left( \frac{170}{\frac{40}{10} \cdot 155} \right)^2} \cdot 1636,2 \cdot 10^3 \cdot 1,2 = 265 \text{ mm}$$

$$\text{Modul } m = \frac{2a_w}{z_2 + q} = \frac{2 \cdot 265}{40 + 10} = 10,6 \text{ mm}.$$

Hisoblab topilgan modul eng yaqin standart qiymatga qadar yaxlitlanadi (jadval I-2). Yaxlitlangan modul o'qlararo masofa va *q*-koeffitsientni o'zgartirishiga olib kelishi mumkin. Shuning uchun, *m* va *q*-ning tanlangan standart qiymatlarida o'qlararo masofaning haqiqiy qiymati hisoblanadi. *a<sub>w</sub>* - ning qiymati butun son bo'lishi kerak. Buning uchun *z<sub>2</sub>* bir-ikki tishga o'zgartirilishi mumkin. Farq 4 % dan oshmasligi kerak.



Ayrim hollarda chervyak va g'ildirak tishining turli sonlarida o'qlararo masofani ikki variantda hisoblash kerak. Agar, loyiha topshi-riqida reduktorni ishlab chiqarish mo'ljallangan bo'lsa *m* va *q* tashqari

hisobiy *a<sub>w</sub>*, *z<sub>1</sub>* va *z<sub>2</sub>* lar ham standart qatordan

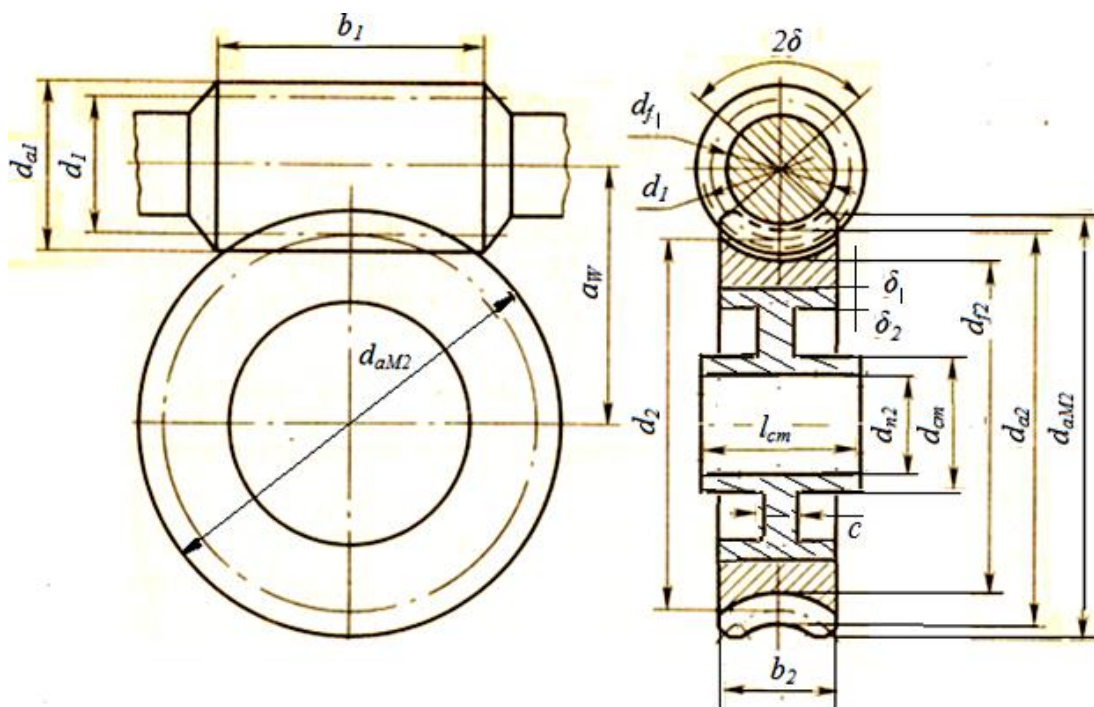
tanlanishi lozim. Kerakli natija olinishi uchun *z<sub>2</sub>* bitta yoki ikkita tishga kamaytirilishi yoki orttirilishi mumkin.



Koeffitsient  $q = (0,212...0,25)z_2 = (0,212...0,25) \cdot 40 = (8,48...10)$

Standart qatordan  $m = 10 \text{ mm}$  va  $q = 10$  qabul qilamiz.

Unda  $a_w = \frac{m(q + z_2)}{2} = \frac{10(10 + 40)}{2} = 250 \text{ mm}$  qabul qilamiz



rasm- 4.12 Chervyakli uzatmaning geometrik o'lchamlari

Chervyak valining asosiy o'lchamlari:

- bo'luvchi diametr  $d_1 = q \cdot m = 10 \cdot 10 = 100 \text{ mm}$

- o'ram tubining diametri  $d_{f1} = d_1 - 2,4m = 100 - 2,4 \cdot 10 = 76 \text{ mm}$

Chervyak o'rami tayyorlangan qismining uzunligi

$$b_1 \geq (11 + 0,06 \cdot z_2) \cdot m + 25 = (11 + 0,06 \cdot 40) \cdot 10 + 25 = 160 \text{ mm}$$

Chervyak g'ildiragi gardishining o'lchamlari:

- bo'luvchi diametri  $d_2 = z_2 \cdot m = 40 \cdot 10 = 400 \text{ mm}$

- tishlar uchining diametri  $d_{a2} = d_2 + 2m = 400 + 2 \cdot 10 = 420 \text{ mm}$

- tishlar tubining diametri  $d_{f2} = d_2 - 2,4m = 400 - 2,4 \cdot 10 = 376 \text{ mm}$

- eng katta diametri  $d_{am} \leq d_{a2} + \frac{6m}{z_1 + 2} = 420 + \frac{6 \cdot 10}{2 + 2} = 435 \text{ mm}$

Chervyak g'ildiragi gardishining eni  $b_2 \leq 0,75 \cdot d_{a1} = 0,75 \cdot 120 = 90 \text{ mm}$

Chervyakning doiraviy tezligi

$$v_1 = \frac{\pi \cdot d_1 \cdot n}{60} = \frac{3,14 \cdot 100 \cdot 10^{-3} \cdot 1440}{60} = 7,536 \frac{\text{m}}{\text{s}}$$

Sirpanish tezligi  $v_s = \frac{v_1}{\cos \gamma} = \frac{7,536}{\cos 11^\circ 18'1} = 7,685 \frac{\text{m}}{\text{s}}$

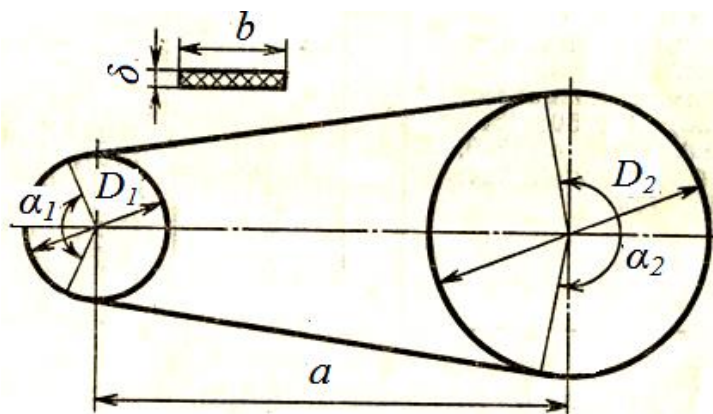
Ruxsat etilgan kontaktli kuchlanishni tanlaymiz  $[\sigma_H] = 156 \frac{H}{\text{мм}^2}$ .

Kontaktli kuchlanishga mustahkamlikni tekshiramiz:

$$\sigma_H = \frac{170}{\frac{z_2}{q}} \sqrt{\frac{M_2 K (\frac{z_2}{q} + 1)^2}{a_w^3}} = \frac{170}{\frac{40}{10}} \sqrt{\frac{1636,2 \cdot 10^3 (\frac{40}{10} + 1)^3}{250^3}} = 153,76 \frac{H}{\text{мм}^2}$$

#### Yassi tasmali uzatmani hisoblash.

**misol-4.7.** Tekis tasmali uzatma harakatni elektrodvigateldan tsilindrik reduktorga uzatadi. Etaklovchi valdagi quvvat  $N_1 = 3,12 \text{ кВт}$ , aylanishlar chastotasi  $n_1 = 955 \frac{\text{айл}}{\text{мин}}$ , etaklanuvchi valning aylanish chastotasi  $n_2 = 415,22 \frac{\text{айл}}{\text{мин}}$ , bir smenali o'zgarmas yuklanishda ishlaydi, tasma rezinalangan va gorizonttal tekislikda o'rnatilgan.



rasm-4.13. Yassi tasmali uzatmaning kinematik sxemasi

$$\begin{aligned} D_{Sh1} &= D_1 \\ D_{Sh2} &= D_2 \\ \text{deb qabul qilamiz} \end{aligned}$$

**echish.** Saverin [22] formulasidan kichik shkiv diametrini topamiz:

$$D_1 = 120 \cdot \sqrt[3]{\frac{N}{n}} = 120 \cdot \sqrt[3]{\frac{3,12 \cdot 10^3}{955}} = 178 \text{ мм}$$

Hisobiy  $D_1$  diametrni standart qiymatiga qadar yaxlitlaymiz [22]: 40, 45, 50, 56, 63, 71, 80, 90, 100, 112, 125, 140, 160, 180, 200, 224, 250, 280, 315, 355, 400, 450, 500, 560, 630, 710, 800, 900, 1000, 1120.

$D_1 = 180 \text{ мм}$  qabul qilamiz.

Etaklanuvchi shkiv diametrini sirpanish koeffitsientini  $\varepsilon = 0,01$  qabul qilib hisoblaymiz:

$$D_2 = i \cdot (D_1 [1 - \varepsilon]) = \frac{955}{415,22} \cdot 180 \cdot 0,99 \approx 409,85 \text{ мм}$$

$D_2 = 400 \text{ мм}$  qabul qilamiz.

Uzatishlar sonini aniqlashtiramiz:

$$i_{TV} = \frac{D_2}{D_1(1-\varepsilon)} = \frac{400}{180 \cdot (1-0,01)} = 2,245$$

Etaklanuvchi valning haqiqiy aylanishlar chastotasi:

$$n_2 = \frac{n_1}{i_{TV}} = \frac{955}{2,245} = 425,4 \frac{\text{aйл}}{\text{мин}}$$

Xatolik 4 % dan ortib ketmasligi kerak: fark - 2,4 %

$$\text{Tasmaning tezligi } v = \frac{\pi \cdot D_1 \cdot n_1}{60} = \frac{3,14 \cdot 180 \cdot 955}{60} = 9 \frac{\text{м}}{\text{с}}$$

Amaliy hisoblarda tasmaning tezdigi  $10 \frac{\text{м}}{\text{с}}$  dan kam bo'lishi mumkin emas. Buning uchun shkiylarning diametrlarini kattalashtirish kerak. Masalan,  $D_1 = 200 \text{ мм}$  qabul qilamiz

$$\text{Unda, } D_2 = \frac{955}{425,4} \cdot 200 \cdot 0,99 = 440,6 \text{ мм.}$$

$D_2 = 450 \text{ мм}$  qabul qilamiz

$$\text{Tasmaning tezligi } v = \frac{3,14 \cdot 200 \cdot 955}{60} = 10 \frac{\text{м}}{\text{с}}$$

$$\text{Doiraviy kuch } F = \frac{N_1}{v} = \frac{3,12 \cdot 10^3}{10} = 312 \text{ Н}$$

Ruxsat etilgan kuchlanish  $[K]$  – foydali ruxsat etilgan kuchlanish bo'lib, tasmani bir birlik ko'ndalang kesim yuzasiga to'g'ri keladigan solishtirma doiraviy kuch deyiladi,  $\frac{H}{\text{мм}^2}$ ;

$$[K] = K_o \cdot C_o \cdot C_\alpha \cdot C_\beta \cdot C_p -$$

buerda:  $K_o$  - gorizontal uzatmalarga tegishli quyidagi jadvaldan olinadi [22].

$$v = 10 \frac{\text{м}}{\text{с}}, \quad \alpha = 180^\circ \quad \text{va} \quad \sigma_0 = 1,8 \frac{H}{\text{мм}^2} \quad \text{uchun } K_o \text{ qiymatlari}$$

| nisbat<br>$\frac{\delta}{D_1}$ | $K_o, \frac{H}{\text{мм}^2}, \text{ tasma turi}$ |       |                     | $\sigma_0$ -tasmani dastlabki taranglash kuchlanishi;<br>$\delta$ -tasmaning qalinligi<br>$\frac{\delta}{D_1} = \frac{1}{40}$<br>Jadvaldan nisbat uchun $K_o = 2,25$ qabul qilamiz |
|--------------------------------|--------------------------------------------------|-------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                | rezina                                           | charm | xlopchato-bumajnaya |                                                                                                                                                                                    |
| $\frac{1}{40}$                 | 2,25                                             | 2,2   | 1,7                 |                                                                                                                                                                                    |
| $\frac{1}{50}$                 | 2,3                                              | 2,3   | 1,8                 |                                                                                                                                                                                    |

$C_o$  – uzatmani o'rnatish holatiga bog'liq gorizontal va og'ishgan burchagi  $60^0$  cha bo'lsa  $C_o = 1$ ; burchak  $60...80^0$ ; da  $C_o = 0,9$  va burchak  $80...90^0$  da  $C_o = 0,8$ , tasmali uzatmani gorizontal joylashuvida  $C_o = 1$ ;

$C_\alpha$  – kichik shkivni qamrov burchagi  $\alpha_1^0$  – ga bog'liq.

$\alpha_1^0$  – burchak esa o'qlararo masofaga bog'liq:

$$a_w = 2 \cdot (D_1 + D_2) = 2 \cdot (200 + 450) = 1300 \text{ mm}$$

Kichik shkivdagi qamrov burchagi  $\alpha = 180^0 - \frac{D_2 - D_1}{a_w} \cdot \frac{180^0}{\pi}$  yoki

$$\alpha = 180^0 - \frac{450 - 200}{1300} \cdot 60 = 168^0$$

$$\text{Koeffitsient } c_\alpha = 1 - 0,003 \cdot (180 - 168) = 0,949 \approx 0,964$$

$C_g$  – tezlik  $g_1$  ni hisobga oladi  $C_g = 1,04 - 0,0004 g^2$

$$\text{yoki } C_g = 1,04 - 0,0004 \cdot (10)^2 = 1,0$$

$C_p$  – uzatmadan foydalanish koeffitsienti :

- lentali transporter uchun  $C_p = 1,0$ ;

Ikki smenali ishlashda  $C_p$  – koeffitsient 0,1 ga kamaytiriladi. Unda

$$[K] = 2,25 \cdot 1 \cdot 0,964 \cdot 1 \cdot 1 = 2,18$$

- Tasmani ko'ndalang kesim yuzasi quyidagicha aniqlanadi

$$b\delta = \frac{P}{[K]}, \quad \text{yoki} \quad b\delta = \frac{312}{2,18} = 143,2 \text{ mm}^2$$

Tasmaning qalinligi  $\frac{\delta}{D_1} = \frac{1}{40}$  shartidan topiladi ( I-1-jadval ) .  $\frac{200}{40} = 5 \text{ mm}$

qalinlikda, bitta prokladkaning qalinligi 1,25 mm ( B turdagi tasma ) bo'lsa, prokladkalar soni 4 ta bo'lishi lozim. Tasmaning qalinligi kamaysa uning xizmat mudati ortadi.  $\delta = 4 \cdot 1,25 = 5 \text{ mm}$ .

$$\text{Tasma kesimining eni } b = \frac{143,2}{5,0} = 28,86 \text{ mm}$$

$$\text{Standart qatordan } b = 30,0 \text{ mm} \quad \text{va} \quad b\delta = 30 \cdot 5 = 150,0 \text{ mm}^2$$

Tasmaning hisobiy uzunligi

$$L = 2a + \frac{\pi}{2}(D_2 + D_1) + \frac{(D_2 - D_1)^2}{4a} = 2 \cdot 1300 + \frac{\pi}{2}(200 + 450) - \frac{(450 - 200)^2}{4 \cdot 1300} (\text{m})$$

$$\bar{Y} \text{qlararo masofa} \quad a = 0,25 \left[ (L - W) + \sqrt{(L - W)^2 - 8y} \right]$$

$$\text{bu erda} \quad W = \frac{\pi(D_2 + D_1)}{2} = \frac{3,14(450 + 200)}{2} \quad \text{va} \quad y = \frac{(D_2 - D_1)^2}{2} = \frac{(450 - 200)^2}{2}$$

$$a = 0,25 \left[ (5104 - 143) + \sqrt{(5104 - 143)^2 - 8 \cdot 130050} \right] = 2454 \text{ mm}$$

$$\text{Tasmaning boshlang'ich taranglashdagi kuchlanishi} \quad \sigma_O = \frac{S_O}{A} \leq [\sigma]_O$$

Tasma tarmoklarining tarangligi

$$2S_0 = S_1 + S_2 \quad \text{bu erda,} \quad S_0 = \sigma_0 b \cdot \delta = 1,8 \cdot 40 \cdot 5 = 360 H$$

$$\text{Etaklovchi tarmoq taranglik kuchi} \quad S_1 = S_0 + 0,5F = 360 + \frac{312}{2} = 516 H$$

$$\text{va etaklanuvchi tarmoqdagi kuch} \quad S_2 = S_0 - 0,5F = 360 - \frac{312}{2} = 206 H$$

$$\text{Doiraviy kuch} \quad F = S_1 - S_2 = 516 - 206 = 312 H$$

Val va val tayanchlariga tushadigan kuch

$$R = 2S_0 \cdot \sin\left(\frac{\alpha_1}{2}\right) = 2 \cdot 360 \cdot \sin\left(\frac{163}{2}\right) = 534 H$$

### Zanjirli uzatmani hisoblash.

**misol-4.8.** Etaklovchi yulduzchadagi aylantiruvchi moment

$$M_2 = 113,1 Hm;$$

Etaklovchi yulduzcha tishlarining soni

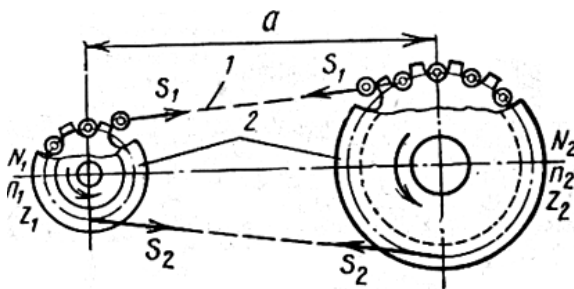
$$Z_3 = 31 - 2 \cdot i_3 = 31 - 2 \cdot 5,67 = 19,66$$

$$Z_3 = 20 \quad \text{qabul qilamiz}$$

-Etaklanuvchi yulduzcha

tishlarining soni

$$Z_4 = Z_3 \cdot i_3 = 20 \cdot 5,67 = 113$$



rasm-4.14

Yuklanish koeffitsenti

$$K = K_g \cdot K_a \cdot K_H \cdot K_p \cdot K_c \cdot K_n = 1 \cdot 1 \cdot 1 \cdot 1,25 \cdot 1 \cdot 1 = 1,25$$

Zanjir sharnirlaridagi ruxsat etilgan bosim

$$[P] = 22[1 + 0,01(z_3 - 17)] = 22[1 + 0,01(20 - 17)] = 22,66 \frac{H}{mm^2}$$

Jadval I-20 dan  $n_2 = 300 \frac{a_{\text{йл}}}{\text{мил}}$  aylanish chatotali val va qadami

$t = 19,05 \text{ mm}$  bo'lgan zanjir uchun ruxsat etilgan bosim  $22 \text{ N/m}^2$  ni tanlaymiz.

$$\text{Zanjirning qadami } t \geq 2,8 \cdot \sqrt[3]{\frac{M_2 \cdot K_3}{Z_3 \cdot [p]}} = 2,8 \cdot \sqrt[3]{\frac{113,4 \cdot 10^3 \cdot 1,25}{20 \cdot 22,66}} = 19_{\text{мм}}$$

$t = 19,05 \text{ мм}$ . qabul qilamiz.

Unda  $Q = 3180 \text{ Н}$ ;  $q = 1,5 \frac{\text{кГ}}{\text{м}}$ ;  $A = 105,8 \text{ мм}^2$  (jadval –I-21)

Zanjirni tezligi  $\vartheta = \frac{Z_3 \cdot t \cdot n_2}{60 \cdot 10^3} = \frac{20 \cdot 19,05 \cdot 303,15}{60 \cdot 10^3} = 1,924 \frac{\text{м}}{\text{с}}$

2 valni aylanish chastotasi  $n_2 = \frac{30 \cdot \omega_2}{\pi} = \frac{30 \cdot 31,73}{3,14} = 303,15 \frac{\text{айл}}{\text{мин}}$

Doiraviy kuch  $F_y = \frac{M_2 \omega_2}{\vartheta} = \frac{113,4 \cdot 31,73}{1,924} = 1870 \text{ Н}$

Sharnirdagi bosim :  $P = \frac{F_y \cdot K_9}{A} = \frac{1870 \cdot 1,25}{105,8} = 22 \frac{\text{Н}}{\text{мм}^2}$

$P \leq [P]$  - shart bajarildi.

O'qlararo masofa .  $a_y = 50 \cdot t = 50 \cdot 19,05 = 0,952 \text{ м}$

Jadval I-21 dan  $K_f = 1,5$ ;  $q = 1,5 \frac{\text{кГ}}{\text{м}}$ ;

Zanjirdagi kuch  $F_f = 9,81 \cdot K_f \cdot q \cdot a_y = 9,81 \cdot 1,5 \cdot 1,5 \cdot 0,952 = 21 \text{ Н}$

Vallarga ta'sir qiladigan kuch  $R_y = F_y + 2F_f = 1870 + 2 \cdot 21 = 1912 \text{ Н}$

Etakchi yulduzchaning diametrlari  $d_3 = \frac{t}{\sin \frac{180}{Z_3}} = \frac{19,05}{\sin \frac{180}{20}} = 121,8 \text{ мм}$

$$D_3 = \frac{t}{\text{tg} \frac{180}{Z_3}} + 0,6 \cdot t = \frac{19,05}{\text{tg} \frac{180}{20}} + 0,6 \cdot 19,05 \approx 131,7 \text{ мм}$$

Yulduzcha stupitsasining o'lchamlari

$d_{cT} = 1,6 \cdot 32 = 51,2 \text{ мм}$ ;  $l_{ct} = (1,2 \dots 1,5) \cdot 32 = 38,4 \dots 48 \text{ мм}$ ,

$l_{ct=} = 45 \text{ мм}$  qabul qilamiz.

Yulduzcha diskinining qalinligi  $0,93B_{BH} = 0,93 \cdot 19,05 = 18 \text{ мм}$

## Valni mustahkamlikka hisoblash ketma - ketligi

jadval-4.7.

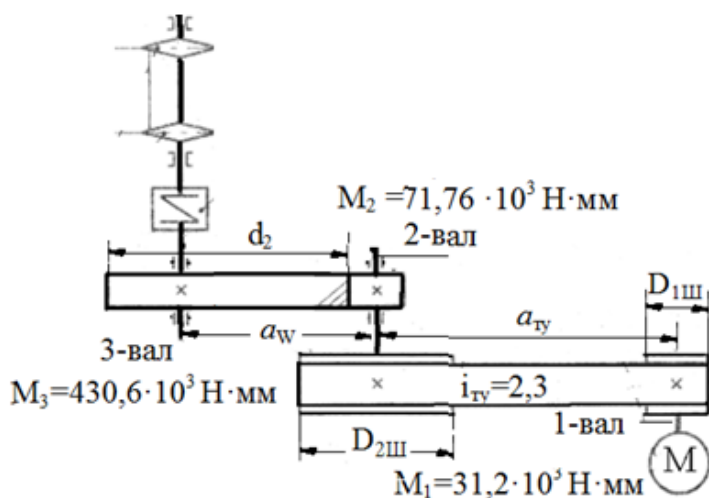
|                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Etaklovchi val kirish qismining diametri $[\tau_k] = 25 \text{ mPa}$ . ruxsat etilgan kuchlanish va etaklanuvchi val chiqish qismining diametri kamaytirilgan $[\tau_k] = 20 \text{ mPa}$ ruxsat etilgan kuchlanish bo'yicha faqat buralishga hisoblanadi | $d_e \geq \sqrt[3]{\frac{M_K}{0,2 \cdot [\tau_K]}}$ <p>Hisobiy diametr - 10;10,5;11;11,5; 12;13;14;15;16;17; 18;19;20;21;22; 24; 25;26;28;30;32;34; 36;38;40;45;48; 50; 52;55;60;63;65;70; 75;80;85;90;95; 100 105;110; 120;125; 130; 140;150;160. standart qiymatiga qadar yaxlitlanadi</p> |
| 2. Val pog'onalar kesimlarining diametrlari va pog'ona uzunligi hisoblanadi. Valni konstruktiv shakli (konstruksiya) ishlab chiqiladi                                                                                                                        | <p>Val podshipnik o'rni pog'onasining diametri <math>d_{n1} = d_{b1} + (5 \cdots 10) \text{ mm}</math></p> <p>Valning shesternya o'rnatiladigan pog'onasining diametri <math>d_K = d_n + (5 \cdots 10) \text{ mm}</math></p>                                                                 |
| 3. Konstruktiv ishlab chiqilgan val asosida uning hisoblash sxemasi tuziladi                                                                                                                                                                                 | Misollarni qarang                                                                                                                                                                                                                                                                            |
| 4. Burovchi moment va eguvchi moment epyuralari quriladi                                                                                                                                                                                                     | Misollarni qarang                                                                                                                                                                                                                                                                            |
| 5. Nominal urinma va normal kuchlanishlar hisoblanadi, valni xavfli kesimi belgilanadi                                                                                                                                                                       | $\tau_{\max} = \frac{M_{\delta}}{W_{\rho}} \quad \text{va} \quad \sigma_{\max} = \frac{M_{\vartheta}}{W}$                                                                                                                                                                                    |
| 6. Normal va urinma kuchlanishlar bo'yicha mustahkamlikka ehtiyotlik koefitsientlari aniqlanad: egilishda normal kuchlanish bo'yicha<br><br>buralishda urinma kuchlanish bo'yicha                                                                            | $n_{\sigma} = \frac{\sigma_{-1} \varepsilon_{\sigma} \beta}{k_{\sigma} \sigma_{\max}}$ $n_{\tau} = \frac{2 \tau_{-1}}{(\frac{k_{\tau}}{\varepsilon_{\tau} \beta} + \psi_{\tau}) \cdot \tau_{\max}}$                                                                                          |
| 7. Mustahkamlikka umumiy ehtiyotlik koefitsient                                                                                                                                                                                                              | $n = \frac{n_{\sigma} n_{\tau}}{\sqrt{n_{\sigma}^2 + n_{\tau}^2}}$                                                                                                                                                                                                                           |
| 8. Hisobiy va mustahkamlik shartlari bo'yicha ehtiyotlik koefitsientlari taqqoslanadi                                                                                                                                                                        | $n_{\min} \geq [n]$ $[n] = 1,5 \cdots 3,0 \quad \text{talab etilgan mustahkamlik koefitsienti}$                                                                                                                                                                                              |

Vallarni loyihaviy hisoblashda egilishdagi kuchlanish, kuchlanishlar konsentratsiyasi va tsikl davomida o'zgaruvchan kuchlanishlarni e'tiborga

olmasdan faqat buralish kuchlanishi asosida hisoblanadi. Ushbu usulni taqribanligini kompensatsiya qilish uchun buralishga kamaytirilgan ruxsat etilgan kuchlanish qabul qilinadi  $[\tau_k] = 20 \dots 25 \frac{H}{mm^2}$ . Bunda ruxsat etilgan kuchlanishning kichik qiymati tezyurar val uchun va katta qiymati sekin yurar val uchun tavsiya etiladi.

**Val pog'onalarining geometrik o'lchamlarini aniqlash.** Val pog'onali tsilindr bo'lib, pog'onaning soni va o'lchamlari unga o'rnatiladigan detallarning soniga o'lchamiga bog'liq. Loyihaviy hisoblash har bir pog'onaning diametri va uzunligini aniqlashdan iborat.

12 dan 26 mm.gacha 0,5 farqi, 26 dan 30 mm.gacha 1 mm. farqi bilan bilan diametr o'lchamlari belgilanadi. Podshipnik, tishli g'ildirak va boshqa detallarni yig'ish qulay bo'lishi uchun vallar pog'onali tayyorlanadi. Elektrodvigatel reduktor bilan mufta orqali biriktirilsa valni diametri elektrodvigatelning diametridan 20 % farq etishi mumkin yoki  $d_e \approx 0,75 d_{de}$  formulada hisoblanadi.



rasm-4.15

**Bir pog'onali tsilindrik uzatamani hisoblash.**

**misol-4.9.** Berilgan misolda reduktorning etaklovchi vali yuritmaning tarkibidagi ikkinchi val hisoblanadi, unda reduktorning etaklanuvchi vali yuritmaning tarkibidagi uchinchi val. Shuning uchun

$$M_{K1} = M_2 = 71,76 \cdot 10^3 H \cdot mm$$

$$M_{K2} = M_3 = 430,6 \cdot 10^3 H \cdot mm$$

**Etaklovchi val.** Etaklovchi valning kirish qismida tekis tasmali uzatmaning shkivi o'rnatiladi. Tasmalarning taranglik kuchlari ta'siridan val egilishga qarshilik ko'rsatadi. Bu holda ruxsat etilgan kuchlanishni  $[\tau_k] = 20 \frac{H}{mm^2}$  qabul qilamiz.

Val kirish qismining diametri:

$$d_{e1} \geq \sqrt[3]{\frac{M_{K1}}{0,2 \cdot [\tau_k]}} = \sqrt[3]{\frac{71,76 \cdot 10^3}{0,2 \cdot 20}} = 26 mm$$

Standart qatordan  $d_{e1} = 26 mm$  qabul qilamiz.

Val podshipnik o'rni pog'onasining diametri

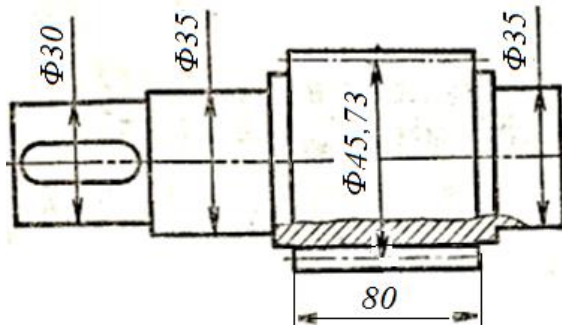
$$d_{n1} = d_{b1} + (5 \dots 10) mm = 26 + 4 = 30 mm$$



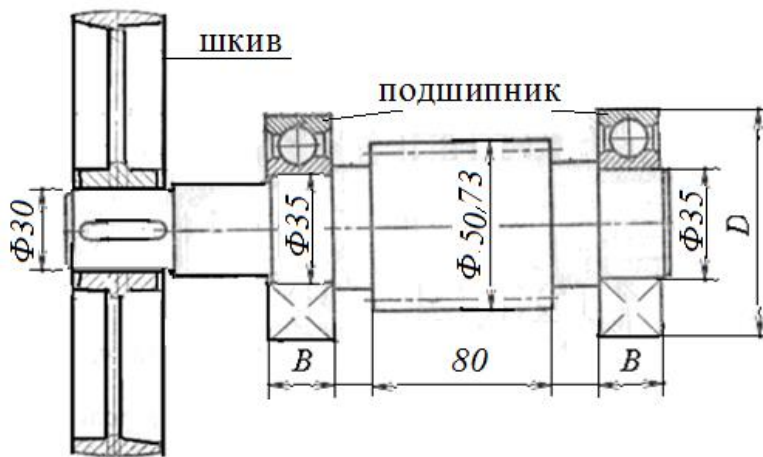
Valning shesternya o'rnatiladigan pog'onasining diametri

$$d_K = d_n + (5 \cdots 10) \text{ мм} = 30 + 5 = 35 \text{ мм}$$

Agar shesternya alohida tayyorlansa ushbu pog'onada shponka o'rni tayyorlanadi va valning kesimi zaiflashadi. Shuning uchun val shesternya bilan birga tayyorlanadi.



Val pog'onalarining uzunliklari reduktorni dastlabki komponovkasidan topiladi.



Val-shesternyani konstruksiyalash  
Valga podshipnik va tekis remenli uzatmaning shkivi o'rnatilgan

**Etaklanuvchi val.** Val mufta yordamida zanjirli konveyer bilan tutashtiriladi. Val chiqish qismining diametri

$$d_{e2} \geq \sqrt[3]{\frac{M_{K2}}{0,2 \cdot [\tau_K]}} = \sqrt[3]{\frac{430,6 \cdot 10^3}{0,2 \cdot 25}} = 44,2 \text{ мм}$$

Standart qatordan  $d_{e2} = 45 \text{ мм}$  qabul qilamiz.

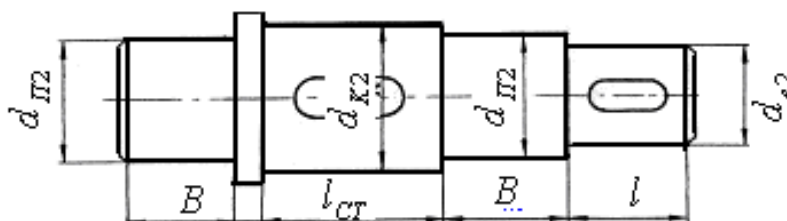
Podshipnik o'rni uchun val diametri

$$d_{n2} = d_b + (5 \cdots 10) \text{ мм} = 45 + 5 = 50 \text{ мм},$$

g'ildirak o'rni uchun val diametri

$$d_{K2} = d_n + (5 \cdots 10) \text{ мм} = 50 + 5 = 55 \text{ мм}$$

va bo'rtik diametri  $d_\delta = d_K + (5 \cdots 10) \text{ мм} = 55 + 10 = 65 \text{ мм}.$



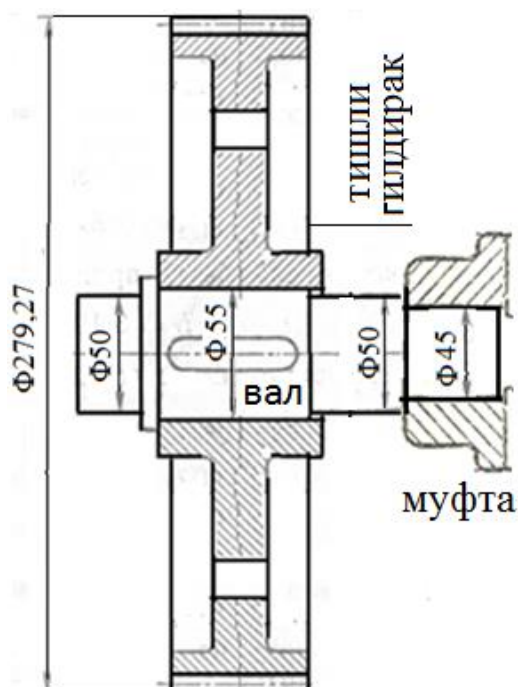
Etaklanuvchi valning eskizli sxemasi

Valni ishchi chizmasi uchun pog'onalar uzunligini quyidagicha qabul qilamiz:

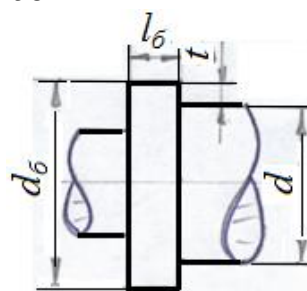
- val oxirining uzunligi  $\ell = (1,5 \dots 2)d_6$ ;

- podshipnik o'rnatiladigan pog'onani uzunligi tanlangan podshipnik xalqasining eniga teng ( $\ell_{dn} = B$ ),

val o'rta pog'onasi ning uzunligi  $\ell_{dk} = \ell_{cm} = (1,2 \dots 1,5) \cdot d_K$  - tishli g'ildirak stupitsasi ning uzunligiga teng.



Hisoblangan o'lchamlar valni to'liq hisoblash va reduktorni komponovka-sida aniqlashtiriladi

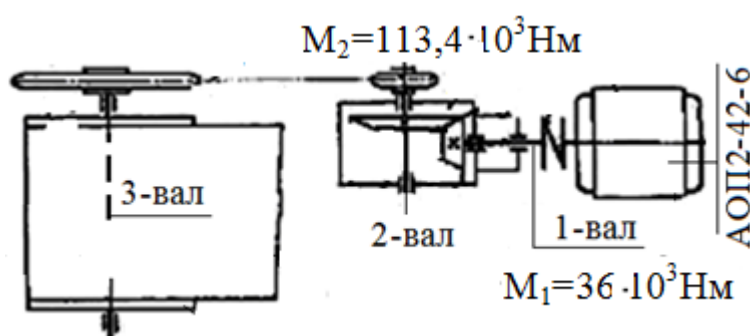


Burtikning balandligi val pog'onasi-ning diametriga bog'liq holda quyida-gi 4.8-jadvaldan ham qabul qilinishi mumkin

Etaklanuvchi val

jadval-4.8.

|     |         |         |         |         |         |         |         |
|-----|---------|---------|---------|---------|---------|---------|---------|
| $d$ | 17...24 | 25...30 | 32...40 | 42...50 | 52...60 | 62...70 | 71...85 |
| $t$ | 2       | 2,2     | 2,5     | 2,8     | 3       | 3,5     | 3,5     |



rasm-4.16

**Bir pog'onali konussimon uzatma vallarini hisoblash**

**misol-4.10.**

Vallarni kamaytirilgan kontakt kuchlanish bo'yicha burovchi moment orqali hisoblaymiz. Vallarning ko'ndalang kesimidagi

burovchi moment-lar :

$$\text{Etaklovchi valda } M_{\kappa 1} = M_1 = 36 \cdot 10^3 H \cdot \text{mm}$$

$$\text{Etaklanuvchi valda } M_{\kappa 2} = 113,4 \cdot 10^3 H \cdot \text{mm}$$

$$\text{Etaklovchi val.} \quad \text{Ruxsat qilingan kuchlanish} \quad [\tau]_{\kappa} = 25 \frac{H}{\text{mm}^2} \text{ qabul}$$

qilib, valning kirish qismi diametrini hisoblaymiz.

$$d_{\kappa 1} = \sqrt[3]{\frac{M_{\kappa 1}}{0,2[\tau]_{\kappa}}} = \sqrt[3]{\frac{36 \cdot 10^3}{0,2 \cdot 25}} = 19,4 \text{ mm}$$

Reduktorning vali mufta orqali elektrodvigatel vali bilan birlashtirilish  $d_{\kappa} \approx 0,75d_{\kappa 6}$  shartidan foydalanamiz. U holda

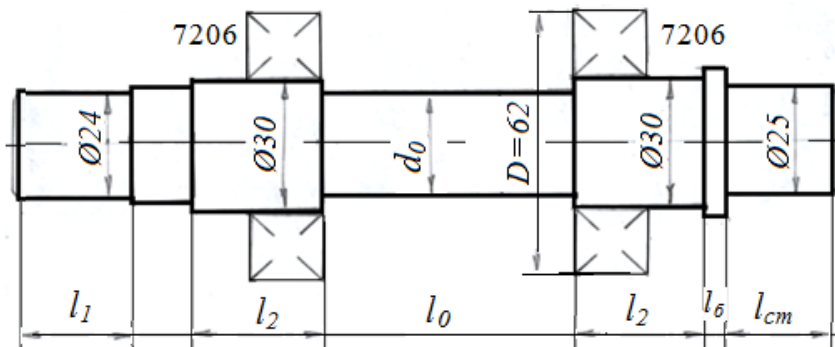
$$d_{\kappa 1} \approx 0,75 \cdot 32 = 24 \text{ mm bo'ladi.}$$

$$d_{\kappa 1} = 24 \text{ mm qabul qilamiz}$$

Podshipnik o'rni diametrini aniqlaymiz.

$$d_{n1} = d_{\kappa 1} + (5 \dots 10) \text{ mm} \text{ yoki } d_{n1} = 24 + 6 = 30 \text{ mm deb qabul qilamiz.}$$

Val- shesternya bilan tayyorlanmaydi  $d_{\kappa 1} = 25 \text{ mm}$ .



rasm-4.17.  
Etaklovchi  
valning eskizli  
sxemasi.

$l_1$  - val kirish qismi kesimining diametri.  $l_1 = 1,5d_{\kappa 1}$  qabul qilinadi yoki MUVF stupitsasining uzunligiga teng.

$l_2$  -podshipnik va zichlagich ichki xalqalarining eniga bog'liq topiladi.

$l_{cm}$  -valning konussimon shesternya o'rnatiladigan kesimining diametri,

$l_{cm} = 1,5d_{\kappa 1}$  yoki shesternya gardishining eniga bog'liq topiladi.

$l_6$  - burtik uzunligi,  $l_6 = (5 \dots 10) \text{ mm}$  olinadi.

$l_0$  - reduktorni komponovkasi asosida aniqlanadi.

$$\text{Etaklanuvchi val: } [\tau]_{\kappa} = 20 \frac{H}{\text{mm}^2} \text{ qabul qilib, val diametrini aniqlaymiz.}$$

$$d_{\kappa 2} = \sqrt[3]{\frac{M_{\kappa 2}}{0,2[\tau]_{\kappa}}} = \sqrt[3]{\frac{113,4 \cdot 10^3}{0,2 \cdot 20}} = 30,5 \text{ mm}$$

$d_{\epsilon_2} = 32 \text{ мм}$  deb qabul qilamiz.

Podshipnik o'ri diametri  $d_{n2} = 40 \text{ мм}$  qabul qilamiz.

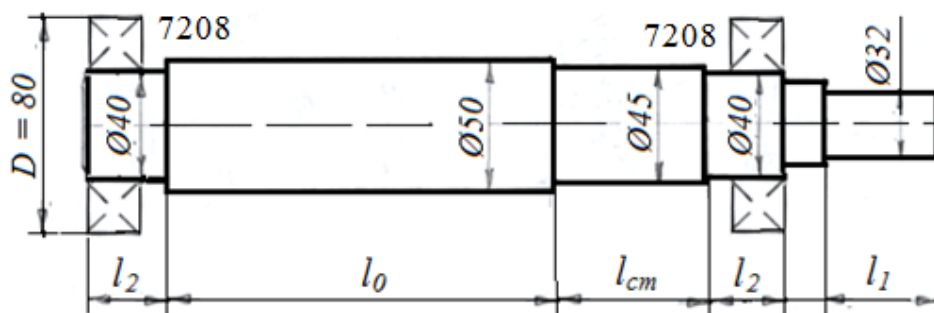
Valni g'ildirak o'rnatiladigan qismining diametr

$d_{\kappa 2} = 45 \text{ мм}$  qabul qilamiz.

Vallar uchun podshipnik tanlaymiz:

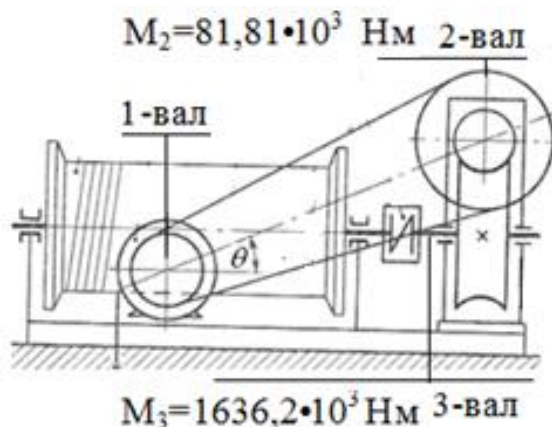
jadval-4.9

| Podshipnik № | $d$              | $D$ | $T$ | $C$  | $C_0$ | $e$   |
|--------------|------------------|-----|-----|------|-------|-------|
|              | o'lchamlar mm.da |     |     |      |       |       |
| 7206         | 30               | 62  | 17  | 29,6 | 21,9  | 0,365 |
| 7208         | 40               | 80  | 20  | 41,6 | 32,1  | 0,383 |



rasm-4.18.  
Etaklanuvchii  
valning eskizli  
sxemasi

$l_0$  - reduktorni komponentkasida aniqlanadi.



rasm-4.19

**Bir pog'onali chervyakli uzatma  
vallarini hisoblash.**

**misol-4.11.** Vallarni kamaytirilgan kontakt kuchlanish bo'yicha burovchi moment orqali hisoblayg' miz.

Vallarning ko'ndalang kesimidagi burovchi momentlar :

Etaklovchi val

$$M_{\kappa 1} = M_1 = 81,81 \cdot 10^3 \text{ H} \cdot \text{мм}$$

Etaklanuvchi val

$$M_{\kappa 2} = 1636 \cdot 10^3 \text{ H} \cdot \text{мм}$$

**Etaklovchi valni hisoblash.** Ruxsat qilingan kuchlanish  $[\tau]_{\kappa} = 25 \frac{\text{H}}{\text{мм}^2}$

qabul qilib, valning kirish qismining diametri.

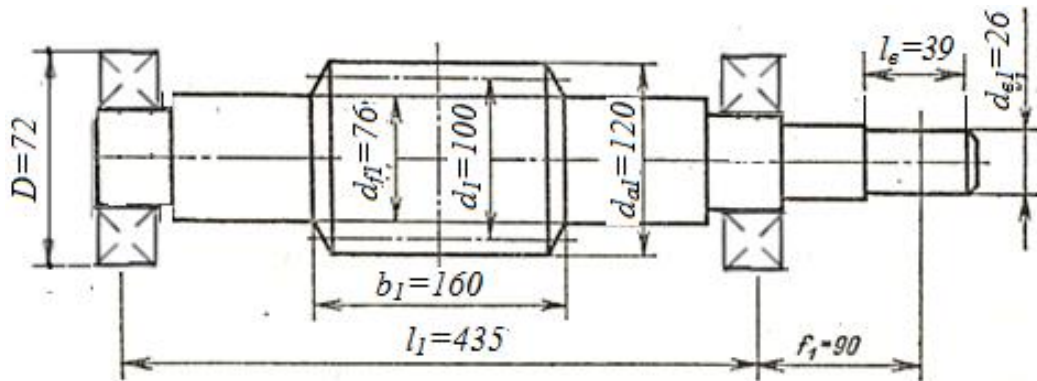
$$d_{\epsilon 1} = \sqrt[3]{\frac{M_{\kappa 1}}{0,2[\tau]_{\kappa}}} = \sqrt[3]{\frac{81,81 \cdot 10^3}{0,2 \cdot 25}} = 25,5 \text{ мм}$$

$d_{\epsilon 1} = 26 \text{ мм}$  qabul qilamiz

Podshipnik o'ri diametrini aniqlaymiz

$$d_{n1} = d_{e1} + (5...10)_{\text{mm}} \quad \text{yoki} \quad d_{n1} = 26 + 4 = 30_{\text{mm}} \quad \text{deb qabul qilamiz.}$$

Val- shesternya bilan birga tayyorlanmaydi  $d_{\kappa1} = 25_{\text{mm}}$ .



rasm-4.20. Etaklovchi valning eskizli sxemasi.

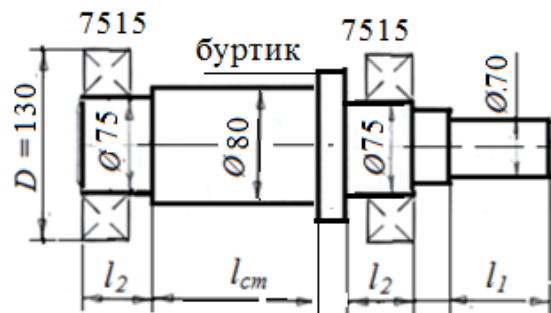
**Etaklanuvchi val:**  $[\tau]_{\kappa} = 25 \frac{H}{\text{mm}^2}$  qabul qilib, val diametrini aniqlaymiz.

$$d_{e2} = \sqrt[3]{\frac{M_{\kappa2}}{0,2[\tau]_{\kappa}}} = \sqrt[3]{\frac{1636 \cdot 10^3}{0,2 \cdot 25}} = 69_{\text{mm}}$$

$d_{e2} = 70_{\text{mm}}$  deb qabul qilamiz.

Podshipnik o'ri diametri  $d_{n2} = 75_{\text{mm}}$  qabul qilamiz.

Valni g'ildirak o'rnatiladigan qismining diametr  $d_{\kappa2} = 80_{\text{mm}}$  qabul qilamiz.



rasm-4.21  
Etaklanuvchi  
valning eskizli  
sxemasi

Vallar uchun podshipnik tanlaymiz:

jadval-4.10

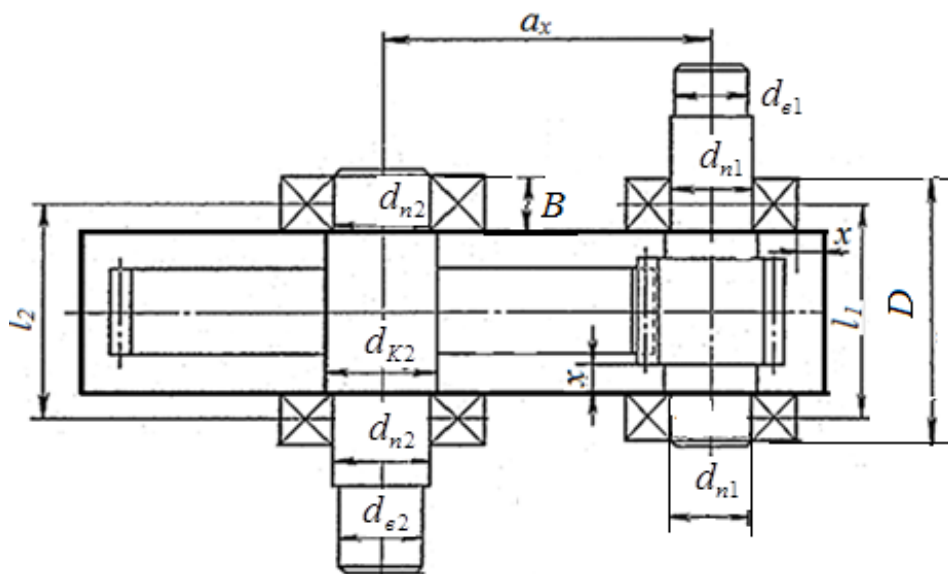
| Podshipnik<br>№ | $d$              | $D$ | $T$ | $C$  | $e$   |
|-----------------|------------------|-----|-----|------|-------|
|                 | o'lchamlar mm.da |     |     | kN   |       |
| 46306           | 30               | 72  | 19  | 25,1 | 0,680 |
| 7515            | 75               | 130 | 31  | 113  | 0,407 |

**Reduktorning eskizli komponovkasi.** Eskizli komponovka podshipnikka nisbatan reduktor g'ildiraklarini ochiq uzatmaning elementlari va muftaning holatini belgilaydi, vallarda podshipnik reaksiyalari qo'yilgan nuqtalar orasidagi  $\ell_1$  va  $\ell_2$  masofalarni aniqlaydi, ochiq uzatma va muftani valga bosim kuchi bilan podshipnik reaksiyalarining orasidagi masofalarni belgilaydi.

**Tsilindrik tishli reduktorning komponovkasi.** Reduktorni komponovkasi ikki etapda o'tkaziladi. Komponovkani birinchi etapi shesternya va tishli g'ildirak holatini, podshipniklar o'rmini va tayanch kuchlarini aniqlash uchun bajariladi.

Komponovka  $M1:1$  masshtabda bir proektsiyada amalga oshiriladi. Buning uchun qog'ozni o'rtasidan gorizontaal chiziqqa bir-biridan  $a_w$  masofada joylashgan (rasm-4.22) ikkita vertikal o'q o'tkazamiz. Bu o'qlarda shesternya  $b_1$ ,  $d_1$  o'lchamlarda va tishli g'ildirakni  $b_2$ ,  $d_2$  o'lchamlarda ko'rsatiladi, tishli g'ildirakda stupitsani diametri  $d_{cm}$  va uzunligi  $l_{cm}$  belgilanadi. Shesternya gardishi bilan reduktor korpusi devorining ichki tomoni oraliq masofasini  $x_1 = (10 \dots 15) \text{ mm}$  qoldiriladi

Etaklovchi valni  $d_{\epsilon 1}$   $d_{n1}$  diametrlarda va etaklanuvchi valni  $d_{\epsilon 2}$ ,  $d_{n2}$  va  $d_{K2}$  diametrlarda ko'rinishini belgilaymiz.



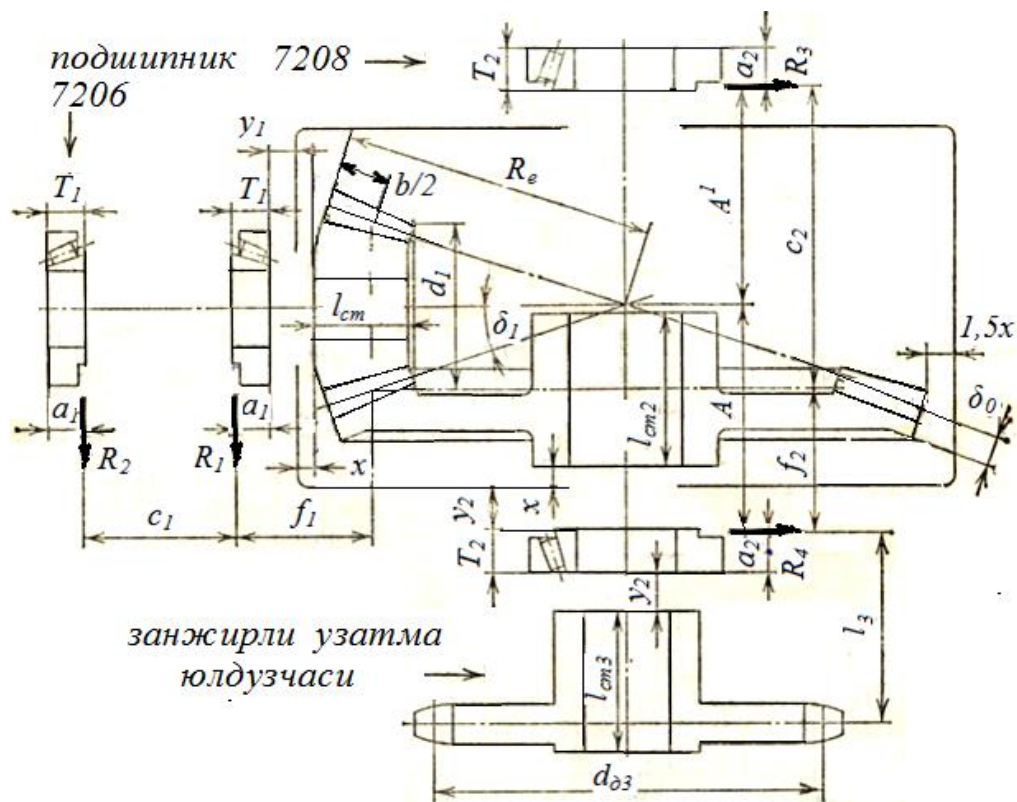
rasm-4.22  
Bir pog'onali  
tsilindrik  
tishli  
redutorning  
birinchi etap  
komponovkasi

Vallarda reduktor korpusining ichki devoridan 3-4mm chuqurlikda podshipniklarning o'rinlarini  $d_n$ ,  $D$  va  $B$  o'lchamlarda belgilaymiz.

Reduktor korpusi poyasining eni  $l_r = 1,5 \cdot B$  qabul qilinadi. Etaklovchi val podshipnikining tashqi diametri bilan reduktor korpusi devorining ichki tomoni orasidagi masofani ham  $A_1 = A$  ga teng qilib olamiz. Agar shesternyani tishlar



uchi bo'yicha diametri podshipnikni tashqi diametridan katta bo'lsa, A- masofa shesternya tashqi diametrdan belgilanadi.



rasm-4.23

**Konussimon tishli reduktorning dastlabki komponovkasi.** Varaqni o'rtasidan etaklovchi val o'qini ifodalovchi chiziq o'tkazamiz, etaklanuvchi val o'qining holatini belgilaymiz. Ikki o'qni kesishgan nuqtasidan  $\delta_1=17^{\circ}34'$  burchak ostida bo'luvchi konusni bo'ylama chiziqlarini o'tkazamiz va  $R_e$  - kesma uzunligini belgilaymiz (rasm-4.23).

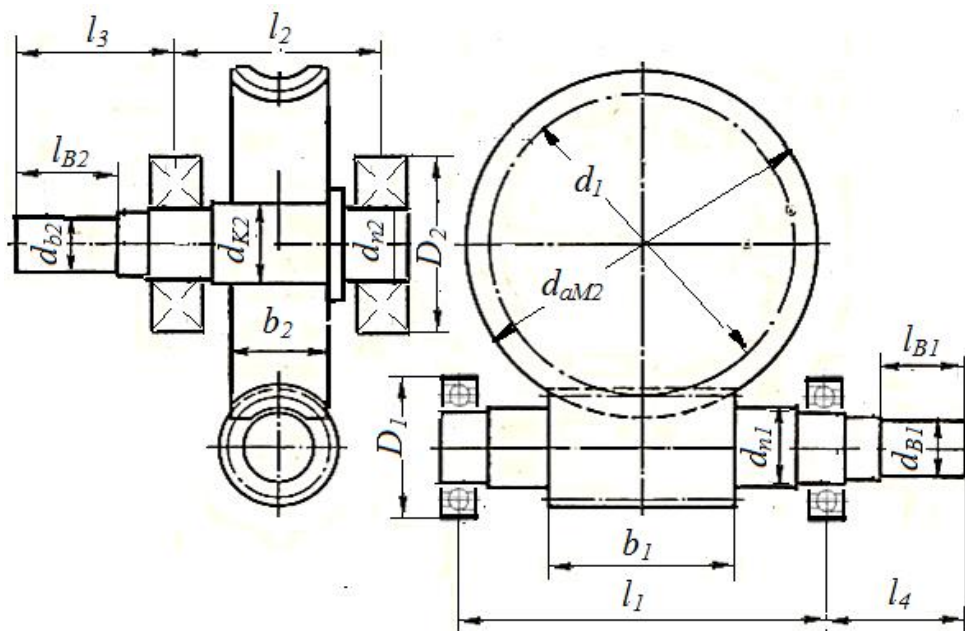
Shesternya, g'ildirak va podshipniklar gabaritlarini ko'rsatamiz. Reduktor devorining ichki tomonini shesternyani gardishidan  $x=10\text{mm}$  va podshipnik gardishidan  $y_1=15\text{mm}$  masofada joylashtiramiz (rasm-4.23).

Reduktor devorining ichki tomoni bilan g'ildirak stupitsasidan  $x=10\text{mm}$  va podshipnik gardishidan  $y_2=20\text{mm}$  masofada joylashadi. Etaklovchi val o'qiga nisbatan reduktor simmetrik holda loyihalanadi. Unda etaklovchi val o'qi bilan etaklanuvchi val podshipniki reaksiya kuchining chiziqigacha bo'lgan masofalar aniqlanadi. Komponovkada  $A^1 + A = C_2 + f_2$  saqlanishi lozim. Etaklanuvchi valda konveyer barabani yoki zanjirli uzatma yulduzchasining holati ko'rsatiladi va  $l_3$  - masofa aniqlanadi.

Tishli g'ildirak, podshipnik va boshqa elementlar o'rni uchun val diametri va uzunligini hisoblashlar natijasi va ishlov berish va yig'ish texnologik talabalari

asosida belgilanadi. Etaklovchi val podshipniklarini stakan ichida joylashtiramiz. Raspor vtulka devorining qalinligini  $(0,1...0,15)d$  belgilaymiz. Moy ushlagich halkalarni stakanni ichkarisiga 1-2 mm kiritiladi. Podshipniklar devorining qalinligi  $\delta_{CT} = (0,08...0,12)D$  bo'lgan stakanga joylashtiramiz.

**Chervyakli reduktorning komponovkasi** (rasm-4.24). Komponovka ikkita proektsiyada bajariladi - g'ildirak o'qi va chervyak o'qlari bo'ylab qirqim. Chervyak g'ildiragining stupitsasi bilan reduktor devorining ichki tomoni o'rtasida  $u_1$  masofa qoldiramiz va uni ingichka chiziq bilan belgilaymiz.  $\ell_1$  masofada chervyak podshipniklarini va  $\ell_2$  chervyak g'ildiragi podshipnikalarini chizamiz ( $u_1 = 15 \text{ mm}$ )



rasm-4.24.  
Chervyakli  
uzatmaning  
komponov-kasi

Tez yurar va sekin yurar vallardagi podshipniklar reaksiyalarining qo'yilish nuqtalari orsidagi  $\ell_1$  va  $\ell_2$  masofalarni aniqlash: Radial kuch – podshipnik dumalash elementi va tashqi xalqani kontaktlashish tekisligi normal bilan val o'qini kesishish nuqtasiga qo'yilgan bo'ladi

a) radial podshipniklar uchun reaksiyaning qo'yilish nuqtasi podshipnik tekisligining o'rtasida qabul qilinadi;

b) radial – tirakli podshipniklarda reaksiyani qo'yilish nuqtasi  $a$  masofa bilan topiladi:

bir qatorli sharikli radialtirakli 
$$a = 0,5(B + \frac{d + D}{2} \operatorname{tg} \alpha)$$

bir qatorli konussimon rolikli 
$$a = 0,5(T + \frac{d + D}{3} e)$$



## Dumalash podshipniklarini tanlash metodikasi

jadval-4.11

| Nima qilish kerak                                                                                   | Nimadan foydalanish mumkin                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.Valni yuklanish sxemasini aniq-lang, podshipnik o'rni pog'onasining diametri topilsin             | Tishli, tasmali va boshqa uzatmalar xarakteristikalarini asosida bajariladi. Misollarga qarang                                                                                                                                                                                                                                                                                                                                            |
| 2.Podshipniklar va ularni o'rnatish sxemasi tanlanadi                                               | Podshipnikni tanlash, u qabul qiladigan kuchga bog'liq. Ma'lumot [7,22,23] qo'llanmalarda berilgan                                                                                                                                                                                                                                                                                                                                        |
| 3.Podshipniklardagi radial yuklar (radial reaksiyalar) aniqlansin                                   | Statikaning muvozanat tenglamalari yordamida aniqlanadi.                                                                                                                                                                                                                                                                                                                                                                                  |
| 4. Podshipniklardagi ekvivalent kuchlar aniqlanadi                                                  | Radial sharikli va radial tirak hamda rolikli radial tirak podshipniklar uchun ekvivalent kuch quyidagi formuladan topiladi<br>$F_{\text{эк}} = (X \cdot F_{r2} \cdot V + Y \cdot F_{a2}) K_{\delta} \cdot K_T$ Kalta tsilindrik rolikli radial rolikli podshipniklar uchun ekvivalent kuch quyidagi formuladan topiladi<br>$F_{\text{эк}} = F_{r3} V K_{\delta} K_T$ Ekvivalent kuchni hisoblash usuli [7,22,23] qo'llanmalarda berilgan |
| 5.Katalogdan podshipnikni dinamik yuk ko'tarish qobiliyati aniqlanadi va xizmat muddati hisoblanadi | $L_h = \frac{10^6}{60 \cdot n} \left( \frac{C}{F_{\text{эк}}} \right)^m$ Sharikli podshipnik uchun $m = 3$<br>Rolikli podshipnik uchun $m = \frac{10}{3}$<br>Agar $L_h$ talab qilingan xizmat muddatidan kichik bo'lsa, boshqa podshipnik yoki podshipnikni o'rnatish sxemasi o'zgartirilishi mumkin                                                                                                                                      |

### Podshipniklarni tanlash va xizmat muddatini hisoblash

Podshipnik uzelarining konstruksiyasi vallarning o'qi bo'ylab ko'chishini va temperaturali deformatsiyani cheklashi (fiksatsiya), ishonchli moylash tashqi muhitdan ifloslanishdan himoyalash, detallarni yig'ish va bo'laklarga ajratish hamda regulirovkani aniq bajarilishini ta'minlash.

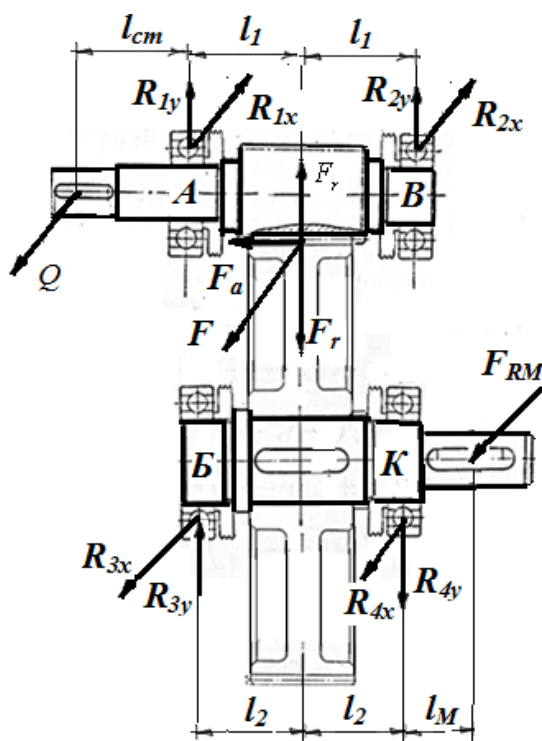
**Podshipnik turini aniqlash.** Podshipnik turini aniqlashda konstruktiv va iqtisodiy mulohazalarga e'tibor berish kerak. Masalan, sharikli podshipnik rolikli

podshipnikdan arzon, yuqori aniqlik klassida bajarilgan podshipniklarning narxi normal klassda tayyorlangan podshipniklardan qimmat.

Zarb ta'sirida ishlaydigan tayanchlarda rolikli podshipnik qo'llaniladi, uzalgacha faqat radial kuchlar ta'sir qilsa sharikli podshipnik o'rnatiladi.

Aylanishlar chastotasi  $n \leq 1 \frac{a_{\text{ayl}}}{\mu_{\text{MH}}}$  bo'lgan podshipniklar uchun asosiy xarakteristika statik yuklanish  $C_0$  va yuqori aylanish chastotasida dinamik yuklanish -  $C$  hisoblanadi.

Radial va radial - upor podshipniklarda dinamik yuk ko'tara olishlik o'zgarmas radial yuklanish qiymati deyiladi. Tashqi qo'zg'almas xalqali podshipniklarda ichki xalqani 1 mln. aylanish chastotasida ham bunday yuklanishni qabul qila oladi. Tirak podshipniklarda dinamik yuk ko'tara olishlik o'zgarmas bo'ylama yuklanish qiymati deyiladi. 1 mln. Aylanish chastotasida podshipnikning birorta xalqasi bunday yuklanishni qabul qila oladi. Ushbu vaqtda, bir xil sharoitda barcha podshipniklar metallida charchash alomatlari sodir bo'lmasligi podshipnikning nominal xizmat muddati deyiladi



rasm-4.22. Ilashmadagi kuchlar va vallarning tayanchlaridagi reaksiya kuchlari

**Etaklovchi val.** Ilashmadagi ta'sir qiluvchi kuchlar:  $F = 3138,4H$ ,  $F_r = 1160,9H$  va  $F_a = 553,3H$ . Tasmali uzatmadan  $Q = 534H$  bosim kuchi ta'sir qiladi. Reduktorni komponovkasidan  $l_{cm} = 70 \text{ mm}$

**Bir pog'onali tsilindrik qiyshiq tishli uzataning vallari uchun podshipniklarning xizmat muddatini hisoblash.**

**misol-4.12.** Tanlangan podshipniklarning xizmat muddati vallarning tayanchlaridagi reaksiyalarga bog'liq. Yuritmaning tarkibidagi ikkinchi val reduktor uchun etaklovchi val hisoblanadi. Etaklovchi valdagi aylantiruvchi moment uning kesimida burovchi momentni keltirib chiqaradi:

$$M_{\sigma 1} = M_1 = 71,76 \cdot 10^3 H_{\text{MM}}$$

Reduktorni etaklovchi va etaklanuvchi vallardagi reaksiya kuchlarini alohida - alohida topamiz.

$XZ$  tekisligida reaksiya kuchlarini aniqlaymiz (*rasm-4.23*)

$$\sum M_A = -Fl_1 + R_{2X} 2l_1 + Q \cdot l_{cm} = 0 \quad \text{va}$$

$$R_{2X} = \frac{1}{2l_1} (F \cdot l_1 - Q \cdot l_{cm}) = \frac{1}{2 \cdot 70} (3138 \cdot 70 - 534 \cdot 25) = 1473,6H$$

$$\sum M_B = Fl_1 - R_{1X} 2l_1 + Q \cdot (2l_1 + l_{cm}) = 0 \quad \text{va}$$

$$R_{1X} = \frac{1}{2l_1} [F \cdot l_1 + Q \cdot (l_{cm} + 2l_1)] = \frac{1}{2 \cdot 70} [3138 \cdot 70 + 534 \cdot (25 + 2 \cdot 70)] = 2198,4H$$

$$\text{Tekshirish: } \sum z = R_{1X} + R_{2X} - F - Q = 0$$

$$2198,4 + 1473,6 - 3138 - 534 = 0$$

Reduktorning xarakterli nuqtalari uchun eguvchi momentlarni topamiz.

$$\text{A tayanchda } M_A = -Q \cdot l_{cm} = -534 \cdot 25 = -13350 H \cdot \text{mm} = 13,35H \cdot \text{m}$$

C tayanchda

$$M_C = -Q \cdot (l_{cm} + l_1) + R_{1X} l_1 = -534 \cdot 95 + 2198,4 \cdot 70 = 103,15H \cdot \text{m}$$

$$\text{yoki } M_C = R_{2X} l_1 = 1473,6 \cdot 70 = 103158 H \cdot \text{mm} = 103,15H \cdot \text{m}$$

$YZ$  tekisligida ta'sir qiluvchi kuchni aniqlaymiz (*rasm-4.23*).

$$\sum M_B = -R_{1Y} 2l_1 - F_a \frac{d_1}{2} - F_r l_1 = 0 \quad \text{tenglamadan}$$

$$R_{1Y} = -\frac{1}{2l_1} \left( F_r l_1 + F_a \frac{d_1}{2} \right) = -\frac{1}{2 \cdot 70} \left( 1161 \cdot 70 + 553,3 \cdot \frac{45,73}{2} \right) = -667,6H$$

$$\sum M_A = R_{2Y} 2l_1 - F_a \frac{d_1}{2} + F_r l_1 = 0 \quad \text{tenglamadan}$$

$$R_{2Y} = \frac{1}{2l_1} \left( -F_r l_1 + F_a \frac{d_1}{2} \right) = \frac{1}{2 \cdot 70} \left( -1161 \cdot 70 + 553,3 \cdot \frac{45,73}{2} \right) = -493,4H$$

$$\textbf{Tekshirish: } R_{1Y} + R_{2Y} + F_r = -667,6 + 1161 - 493,4 = 0$$

Reaksiya kuchlari.

$$R_1 = \sqrt{R_{1X}^2 + R_{1Y}^2} = \sqrt{2198,4^2 + 667,6^2} = 2297,5H$$

$$R_2 = \sqrt{R_{2X}^2 + R_{2Y}^2} = \sqrt{1473,6^2 + 493,4^2} = 1554H$$

Birinchi tayanchdagi (podshipnik -306) radial reaksiya kuchi ikkinchi tayanchdagi radial reaksiya kuchidan katta. Demak, birinchi tayanch yuklanishi katta: radial kuch  $R_1 = 2297,5H$  va bo'ylama kuch  $F_a = 553,3H$ . Shuning uchun birinchi tayanch podshipnikining xizmat muddatini topamiz.

$$\text{Ekvivalent kuch } P_9 = (XVF_{21} + YF_a) K_\delta K_T$$

formula bilan aniqlanadi.

buerda  $V = 1$  (ichki halqa aylanadi),.

$K_{\sigma}$  - koefitsient podshipniklarni yuklanishidagi kuchni statik yoki dinamik xarakterda bo'lishga bog'liq holda tanlanadi.

Tinch va turtkisiz yuklanishda  $K_{\sigma}=1 \dots 1,2$ .

$K_T$  - koefitsient podshipnikni ishchi temperaturasi bog'liq. Ishchi temperatura  $100 \dots 125^{\circ}$  da  $K_T=1 \dots 1,05$  va  $150 \dots 200^{\circ}$  da

$K_T = 1,1 \dots 1,25$  qabul qilinadi.

| kontakt burchagi | $\frac{F_a}{C_0}$ | $\frac{F_a}{V \cdot C_0} \succ e$ |      | $e$  |
|------------------|-------------------|-----------------------------------|------|------|
|                  |                   | $X$                               | $Y$  |      |
| 0                | 0,028             |                                   | 1,99 | 0,22 |
|                  | 0,056             | 0,56                              | 1,71 | 0,26 |

$Y$  - koefitsient  $\frac{F_a}{C_0}$  nisbatdan foydalanib topiladi.

Ushbu misolda  $\frac{F_a}{C_0} = \frac{553,3}{14800} = 0,036$  va  $\frac{F_a}{R_1} = \frac{553,3}{2297,6} = 0,232 \succ \ell$

qiymatlarga tegishli  $Y$  koefitsient interpolatsiya usuli bilan topiladi.

Jadvaldagi raqamlarni harflar bilan belgilaymiz:

$$z_1 = 0,028, z_2 = 0,056, Y_1 = 1,99 \text{ va } Y_2 = 1,71, e_1 = 0,22, e_2 = 0,26$$

Jadvaldagi raqamlar farqi:

$$\Delta z_1 = z - z_1 = 0,036 - 0,028 = 0,008 \text{ va}$$

$$\Delta z_2 = z_2 - z = 0,056 - 0,036 = 0,02$$

$$\text{Unda } \Delta Y = Y_1 - Y_2 = 1,99 - 1,71 = 0,28 \text{ va}$$

$$\Delta z = z_2 - z_1 = 0,056 - 0,028 = 0,028$$

$$\Delta Y_1 = \frac{\Delta z_1 \cdot \Delta Y}{\Delta z} = \frac{0,008 \cdot 0,28}{0,028} = 0,08$$

$$\Delta Y_2 = \frac{\Delta z_2 \cdot \Delta Y}{\Delta z} = \frac{0,02 \cdot 0,28}{0,028} = 0,2$$

$Y$  koefitsientning haqiqiy qiymati

$$Y = Y_1 - \Delta Y_1 = 1,99 - 0,08 = 1,91 \text{ va } Y = Y_2 + \Delta Y_2 = 1,71 + 0,2 = 1,91$$

$e$  miqdorni interpolatsiya usuli bilan topamiz:

$$\Delta e = e_1 - e_2 = 0,26 - 0,22 = 0,04 \text{ va}$$

$$\Delta z = z_2 - z_1 = 0,056 - 0,028 = 0,028$$

$$\Delta e_1 = \frac{\Delta z_1 \cdot \Delta e}{\Delta z} = \frac{0,008 \cdot 0,04}{0,028} = 0,0114285$$

$$\Delta e_2 = \frac{\Delta z_2 \cdot \Delta e}{\Delta z} = \frac{0,02 \cdot 0,04}{0,028} = 0,0285714$$

$e$  koefitsientning haqiqiy qiymati

$$e = e_1 - \Delta e_1 = 0,26 - 0,0114285 = 0,2486$$

$$e = e_2 + \Delta e_2 = 0,22 + 0,02857 = 0,2486$$

Hisoblashlar asosida  $e = 0,2486$ ,  $X = 0,56$  va  $Y = 1,91$  qabul qilamiz.

$$\text{Ekvivalent kuch } P_9 = (0,56 \cdot 2297,5 + 1,91 \cdot 553,3) \approx 2305,2H.$$

$$\text{Podshipnikning xizmat muddati } L = \left( \frac{C}{P_9} \right)^3 = \left( \frac{19,7 \cdot 10^3}{2305,2} \right)^3 \approx 624 \text{ млн.айл}$$

$$\text{Podshipnikning ishlash muddati. } L_h = \frac{L \cdot 10^6}{60 \cdot n} = \frac{624 \cdot 10^6}{60 \cdot 415} \approx 25 \cdot 10^3 \text{ соам}$$

**Etaklanuvchi val.** Valga  $F_t = 3138,4H$ ,  $F_r = 1161H$ ,  $F_\alpha = 553,3H$ . kuchlar va muftani valga bosim kuchi ta'sir qiladi. Muftani valga bosim kuchi  $F_{RM}$  radial kuch bilan ifodlanadi.

$$\text{Tez yurar val uchun } F_{RM1} = 50\sqrt{M_1} \dots 125\sqrt{M_1}$$

$$\text{Tishli reduktor uchun } F_{RM2} = 125\sqrt{M_2}.$$

$$\text{Ushbu masalada } F_{RM2} = 125\sqrt{M_2} = 125 \cdot \sqrt{428} = 2586H.$$

$F_{RM}$  kuch val o'qiga tik va doiraviy kuch yo'nalishiga teskari yo'naltiriladi. MUVP- muftasini tanlaymiz. MUVP o'rnatilgan valdagi aylantiruvchi momentga bog'liq tanlanadi

Masalan,  $M = 428Hm$  da muftaning tashqi diametri  $D = 190mm$ ,  $L = 226mm$  va  $l_M = 110mm$

$$\text{Reduktorni komponovkasidan } l_2 = 74mm, d_2 = 274,27mm$$

Tayanchdagi reaksiya kuchlari. XZ tekisligida

$$\sum M_A = F \cdot l_2 - F_{RM}(2l_2 + l) - R_{BX} \cdot 2l_2 = 0 \text{ tenglamadan}$$

$$R_{BX} = \frac{1}{2 \cdot l_2} [F l_2 - F_{RM}(2l_2 + l)] = \frac{1}{2 \cdot 74} [3138 \cdot 74 - 2586(148 + 110)] = -2939,5H$$

$$\sum M_B = R_{AX} 2l_2 - F \cdot l_2 - F_{RM} \cdot l = 0 \text{ tenglamadan}$$

$$R_{AX} = \frac{1}{2 \cdot l_2} (F l_2 + F_{RM} l) = \frac{1}{2 \cdot 74} (3138 \cdot 74 - 2586 \cdot 110) = 3491H$$

$$\text{Tekshirish: } -R_{AX} - R_{BX} + F - F_{RM} = -3491 + 2939 + 3138 - 2586 = 0$$

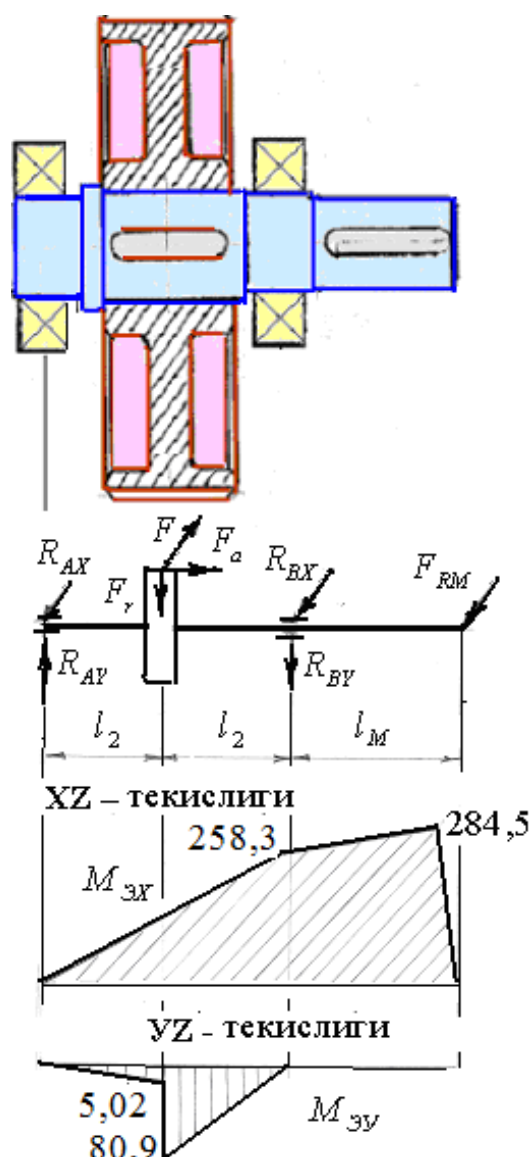
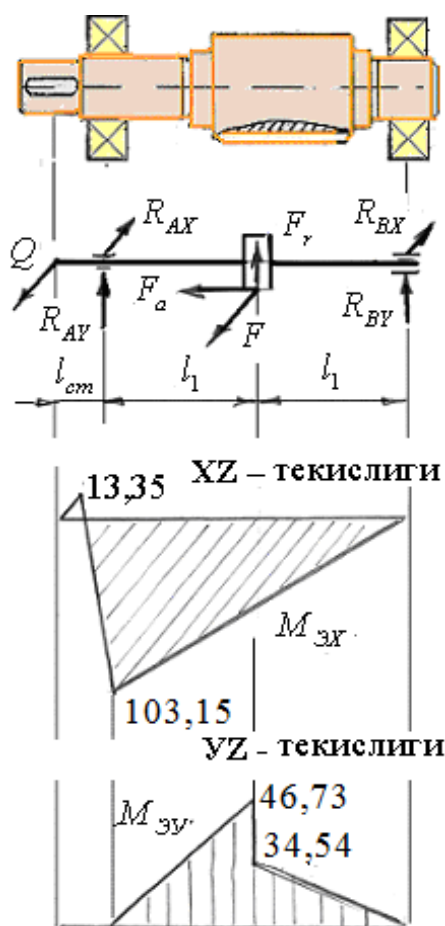
Valning xarakterli nuqtalaridagi eguvchi momentlarni topamiz.

$$\text{S nuqtada } M_C = -R_{AX} l_2 = -3491 \cdot 74 = -258,3Hm$$

$$\text{V nuqtada } M_B = -F_{RM} l = -2586 \cdot 110 = -284,5Hm$$

$$\text{YZ tekisligida: } \sum M_A = -R_{By} \cdot 2l_2 - F_a \frac{d_2}{2} - F_r l_2 = 0$$

$$R_{By} = -\frac{1}{2 \cdot 74} \left[ 1161 \cdot 74 + 553 \frac{274,27}{2} \right] = -1093,2H$$



rasm-4.23. Reduktor etaklovchi va etaklanuvchi vallarining XZ va YZ tekisliklaridagi eguvchi moment epyuralari.

$$\sum M_B = -R_{Ay} \cdot 2l_2 - F_a \frac{d_2}{2} + F_r l_{23} = 0 \quad \text{dan}$$

$$R_{Ay} = \frac{1}{2 \cdot 74} \left( 1161 \cdot 74 - 553 \cdot \frac{274,27}{2} \right) = 67,8H$$

Tekshirish:  $R_{Ay} - (F_r + R_{By}) = 0$  va  $67,8 - 1161 + 1093,2 = 0$

Eguvchi moment:  $M_C = R_{Ay} l_2 = 67,8 \cdot 74 = 5,02 Hm$

$$M_C = R_{By} l_2 = 1093 \cdot 74 = 80,9 Hm$$

$$R_{By} l_2 - R_{Ay} l_2 = F_a \frac{d_2}{2} = 553,3 \cdot \frac{274,27}{2} = 75,87 Hm$$

Teng ta'sir etuvchi kuchlar

$$R_3 = \sqrt{R_{AX}^2 + R_{AY}^2} = \sqrt{3491^2 + 67,8^2} = 3491,6H$$

$$R_4 = \sqrt{R_{BX}^2 + R_{BY}^2} = \sqrt{2939^2 + 1093^2} = 3135,7H$$

Interpolyatsiya usuli bilan  $e$  va  $Y$ ,  $X$  koeffitsientlarni topamiz

| kontakt burchagi | $\frac{F_a}{C_0}$ | $\frac{F_a}{V \cdot C_0} \succ e$ |              | $e$          |
|------------------|-------------------|-----------------------------------|--------------|--------------|
|                  |                   | $X$                               | $Y$          |              |
| 0                | 0,014<br>0,028    | 0,56                              | 2,30<br>1,99 | 0,19<br>0,22 |

Ushbu misolda

$$\frac{F_a}{C_0} = \frac{553,3}{35600} = 0,0155 \text{ va}$$

$$\frac{F_a}{R_3} = \frac{553,3}{3491} = 0,158 \succ \ell$$

Interpolyatsiya usuli bilan  $e = 0,2168$ ,  $X = 0,56$  va  $Y = 2,2668$  topamiz.

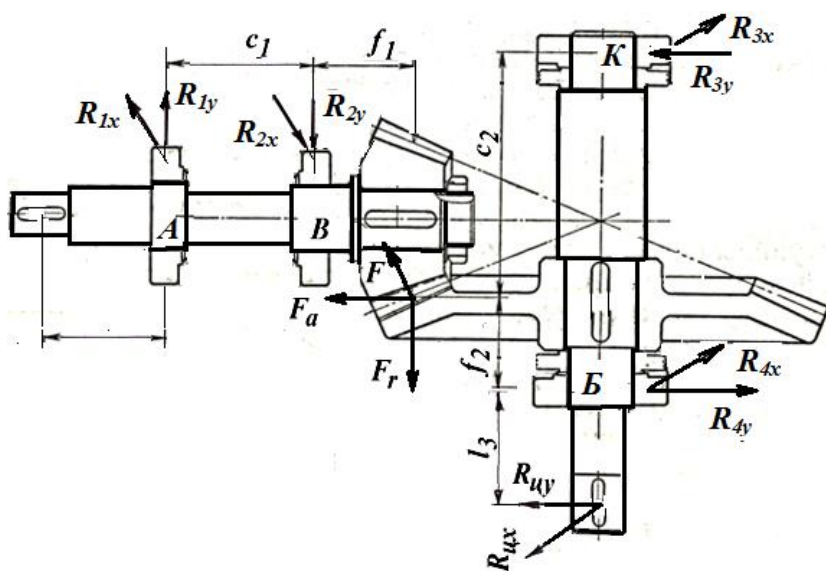
$$\text{Ekvivalent kuch } P_9 = (0,56 \cdot 3491 + 2,2668 \cdot 553) = 3209 \text{ H}$$

310 - Podshipnikning ishlash muddati,

$$L = \left( \frac{C}{F_9} \right)^3 = \left( \frac{47600}{3209} \right)^3 \approx 3261 \text{ млн. айл}$$

Podshipnikning ishlash muddati,

$$L_h = \frac{L \cdot 10^6}{60 \cdot n} = \frac{3261 \cdot 10^6}{60 \cdot 69,66} \approx 780218 \text{ соат}$$



rasm-4.24. Konussimon ilashmadagi kuchlar va tayanchlardagi reaksiya kuchlari.

**Bir pog'onali tsilindrik qiyshiq tishli uzataning vallari uchun podshipniklarning xizmat muddatini hisoblash.**

**misol-4.13**

**Etaklovchi val.**

Ta'sir qiluvchi kuchlar

$$F_t = 1322,8 \text{ H}; F_{r1} = 460$$

$$F_{a1} = 146 \text{ H}; F_{RM} = 750 \text{ H}$$

Dastlabki etab komponentlardan

$$f_1 = 48 \text{ мм}, c_1 = 88 \text{ мм}, d_1 = 54,43 \text{ мм}.$$

Uzatmaning yuklanish sxemasidan foydalanib etaklovchi va etaklanuvchi vallarning yuklanish sxemalarini tuzamiz.

Har bir valning muvozanat shartlaridan tayanchlardagi reaksiya kuchlarini topamiz. Shesternya va tishli g'ildirak ilashmasida bir nuqtada turli yo'nalishda joylashgan kuchlar sistemasi hosil bo'lganligi uchun, tayanchlardagi reaksiya kuchlari ham turli tekisliklarda yuzaga keladi.

Tayanch kuchlarni aniqlaymiz.

$$UX \text{ o'qi tekisligida: } \sum M_B = F_{RM}(l_3 + c_1) - R_{1x} \cdot c_1 + F_t f_1 = 0$$

$$R_{1x} = \frac{1}{c_1} [F_{RM}(l_3 + c_1) + F_t f_1] = \frac{1}{88} [750 \cdot (25 + 88) + 1322,8 \cdot 48] = 1684,6H$$

$$\sum M_A = F_{RM} l_3 - R_{2x} \cdot c_1 + F_t (c_1 + f_1) = 0, \text{ tenglamadan}$$

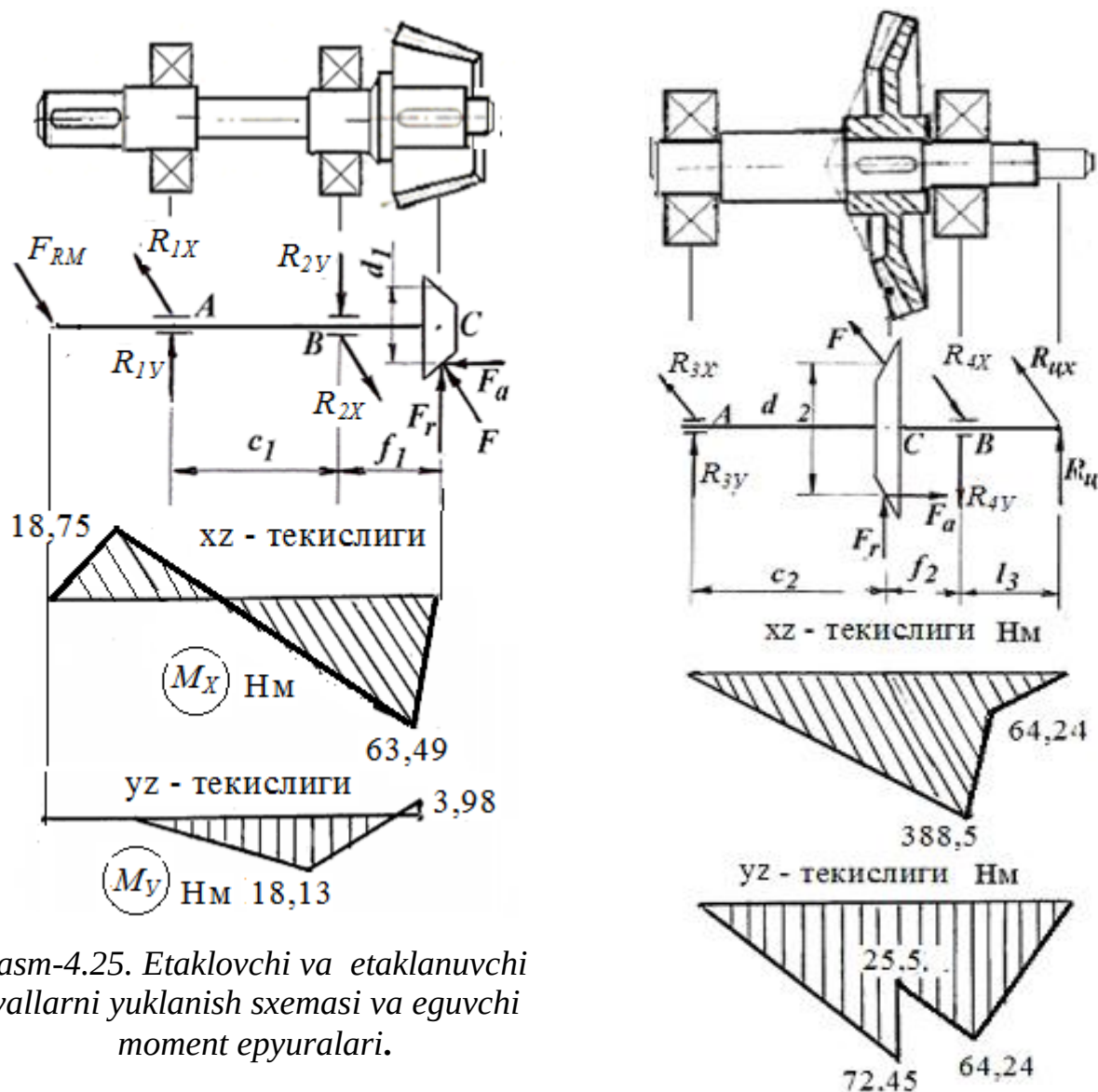
$$R_{2x} = \frac{1}{c_1} [F_{RM} l_3 + F_t (c_1 + f_1)] = \frac{1}{88} [750 \cdot 25 + 1322,8 \cdot (88 + 48)] = 2257,4H$$

$$\text{Tekshirish: } -F_{RM} - R_{2x} + R_{1x} + F_t = -750 + 1684,6 - 2257,4 + 1322,8 = 0$$

Etaklanuvchi valni xarakterli nuqtalaridagi eguvchi momentlarni topamiz:

$$M_A = -F_{RM} l_3 = -750 \cdot 25 = -18,75 Hm \quad M_B = -F_t \cdot f_1 = 1322,8 \cdot 48 = 63,49 Hm$$

$$M_B = -F_{RM}(l_3 + c_1) + R_{1x} c_1 = -750 \cdot (25 + 88) + 1684,6 \cdot 88 = 63,49 Hm$$



rasm-4.25. Etaklovchi va etaklanuvchi vallarni yuklanish sxemasi va eguvchi moment epyuralari.



$$YZ \text{ tekisligida: } \sum M_A = -R_{2y}c_1 + F_r(f_1 + c_1) - F_a \cdot \frac{d_1}{2} = 0$$

$$R_{2y} = \frac{1}{c_1} \left[ F_r(f_1 + c_1) - F_a \frac{d_1}{2} \right] = \frac{1}{88} (460 \cdot 136 - 146 \cdot \frac{54,43}{2}) = 666 H$$

$$\sum M_B = 0 \quad \text{va} \quad -R_{1y}c_1 + F_r f_1 - F_a \frac{d_1}{2} = 0 \quad \text{tenglamadan}$$

$$R_{1y} = \frac{1}{c_1} (-F_a \frac{d_1}{2} + F_r f_1) = \frac{1}{88} (-146 \frac{54,43}{2} + 460 \cdot 48) = 206 H$$

$$\textbf{Tekshirish:} \quad -R_{2y} + R_{11} + F_r = 206 - 666 + 460 = 0$$

Valni xarakterli nuqtalaridagi eguvchi momentlarni topamiz:

$$M_C = -F_a \frac{d_1}{2} = -146 \cdot \frac{54,43}{2} = -3,98 Hm \quad \text{va} \quad M_B = R_{1y} \cdot c_1 = 206 \cdot 88 = 18,13 Hm$$

$$M_B = -F_a \frac{d_1}{2} + F_r \cdot f_1 = -146 \cdot \frac{54,43}{2} + 460 \cdot 48 = 18,1 Hm$$

$$\textbf{Umumiy kuchlar :} \quad F_{r1} = R_1 = \sqrt{R_{1x}^2 + R_{2y}^2} = \sqrt{1684^2 + 206^2} = 1696 H$$

$$F_{r2} = R_2 = \sqrt{R_{2x}^2 + R_{2y}^2} = \sqrt{2257^2 + 666^2} = 2353 H;$$

Radial kuchlarning bo'ylama tashkil etuvchilari ( rasm).

$$S_2 = 0,83 \ell F_{r2} = 0,83 \cdot 0,365 \cdot 2353 = 718,8 H$$

$$S_1 = 0,83 \ell F_{r1} = 0,83 \cdot 0,365 \cdot 1696 = 513,8 H$$

7206 podshipnik uchun  $\ell = 0,365$ ;

$$S_1 < S_2; \text{ unda } F_{a2} = S_2 = 718,8 H.$$

Valning o'ng qismidagi podshipnikning ishlash muddatini aniqlaymiz. Nisbat

$$\frac{F_{a2}}{F_{r2}} = \frac{718,8}{2353} = 0,305 < e \quad \text{o'q bo'ylab}$$

yuklanishni hisobga olmaymiz

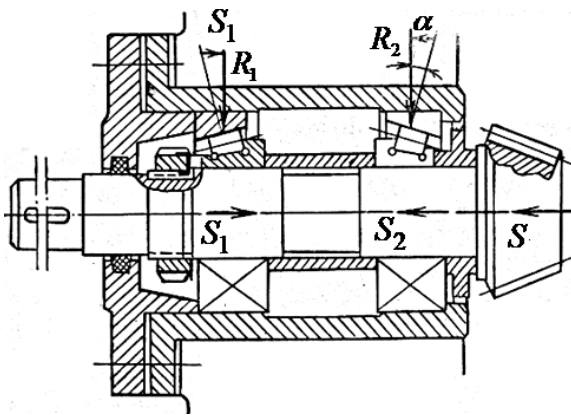
Radial tirakli podshipniklarda radial kuchlar ta'siridan reaksiyalar- ning bo'ylama tashkil qiluvchilari (4.26-rasm) hosil bo'ladi:

$$S = e F_r, \text{ konussimon rolikli podshipniklarda } S = 0,83 e F_r$$

Ekvivalent yuklanishni aniqlaymiz:

$$P_{\Sigma K} = V F_{r2} K_{\delta} K_T = 2353 H$$

$$\text{Ishlash muddati } L = \left( \frac{C}{P_{\Sigma K}} \right)^{\frac{10}{3}} = \left( \frac{C}{P_{\Sigma K}} \right)^3 \sqrt[3]{\frac{C}{P_{\Sigma K}}} = \left( \frac{2196}{2,35} \right)^3 \sqrt[3]{\frac{21,9}{2,35}} \approx 1700 \text{ млн.айл.}$$



rasm-4.26. Bo'ylama kuchlar

$$\text{Ishlash muddati } L_h = \frac{L \cdot 10^6}{60n} = \frac{1700 \cdot 10^6}{60 \cdot 955} = 29668 \quad \text{coam}$$

**Etaklanuvchi val.** Oldingi hisoblardan.  $F_a = 460 H$ ;

$$F_t = 1322,8 H; F_r = 146 H;$$

Zanjirli uzatmadan valga tushadigan yuk:  $R_{\text{II}} = 1912 H$

$$R_{\text{II}x} = R_{\text{II}y} = R_{\text{II}} \sin \gamma = 1912 \sin 45^\circ \approx 1338,4 H$$

Dastlabki kompanovka  $f_2 = 60 \text{ mm}$ ;  $c_2 = 150 \text{ mm}$   $l_3 = 48 \text{ mm}$

G'ildirakning o'rtacha diametri

$$d_2 = m \cdot z_2 = 2,5316 \cdot 79 = 200 \text{ mm}$$

XZ tekisligida  $\sum M_B = 0$  va  $-R_{3X}(c_2 + f_2) - F \cdot f_2 + R_{\text{II}x} \ell_3 = 0$

$$R_{3X} = \frac{1}{c_2 + f_2} (-F_t f_2 + R_{\text{II}x} l_3) = \frac{1}{210} (-1322,8 \cdot 60 + 1338,4 \cdot 48) = -72 H$$

$$\sum M_A = 0 \quad \text{va} \quad R_{\text{II}X}(c_2 + f_2 + l_3) + F_t \cdot c_2 - R_{4X}(c_2 + f_2) = 0$$

$$R_{4X} = \frac{1}{c_2 + f_2} (F_t c_2 + R_{\text{II}X}(c_2 + f_2 + l_3)) = \frac{1}{210} (1322,8 \cdot 150 + 1338,4 \cdot 258) = 2590 H$$

$$\text{Tekshirish: } R_{3X} + R_{\text{II}x} + F_t - R_{4X} = -72 + 1338,4 + 1322,8 - 2590 = 0$$

YZ tekislikda  $\sum M_B = 0$   $-R_{3Y}(C_2 + f_2) - F_r f_2 + F_a \frac{d_2}{2} + R_{\text{II}y} \cdot \ell_3 = 0$

$$R_{3Y} = \frac{1}{c_2 + f_2} (-F_r f_2 + F_a \frac{d_2}{2} + R_{\text{II}y} l_3) = \frac{1}{210} (-146 \cdot 60 + 460 \cdot \frac{200}{2} + 1338,4 \cdot 48) = 483 H$$

$$\sum M_A = 0 \quad F_r C_2 + F_a \frac{d_2}{2} - R_{4Y}(C_2 + f_2) + R_{\text{II}y}(C + f_2 + \ell_3) = 0$$

$$R_{4Y} = \frac{1}{c_2 + f_2} (F_r c_2 + F_a \frac{d_2}{2} + R_{\text{II}y}(c_2 + f_2 + l_3)) =$$

$$= \frac{1}{210} (146 \cdot 150 + 460 \cdot \frac{200}{2} + 1338,4 \cdot 258) = 1967,6 H$$

$$\text{Tekshiramiz: } R_{3Y} + F_r - R_{4Y} + R_{\text{II}y} = 483 + 146 - 1967 + 1338 = 0$$

Teng ta'sir etuvchi kuchlar.

$$F_{r3} = R_3 = \sqrt{R_{3X}^2 + R_{3Y}^2} = \sqrt{72^2 + 483^2} = 488 H$$

$$F_{r4} = R_4 = \sqrt{R_{4X}^2 + R_{4Y}^2} = \sqrt{2590^2 + 1967^2} = 3252 H;$$

Radial kuchni aniqlaymiz.

$$S_3 = 0,83e \cdot F_{r3} = 0,83 \cdot 0,383 \cdot 488 = 155,3 H;$$

$$S_4 = 0,83e \cdot F_{r3} = 0,83 \cdot 0,383 \cdot 3252 = 1033,7 H;$$

7208 podshipnik uchun  $e = 0,383$  ;

$$S_3 < S_4 \quad \text{va} \quad F_{a4} = S_4 = 1033,7H$$

Valning o'ng tomonidagi podshipnikining yuklanishini aniqlaymiz.

$$\text{Nisbat} \quad \frac{F_{a4}}{F_{r4}} = \frac{1033,7}{3252} = 0,317 < e \quad \text{hisobga olamiz.}$$

Ekvivalent yuklanish:  $P_{\Sigma} = F_{r3} \cdot V \cdot K_{\delta} \cdot K_T = 3252 \cdot 1 \cdot 1,2 \cdot 1 = 3902 H$ .

$K_{\delta} = 1,2$  zanjirli uzatmadan tushadigan yuk hisobga olindi.

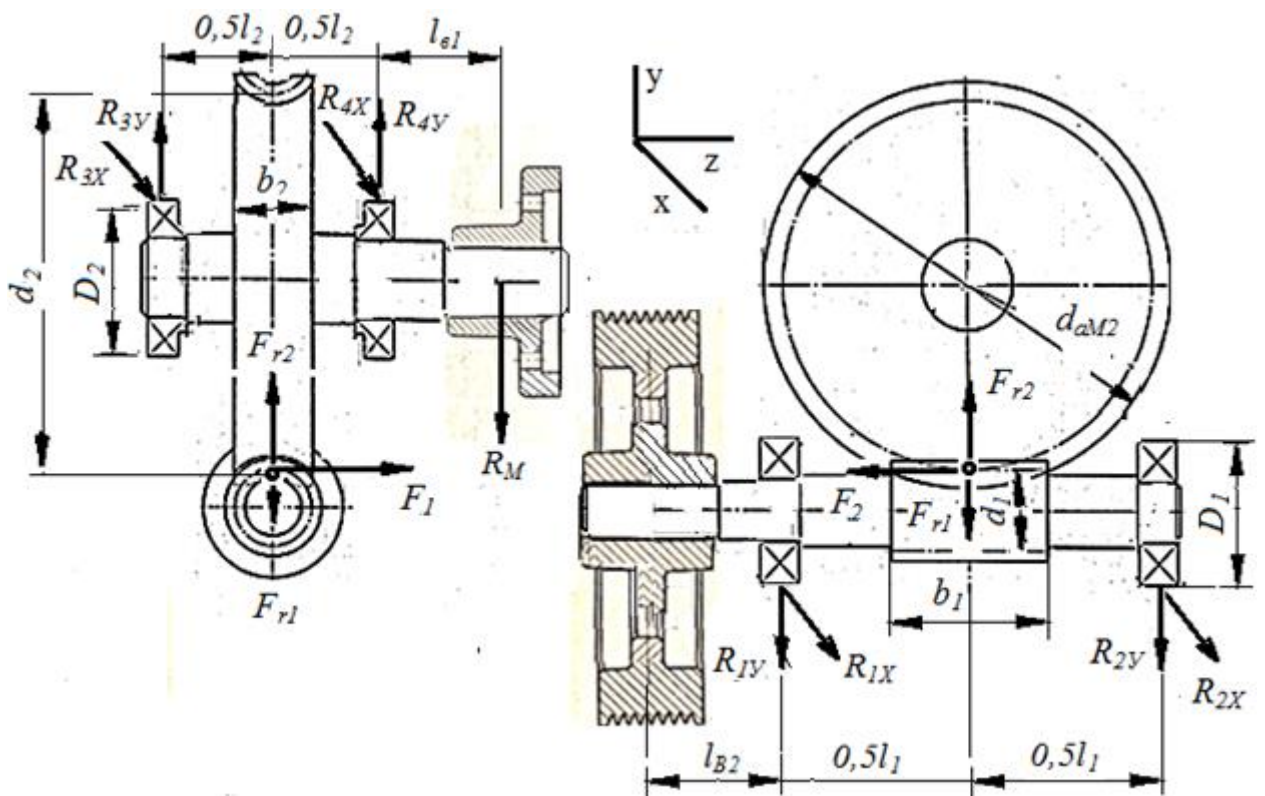
$$\text{Ishlash muddati} \quad L = \left( \frac{C}{P_{\Sigma}} \right)^{\frac{10}{3}} = \left( \frac{41,6}{3,92} \right)^3 \sqrt[3]{\frac{41,6}{3,92}} \approx 2620 \text{ млн. айл.}$$

$$\text{Ishlash muddati .} \quad L_h = \frac{L \cdot 10^6}{60 \cdot n} = \frac{2620 \cdot 10^6}{60 \cdot 303} \approx 149 \cdot 10^3 \text{ соам}$$

bu erda  $n = 303 \frac{\text{айл}}{\text{мин}}$  - etaklanuvchi valning aylanishlar soni.

#### misol-4.14. Bir pog'onali chervyakli uzatma podshipniklarning xizmat muddatini hisoblash.

Misolni echish uchun ma'lumotlar 4.6-misoldan olindi.



rasm-4.28. Ilashmadagi kuchlar

- chervyak g'ildiragidagi doiraviy kuch, chervyakdagi bo'ylama kuchga teng

$$F_{t2} = F_{a1} = \frac{2M_3}{d_2} = \frac{2 \cdot 1636 \cdot 10^3}{400} = 8180 H$$

- chervyakdagi doiraviy kuch, g'ildiragidagi bo'ylama kuchga teng.

$$F_{t1} = F_{a2} = \frac{2M_2}{d_1} = \frac{2 \cdot 81,8 \cdot 10^3}{100} = 1636 H$$

-g'ildirak va chervyakdagi radial kuchlar

$$F_{r2} = F_{r1} = F_{t2} \cdot \operatorname{tg} \alpha = 8180 \cdot \operatorname{tg} 20^\circ = 2986 H$$

Tasmali uzatmadan valga tushadigan bosim kuchi  $Q = 1024,7 H$

Oldingi hisoblashlardan quyidagilarni olamiz:  $d_1 = 100 \text{ mm}$ ,  $d_2 = 400 \text{ mm}$ ,  
 $d_{a2} = 435 \text{ mm}$ , va komponovkadan  $l_1 = 435 \text{ mm}$ ,  $l_2 = 120 \text{ mm}$ ,  $l_{B1} = 40 \text{ mm}$ ,  
 $l_{B2} = 40 \text{ mm}$ .

**Chervyak vali:** Chervyak o'ramini valda o'ng yo'nalishda qabul qilinadi. Tayanch reaksiyalari (4.29-rasm):

$$xz - \text{tekisligida} \quad \sum M_A = 0 \quad -R_{2X}l_1 + F_1 \cdot \frac{l_1}{2} + Q_X l_{B1} = 0$$

$$R_{2X} = \frac{1}{l_1} (F_1 \cdot \frac{l_1}{2} + Q_X l_{B1}) = \frac{1}{435} (1636 \cdot \frac{435}{2} + 1024,7 \div \sin 45^\circ \cdot 40) = 834,6 H$$

$$\sum M_B = 0 \quad R_{1X}l_1 - F_1 \cdot \frac{l_1}{2} + Q_X (l_{B1} + l_1) = 0$$

$$R_{1X} = \frac{1}{l_1} (F_1 \cdot \frac{l_1}{2} - Q_X (l_{B1} + l_1)) = \frac{1}{435} (1636 \cdot \frac{435}{2} - 1024,7 \div \sin 45^\circ \cdot 475) = 26,9 H$$

$$\text{Tekshirish: } -R_{2X} + F_1 - R_{1X} - Q_X = 0$$

$$-1024,7 \cdot \sin 45^\circ - 26,9 + 1636 - 884,6 = 0$$

Valni xarakterli nuqtalaridagi eguvchi momentlarni topamiz:

$$M_A = -Q_X l_{B1} = -1024,7 \cdot \sin 45^\circ \cdot 40 = -724,6 Hm$$

$$M_C = -R_{2X} \cdot \frac{l_1}{2} = -884,6 \cdot \frac{435}{2} = -192 Hm$$

$$yz - \text{tekisligida} \quad \sum M_B = 0 \quad -R_{y1} \ell_1 + F_{r1} \cdot \frac{\ell_1}{2} - F_{a1} \cdot \frac{d_1}{2} + Q_y (l_{B1} + l_1) = 0$$

$$R_{y1} = \frac{1}{l_1} (F_{r1} \cdot \frac{\ell_1}{2} - F_{a1} \cdot \frac{d_1}{2} + Q_y (l_{B1} + l_1)) = \frac{1}{435} (2986 \cdot \frac{435}{2} - 1636 \cdot \frac{100}{2} + 1024,7 \cdot 80) = 134 H$$

$$\sum M_A = 0 \quad Q_y l_{B1} + R_{y2} \cdot \ell_1 - F_{r1} \cdot \frac{\ell_1}{2} - F_{a1} \cdot \frac{d_1}{2} = 0$$

$$R_{y2} = \frac{1}{l_1} (F_{r1} \cdot \frac{\ell_1}{2} - F_{a1} \cdot \frac{d_1}{2} - Q_y l_{B1}) = \frac{1}{435} (-724,6 \cdot 40 + 2986 \cdot \frac{435}{2} + 8180 \cdot \frac{100}{2}) = 2366,6H$$

Tekshirish:  $R_{2y} - F_{r1} + R_{1y} - Q_y = 0$

$$-1024,7 \cdot \sin 45^\circ + 1344 - 2986 + 2366,6 = 0$$

$$F_{r1} = R_1 = \sqrt{R_{x1}^2 + R_{y1}^2} = \sqrt{(405)^2 + (211)^2} = 456H$$

Umumiy reaksiya

$$F_{r2} = R_2 = \sqrt{R_{x2}^2 + R_{y2}^2} = \sqrt{(405)^2 + (9891)^2} = 1070H$$

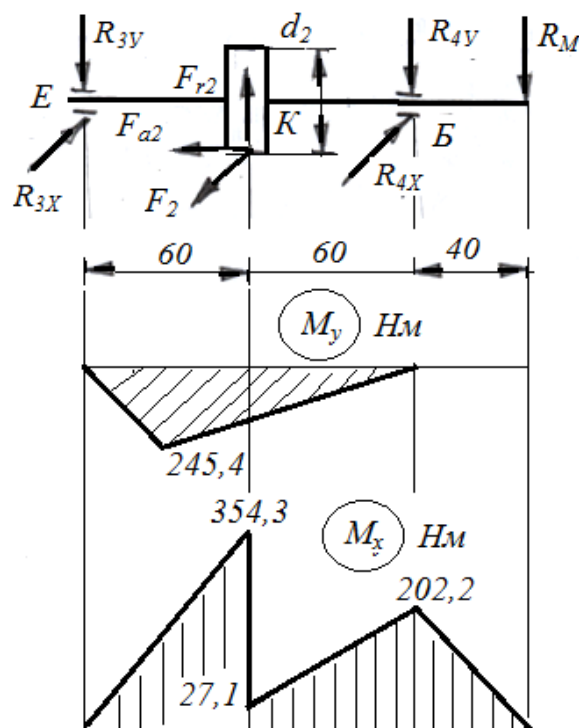
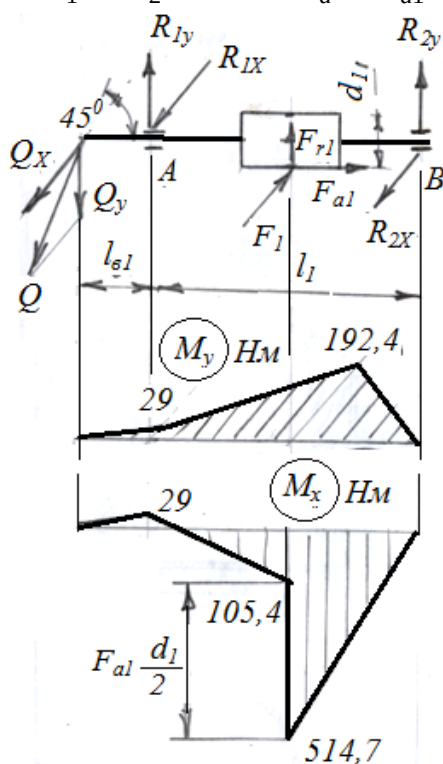
Radial tirakli sharikli podshipniklardagi radial reaksiyalar bo'yicha ajratuvchilarni aniqlaymiz

$$S_1 = \ell \cdot F_{r1} = 0,68 \cdot 456 = 310H; \quad \text{va} \quad S_2 = \ell \cdot F_{r2} = 0,68 \cdot 1070 = 730H$$

$\alpha = 26^\circ$  da bo'ylama yuklanish koeffitsienti  $\ell = 0,68$ .

Podshipniklardagi bo'ylama kuchlar:

$$S_1 < S_2; \quad F_a = P_{a1} \geq S_2 - S_1$$



rasm-4.29. Chervyak vali va g'ildirakni yuklanish sxemalari va eguvchi moment epyuralari

unda  $F_{a1} = S_1 = 310H$ ;  $F_{a2} = S_1 + F_a = 310 + 3310 = 3620H$

Chap (birinchi) podshipnikni tekshiramiz:

$$\frac{F_{a1}}{F_{r1}} = \frac{310}{456} = 0,68 = \ell, \text{ bo'ylama kuchni hisobga olmaymiz.}$$

$$\text{Ekvivalent kuch } P_{\sigma 1} = F_{r1} \cdot V \cdot K_{\sigma} \cdot K_T = 456 \cdot 1,3 = 593H$$

Yng (ikkinchi) podshipnik.  $\frac{F_{a2}}{F_{r2}} = \frac{3620}{1070} = 3,28 > \ell$ , shuning uchun ekvivalent

kuchni aniqlashda bo'ylama kuchni hisobga olamiz:

$$P_{92} = (X \cdot F_{r2} \cdot V + Y \cdot F_{a2}) K_{\delta} \cdot K_T = (0,4 \cdot 1070 \cdot 1 + 0,87 \cdot 3620) \cdot 1,3 = 4700 H$$

Mln. aylanish birligidagi ishlash muddati

$$L = \left( \frac{C}{P_9} \right)^3 = \left( \frac{47,2}{4,7} \right)^3 \approx 1050 \frac{mln}{a\ddot{u}l}$$

Soat birligidagi ishlash muddati

$$L_c = \frac{L \cdot 10^6}{60 \cdot n} = \frac{1050 \cdot 10^6}{60 \cdot 1440} \approx 12000 \text{ soat}$$

**Etaklanuvchi val:**  $F_{r2} = 2986 H$ ,  $F_{a2} = 1636 H$   $F_2 = 8180 H$   $d_2 = 400 mm$

$$R_M = 125 \sqrt{1636} = 5056 H, l_2 = 60 mm$$

Reaksiya kuchlarni topamiz:

$$xz\text{-tekisligida} \quad \sum M_E = 0 \quad R_{3X} = R_{4X} = \frac{F}{2} = 4090 H$$

$$yz\text{-tekisligida} \quad \sum M_E = 0 \quad R_{4Y} \cdot 120 + F_{r2} \cdot 60 - F_{a2} \frac{d_2}{2} - R_M \cdot 160 = 0;$$

$$\begin{aligned} R_{4Y} &= \frac{1}{120} (-F_{r2} \cdot 60 + F_{a2} \frac{d_2}{2} + R_M \cdot 160) = \\ &= \frac{1}{120} (5056 \cdot 160 - 2986 \cdot 60 + 1636 \cdot \frac{400}{2}) = 7975 H \end{aligned}$$

$$\sum M_B = 0 \quad R_{3Y} \cdot 120 - F_{r2} \cdot 60 - F_{a2} \frac{d_2}{2} - R_M \cdot 40 = 0;$$

$$\begin{aligned} R_{3Y} &= \frac{1}{120} (F_{r2} \cdot 60 + F_{a2} \frac{d_2}{2} + R_M \cdot 40) = \\ &= \frac{1}{120} (1636 \cdot \frac{400}{2} + 2986 \cdot 60 + 5056 \cdot 40) = 5905 H \end{aligned}$$

$$\text{Tekshirish: } -R_{3Y} - R_{4Y} + F_{r2} - R_M = 0. \quad \text{va} \quad -5905 + 2986 + 7975 - 5056 = 0$$

$$F_{r3} = R_3 = \sqrt{R_{z3}^2 + R_{y3}^2} = \sqrt{1655^2 + 408^2} = 1700 H;$$

$$F_{r4} = R_4 = \sqrt{R_{z4}^2 + R_{y4}^2} = \sqrt{1655^2 + 1608^2} = 2310 H.$$

Radial reaksiyalarni bo'ylama tashkil topuvchilari:

$$S_3 = 0,83eF_{r3} = 0,83 \cdot 0,411 \cdot 1700 = 580 H;$$

$$S_4 = 0,83eF_{r4} = 0,83 \cdot 0,411 \cdot 2310 = 790 H,$$

7211 podshipnik uchun bo'ylama yuklanish koeffitsienti  $e = 0,411$ .

$$S_3 < S_4; \quad F_a = F_{a2} > S_4 - S_3;$$

$$\text{bunda } F_{a3} = S_3 = 580H; \quad F_{a4} = S_3 + F_a = 580 + 810 = 1390H.$$

O'ng podshipnik uchun

$$\frac{F_{a3}}{F_{r4}} = \frac{580}{1700} = 0,341 < e, \text{ va } F_{\beta 3} = F_{r3} V K_{\beta} K_T = 1700 \cdot 1,3 = 2220H$$

$$\text{Chap podshipnik uchun } \frac{F_{a4}}{F_{r4}} = \frac{1390}{2310} = 0,690 > e;$$

$$\text{Koeffitsientlar } V = 1; \quad K_{\beta} = 1,3 \quad K_T = 1;$$

7211 konussimon podshipnik uchun

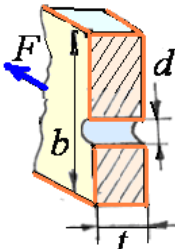
$$\frac{F_{a4}}{F_{r4}} > e \quad X = 0,4 \text{ va } Y = 1,459 \text{ hosil qilamiz}$$

$$F_{\beta 4} = (0,4 \cdot 2310 \cdot 1 + 1,459 \cdot 1390) \cdot 1,3 \cdot 1 = 3840H = 3,84kH$$

$$L = \left( \frac{C}{F_{\beta 4}} \right)^{\frac{10}{3}} = \left( \frac{56,8}{3,84} \right)^{\frac{10}{3}} = \left( \frac{56,8}{3,84} \right)^3 \cdot \sqrt[3]{\frac{56,8}{3,84}} \approx 8320 \text{ mln. ayl.}$$

$$\text{Ishlash muddati } L_h = \frac{L \cdot 10^6}{60n} = \frac{8320 \cdot 10^6}{60 \cdot 74} = 1,8 \cdot 10^6 \text{ soat.}$$

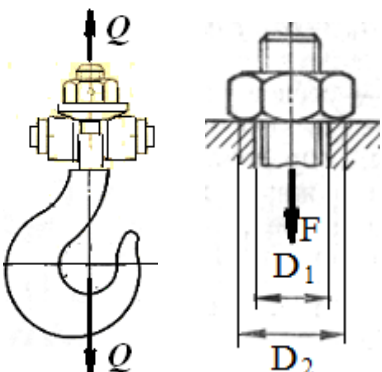
### Birikmalarni hisoblash.

| Parchin mixni hisoblash sxemasi                                                                                              | mustahkamlik shartlar                                                 |                                                            |                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                              | qirqilishga                                                           | ezilishga                                                  | zaiflashgan kesim cho'zilish (siqilish)                                                                                              |
|                                           | $\tau_{\max} = \frac{F}{n \cdot \frac{\pi \cdot d^2}{4}} \leq [\tau]$ | $\sigma_c = \frac{F}{n \cdot d \cdot t_1} \leq [\sigma_c]$ |  $\sigma = \frac{F}{t(b_0 - md)} \leq [\sigma]$ |
| parchin mixlar soni: qirqilishga $n \geq \frac{4F}{\pi \cdot d^2 [\tau]}$ , ezilishga $n \geq \frac{F}{d \delta [\sigma_c]}$ |                                                                       |                                                            |                                                                                                                                      |

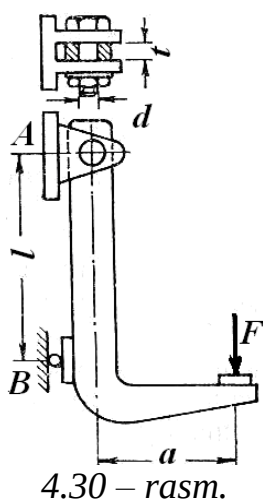
$$\text{Rezbaning ezilishga mustahkamligi: } \sigma_{\text{рез}} = \frac{P}{z \cdot \pi \cdot d_2 \cdot h} \leq [\sigma_{\text{рез}}]$$

| Rezbaning kesilishi: | vint uchun                                                   | gayka uchun                                                |
|----------------------|--------------------------------------------------------------|------------------------------------------------------------|
|                      | $\tau = \frac{F}{\pi \cdot d_1 \cdot k \cdot H} \leq [\tau]$ | $\tau = \frac{F}{\pi \cdot d \cdot k \cdot H} \leq [\tau]$ |

|                                         |                                                  |                                                             |
|-----------------------------------------|--------------------------------------------------|-------------------------------------------------------------|
| Shponkani ezilishga mustahkamlik shart: | segmentsimon                                     | tsilindrik                                                  |
|                                         | $\sigma_c = \frac{2T}{d \ell d} \leq [\sigma_c]$ | $\sigma_c = \frac{4T}{d_{\text{ü}} \ell d} \leq [\sigma_c]$ |

| Yuklanish sxemasi                                                                 | Boltli birikmalar                                                                                                                                                                                                                                                       | Mustahkamlikka hisoblash |
|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
|  | <p>Vint sterjeniga faqat tashqi cho'zuvchi kuch ta'sir qiladi. Yuk ko'taruvchi kryukdagi rezba misol bo'ladi</p> $\sigma = \frac{4F}{\pi \cdot d_1^2} \leq [\sigma]$ <p>buerda <math>D_1 \approx 1,25d_1</math> va <math>D_2 \approx 2,15d_1</math> olinishi mumkin</p> |                          |

### mustaqil echish uchun misollar.

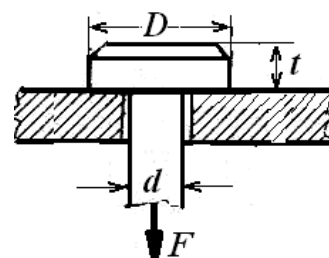


**misol -4.15.** Kuch  $F = 120 \text{ kN}$  bilan yuklangan tirsakli richagni A nuqtada sharnirli po'lat bolt va V nuqtada rolikli tayanch tutib turadi. Po'lat uchun ruxsat etiladigan qirqish va ezish kuchlanishlari  $[\tau] = 120 \text{ MPa}$   $[\sigma_s] = 250 \text{ MPa}$  bo'lsa, boltning zarur diametrini aniqlang. Richag tayanchlari orasidagi masofa  $l = 75 \text{ cm}$  o'lcham  $a = 50 \text{ cm}$ , qalinlik  $t = 3 \text{ cm}$

*Ko'rsatma.* Boltga tushadigan bosimni richagning muvozanatlik shartidan kelib chiqib A nuqtadagi to'liq reaksiya sifatida aniqlang.

**javob:**  $d = 2,8 \text{ cm}$

**misol-4.16.** Cho'zilishga ishlaydigan  $d = 100 \text{ mm}$  diametrli bolt kallagi listga tayanib turibdi. Agar bolt kesimidagi cho'zuvchi kuchlanish  $\sigma = 100 \text{ MPa}$ , kallak tayangan yuzadagi ezish kuchlanishi  $\sigma_s = 400 \text{ MPa}$  va kallakni qirqish kuchlanishi  $\tau = 50 \text{ MPa}$  bo'lsa, kallak diametri  $D$  ni va balandligi  $t$  ni aniqlang.



**echish.** Sterjenni cho'zishga mustahkamlik shartidan tashqi  $F$  kuchning ruxsat etilgan qiymatini topamiz:

$$[F] = [\sigma] \cdot \frac{\pi d^2}{4} = 100 \cdot 10^6 \cdot \frac{3,14 \cdot 0,1^2}{4} = 785,6 \cdot 10^3 \text{ H}.$$



Katta pog'ona devorga tayanadi, u ezilishga qarshilik ko'rsatadi.

$$\sigma_9 = \frac{[F]}{\frac{\pi}{4}(D^2 - d_0^2)} \leq [\sigma]_9$$

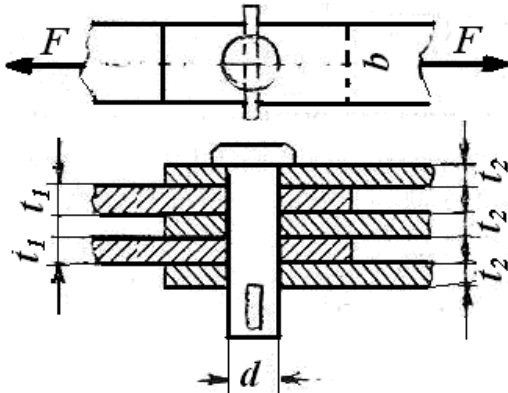
bu erdan 
$$D \geq \sqrt{\frac{4[F]}{\pi[\sigma]_9} + d_0^2} = \sqrt{\frac{4 \cdot 785 \cdot 10^3}{3,14 \cdot 400 \cdot 10^6} + 0,102^2} \approx 0,114 \text{ m}.$$

$D = 114 \text{ mm}$  deb qabul qilamiz.

Katta pog'ona uzunligi  $l$  va  $d_0$  diametriga teng sirti kesilishga qarshilik ko'rsatadi:

$$\tau_k = \frac{F}{A_k} = \frac{[F]}{\pi d_0 l} = \frac{785 \cdot 10^3}{3,14 \cdot 0,102 \cdot l} \leq [\tau] \text{ va buerdan } l \approx 50 \text{ mm}.$$

**misol-4.17.** Boltli birikmaning po'lat valigi orqali kuch  $F = 480 \text{ kN}$  uzatiladi (4.31- rasm). Valikning qirqish va ezilishga mustahkamlik shartlaridan, shuningdek listlarning cho'zilishga mustahkamlik shartidan kelib chiqib valikning zarur diametrini va listlar kesimining o'lchamlari ( $b, t_1$  va  $t_2$ ) ni aniqlang. Po'lat uchun ruxsat



rasm-4.31

etilgan kuchlanishlar:

cho'zilishga  $[\sigma] = 160 \text{ MPa}$  ;

qirqilishga  $[\tau] = 95 \text{ MPa}$  va

ezilishga  $[\sigma_9] = 250 \text{ MPa}$ .

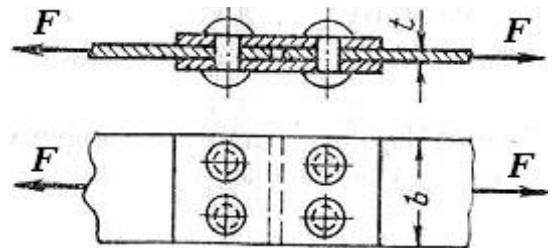
**javob:**

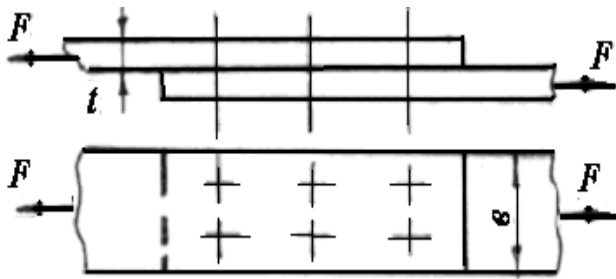
$d = 40 \text{ mm}; \quad b = 102,5 \text{ mm};$

$t_1 = 24 \text{ mm}; \quad t_2 = 16 \text{ mm}.$

**misol-4.18.** Qalinligi  $t = 10 \text{ mm}$  bo'lgan ikki list diametri  $d = 20 \text{ mm}$  li oltita parchin mix bilan usima – ust biriktirilgan. Agar ruxsat etiladigan kuchlanishlar: cho'zilishga  $[\sigma] = 160 \text{ MPa}$ , qirqilishga  $\tau = 120 \text{ MPa}$  va ezilishga  $\sigma_9 = 320 \text{ MPa}$  bo'lsa, ruxsat etiladigan cho'zuvchi kuchlar  $F$  ni va listning zarur eni  $b$  ni aniqlang.

**javob :**  $F = 22,6 \text{ kH}, b = 180 \text{ mm}.$





Rasm-4.32

**misol-4.19..** Qalinligi  $t = 10\text{ mm}$  li ikki ust qo'yma bilan yopilgan kesimi  $10 \times 150\text{ mm}$  bo'lgan ikki listning tutashgan joyi  $F = 125\text{ kN}$  kuch bilan cho'ziladi (4.32-rasm,b). Agar tutashuv joyining har tomonida diametri  $d = 20\text{ mm}$  li ikkitadan parchin mix qo'yilgan bo'lsa, parchin mixli birikmaning mustahkamligini tekshiring.

Ruxsat etilgan kuchlanishlar:  $[\sigma] = 160\text{ MPa}$ ,  $\tau = 100\text{ MPa}$ ,  $\sigma_y = 320\text{ MPa}$ .

**javob:** List uchun  $\sigma_{\max} = 114\text{ MPa} < 160\text{ MPa}$ . Parchin mixlar uchun  $\tau = 99,6\text{ MPa} < 100\text{ MPa}$ ,  $\sigma_y = 312\text{ MPa} < 320\text{ MPa}$ .

**misol-4.20.** Qalinligi  $t = 10\text{ mm}$  bo'lgan ikkita element diametrlari  $d = 20\text{ mm}$  bo'lgan 6 ta parchin mix bilan ustma-ust ulangan. Ruxsat etilgan cho'zuvchi kuch va elementlarning eni topilsin (oldingi misolning rasmi)

Ruxsat etilgan kuchlanish: qirqilishga  $[\tau] = 120 \cdot 10^3 \frac{\text{kg}}{\text{m}^2}$ ;

ezilishga  $[\sigma] = 320 \cdot 10^3 \frac{\text{kg}}{\text{m}^2}$  va cho'zilishga  $[\sigma] = 160 \cdot 10^3 \frac{\text{kg}}{\text{m}^2}$

**echish:** Qirqilishga mustahkamlik shartidan ruxsat etilgan kuch

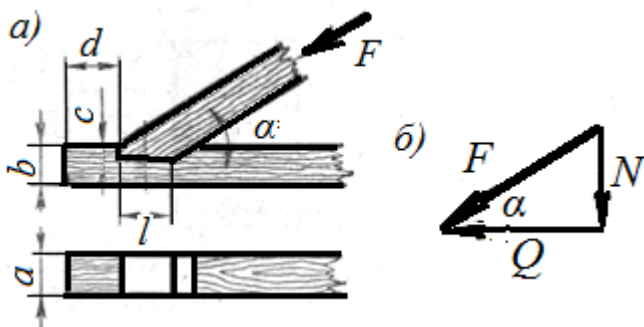
$$[F] = \frac{n \pi \cdot d^2 [\tau]}{4} = \frac{6 \cdot 3,14 \cdot 4 \cdot 10^{-4} \cdot 120 \cdot 10^3}{4} = 226\text{ kg}$$

va ezilishga mustahkamlik shartidan ruxsat etilgan kuch

$$[F] = ntd[\sigma] = 6 \cdot 0,01 \cdot 0,02 \cdot 320 \cdot 10^3 = 384\text{ kg}.$$

Ruxsat etilgan kuchlardan birinchisini qabul qilamiz, chunki bunda parchin mixli birikmani ikkala mustahkamlik sharti ham bajariladi. Ulanuvchi elementlarni enini topamiz.

$$b = \frac{F}{[\sigma] \cdot t} + md = \frac{226}{160 \cdot 10^3 \cdot 0,01} + 2 \cdot 0,02 = 0,18\text{ m}$$



**misol-4.21.** Stropilaning qiya yog'och brusi  $F = 40\text{ kg}$  kuch bilan siqiladi. Stropila bo'g'inlari-ning orsidagi burchak  $\alpha = 30^\circ$ . Stropilaning gorizont bo'g'ini va undagi qiya burchak o'rnatiladigan yacheykaning o'lchamlari

$$a = 10 \text{ cm}; b = 12 \text{ cm}; c = 5 \text{ cm}; d = 15 \text{ cm}$$

;  $l = 8 \text{ cm}$ . Ruxsat etilgan kuchlanishlar: cho'zilishga  $[\sigma] = 100 \frac{\text{kgf}}{\text{cm}^2}$ , ezilishga

$[\sigma]_3 = 70 \frac{\text{kgf}}{\text{cm}^2}$ , qirqilishga  $[\tau] = 25 \frac{\text{kgf}}{\text{cm}^2}$ . Yacheykani mustahkamligi tekshirilsin.

**echish.** Yacheyka tekisligiga ta'sir qiluvchi kuchlarni aniqlash uchun  $F$  kuchni ikkita tashkil qiluvchilarga ajratamiz:

$$N = F \cdot \sin \alpha = 40 \cdot \frac{1}{2} = 20 \text{ kH} \quad \text{va} \quad Q = F \cdot \cos \alpha = 40 \cdot 0,866 = 34,64 \text{ kH}$$

Zaiflashgan kesimda kuchlanish:

$$\sigma = \frac{Q}{A} = \frac{Q}{a \cdot (b - c)} = \frac{34,64 \cdot 10^2}{10 \cdot (12 - 5)} \approx 50 \frac{\text{kgf}}{\text{cm}^2} \leq [\sigma]$$

$A_K = a \cdot d$  yuzasidagi qirqilish kuchlanishi

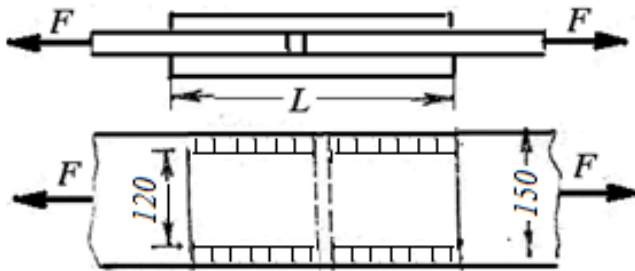
$$\tau = \frac{Q}{A_K} = \frac{Q}{a \cdot d} = \frac{34,64 \cdot 10^2}{10 \cdot 15} \approx 23,1 \frac{\text{kgf}}{\text{cm}^2} \leq [\tau]$$

$A_{33} = a \cdot c$  yuzada  $Q$  kuch ta'siridan hosil bo'ladigan ezilish kuchlanishi

$$\sigma_{33} = \frac{Q}{A_{33}} = \frac{Q}{a \cdot c} = \frac{34,64 \cdot 10^2}{10 \cdot 5} \approx 70 \frac{\text{kgf}}{\text{cm}^2} \leq [\sigma]_3$$

$A_{33} = a \cdot l$  yuzada  $N$  kuch ta'siridan hosil bo'ladigan ezilish kuchlanishi

$$\sigma_{33} = \frac{Q}{A_{33}} = \frac{Q}{a \cdot l} = \frac{25 \cdot 10^2}{10 \cdot 8} \approx 31 \frac{\text{kgf}}{\text{cm}^2} \leq [\sigma]_3$$



**misol-4.22.** Polosa (list) ikki tomonlama nakladka yordamida burchakli flangli chok bilan payvandlangan. Polosadagi hisobiy kuch  $N = 370 \text{ kN}$ , kesimi  $150 \times 12 \text{ mm}$ , material-po'lat. Nakladkaning kesimi chokning uzunligiga va qalinligiga

topilsin. Po'latni hisobiy kuchlanishi  $R = 21 \frac{\text{kgf}}{\text{cm}^2}$ .

**echish.** Chokni hosil qilish uchun nakladkalar eni polosa enidan  $10 \cdots 20 \text{ mm}$  ga har tomondan kichik bo'lishi kerak. Unda nakladka kesimining eni  $150 - 2 \cdot 15 = 120 \text{ mm}$ . Ikkita nakladka uchun talab etilgan kesim yuza:

$$A_{mp} = \frac{N}{R} = \frac{370}{21} = 17,6 \text{ cm}^2.$$

$$\text{Bitta nakladkaning qalinligi } \delta_n = \frac{A_{mp}}{2 \cdot 12} = \frac{17,6}{2 \cdot 12} = 0,73 \text{ cm}.$$

Nakladka qalinligini  $8\text{mm}$  deb qabul qilamiz, unda burchakli choklar qalinligi ham  $h_{uu} = 8\text{mm}$  bo'ladi. Unda nakladkani payvandlash uchun talab etilgan chokning umumiy uzunligi 
$$l_{uu} = \frac{N}{\beta h_{uu} \cdot R_y^{cb}} = \frac{37}{0,7 \cdot 0,8 \cdot 15} = 44\text{cm}.$$

Bu erda  $R_y^{cb} = 15 \frac{\kappa H}{\text{cm}^2}$  - burchakli chok uchun hisobiy qarshilik kuchlanish

Flangli payvandlashda  $\tau_{uu} = \frac{N}{A_{uus}} \leq R_y^{cb}.$

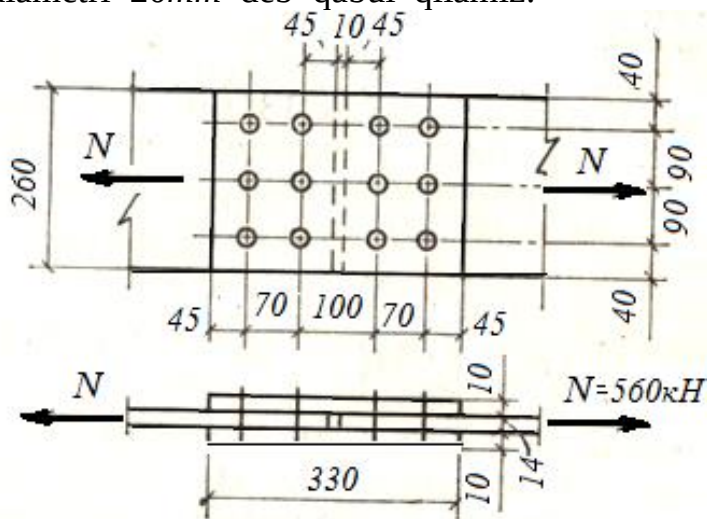
Bitta payvand chokning hisobiy uzunligi  $l_{uu} = 44 : 4 = 11\text{cm}.$

Konstruktiv uzunligi  $l_k = 11 + 1 = 12\text{cm}.$

Nakladkaning uzunligi  $l_H = 240\text{mm}.$

**misol-4.23.** Po'lat polosaning kesimi  $260 \times 14\text{mm}$ , qarshiligi  $\delta = 10\text{mm}$  bo'lgan ikki tomonlama nakladka o'rnatilgan ustma-ust boltli birikma (rasm-4.33) hisoblansin. Polosa  $N = 560\text{kN}$  kuch ta'sirida cho'zilsin.

**echish.** Birikma uchun bolt diametri  $20\text{mm}$  va bolt uchun teshik o'rning diametri  $20\text{mm}$  deb qabul qilamiz.



rasm-4.33

Boltni qirqimi va ezilish mustahkamlik shartlaridan chegaraviy kuchlarni hisob-

laymiz:  $[N]_{cp}^{\delta} = n_{cp} \frac{\pi d^2}{4} \cdot R_{cp}^{\delta}$

va  $[N]_{cm}^{\delta} = d \cdot \delta \cdot R_{cm}^{\delta}.$  Bu erda  $n_{cp}$  -boltni kesimi yuzalarining soni,  $n_{cp} = 2.$   $R_{cp}^{\delta}$  - boltni qirqilishga hisobiy qarshiligi,  $\frac{\kappa H}{\text{cm}^2}.$

$R_{cm}^{\delta}$  -boltni ezilishga hisobiy qarshiligi,  $\frac{\kappa H}{\text{cm}^2}.$

$R_{cp}^{\delta}, R_{cm}^{\delta}$  -hisobiy kuchlanishlar boltli birikmalar standartidan olinadi, po'lat materialining markasiga bog'liq:

$R_{cp}^{\delta} = 30 \frac{\kappa H}{\text{cm}^2}$  va  $R_{cm}^{\delta} = 38 \frac{\kappa H}{\text{cm}^2}$  qabul qilamiz.

Unda  $[N]_{cp}^{\delta} = 2 \cdot \frac{3,14 \cdot 2^2}{4} \cdot 30 = 185\text{kH}.$  va  $[N]_{cm}^{\delta} = 2 \cdot 1,4 \cdot 38 = 106,4\text{kH}.$

Minimal hisobiy chegaraviy kuchni bitta boltni ezilish shartidan topamiz. Birikmadagi boltlar soni  $n \geq \frac{N}{[N]_{\min}^{\delta}} = \frac{560}{106,4} = 5,3$ .

$n = 6$  deb qabul qilamiz.

Polosaning zaiflashgan kesimidagi kuchlanishni topamiz:

$$\sigma = \frac{N}{A_{nt}} = \frac{560}{28} = 20 \frac{\kappa H}{cm^2} < R = 21 \frac{\kappa H}{cm^2}.$$

Bu erda  $A_{nt}$  - polosaning zaiflashgan kesim yuzasi (netto)

$$A_{nt} = (26 - 3 \cdot 2) \cdot 1,4 = 28 cm^2.$$

**misol-4.24.** Bolt o'rniga parchin mix bo'lsa. Parchin mix diametri 20mm, parchin mix o'rnini uchun teshik diametri 21mm.

$$\text{Hisobiy kuchlar } [N]_{cp}^{3akl} = n_{cp} \frac{\pi d^2}{4} R_{cp}^{3akl} = 2 \cdot \frac{3,14 \cdot 2,1^2}{4} \cdot 18 = 124,8 \kappa H,$$

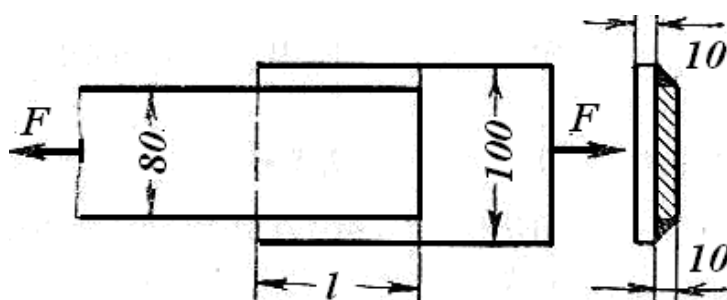
$$[N]_{cm}^{3akl} = d \cdot \delta \cdot R_{cm}^{3akl} = 2,1 \cdot 1,4 \cdot 42 = 123,5 \kappa H.$$

$$\text{Parchin mixlar soni } n \geq \frac{N}{[N]_{min}^{3akl}} = \frac{560}{123,6} = 4,6.$$

$n = 5$  qabul qilamiz ( $n = 5$  parchin mixlar konstruktiv joylashtirish noqulay).

$$A_{ht} = (26 - 3 \cdot 2,1) \cdot 1,4 = 27,6 cm^2.$$

$$\sigma = \frac{N}{A_{ht}} = \frac{560}{27,6} = 20,3 \frac{\kappa H}{cm^2} < R = 21 \frac{\kappa H}{cm^2}$$

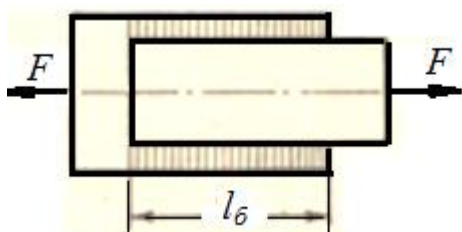


rasm -4.34.

**misol-4.25.** Kesimi 10x10mm va 100x100mm bo'lgan ikki polosani ustma-ust biriktirish uchun mo'ljallangan yon choklarning zarur uzunligini aniqlag (4.34-rasm) Polosalarni bo'ylama kuchlar cho'zishga intiladi.

Polosalarni cho'zishga ruxsat etilgan kuchlanish  $[\sigma] = 160 MPa$  choklarni qirqishga  $[\tau] = 90 MPa$ , har bir chokning boshi va oxirida 5 mm dan payvandlanmay qolgan joy bo'lishi mumkinligini hisobga oling ( $l = l_{xuc} + 25 mm$ ).

**javob:**  $l_x = 10,2 sm$ ;  $l = 11,2 sm$



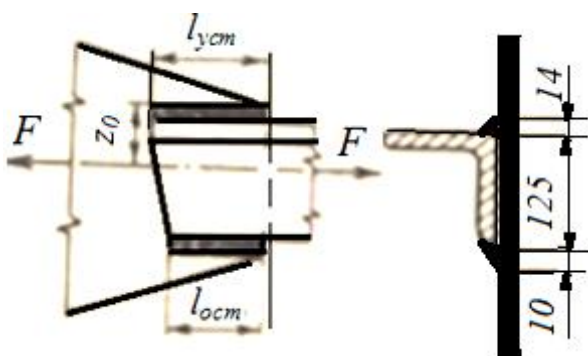
**misol-4.26.** Har xil kenglikdagi ikki list ustma - ust qo'yilib, bo'ylama choklar bilan payvandlangan. Agar payvand  $F = 15 \cdot 10^4 H$  kuch bilan cho'zilsa, bo'ylama chokning uzunligi  $l_\delta$  aniqlansin. Ruxsat etilgan kuchlanish

$$[\tau_\vartheta] = 100 \cdot 10^5 \frac{H}{\text{mm}^2} \quad \text{keng listning qalinligi } 10 \cdot 10^{-3} \text{ m, tor listniki } 8 \cdot 10^{-3} \text{ m.}$$

**echish.** Chokning mustahkamligini ta'minlovchi bo'ylama uzunligini xisoblaymiz:

$$l = \frac{F}{2 \cdot 0,7 \cdot \delta \cdot [\tau_\vartheta]} = \frac{15 \cdot 10^4}{1,4 \cdot 1100 \cdot 10^3} = 9,75 \text{ cm}$$

Payvand chokning haqiqiy uzunligi  $l_\delta = 9,75 + 1 = 10,75 \text{ cm}$



**misol-4.27.**

O'lchamlari 125x125x10 bo'lgan fason listga ppyvandlangan. Ustki va ostki choklarning uzunlik lari ( $l_{ycm}$ ,  $l_{ocm}$ ) aniqlansin. Birikmani cho'zuvchi kuchi  $F = 32 \cdot 10^4 H$  bo'lib, burchaklarning burchagi oldidagi chok qalinligi  $\delta_1 = 14 \text{ mm}$ , chetidagi chok qalinligi chetidagi chok qalinligi  $\delta_2 = 10 \text{ mm}$

Ruxsat etilgan kuchlanish  $[\tau_\vartheta] = 8 \cdot 10^7 \frac{H}{\text{mm}^2}$

**echish.** chokka qo'yiladigan metall uchun zarur bo'lgan yuzani aniqlaymiz:  $A = \frac{F}{[\tau_\vartheta]} = \frac{32 \cdot 10^4}{8 \cdot 10^7} = 4 \cdot 10^{-3} \text{ m}^2$

Kesim og'irlik markazining koordinatasi  $z_0 = 3,54 \text{ cm}$ . Demak, kesimning o'q chizig'i burchak balanligini  $\frac{3,54}{8,96}$  nisbatda kesib o'tadi. Chok yuzini ham xuddi shunday nsibatda bo'lamiz:

$$A_{ocm} = \frac{A \cdot z_0}{b} = \frac{3,54 \cdot 40}{12,5} = 11,2 \text{ cm}^2 = 11,2 \cdot 10^{-4} \text{ m}^2$$

$$A_{ycm} = \frac{b - z_0}{b} A = \frac{12,5 - 3,54}{12,5} \cdot 40 = 28,8 \text{ cm}^2 = 28,8 \cdot 10^{-4} \text{ m}^2$$

Endi, choklarning uzunligini topamiz:

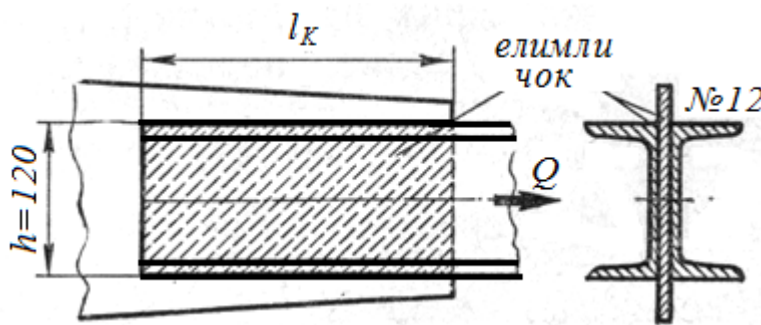
$$l_{ycm} = \frac{A_{ycm}}{0,7 \cdot \delta_1} = \frac{28,8}{0,7 \cdot 1,4} = 29,2 \text{ см} = 29,2 \cdot 10^{-2} \text{ м}$$

Ustki chokning haqiqiy uzunligi  $l_{ycm} = 29,2 + 1 = 30,2 \cdot 10^{-2} \text{ м}$

Chokning metall bilan to'lmay qolgan qismi uchun ikkala tomonga 1 sm.dan qo'shamiz.

Ustki chokning uzunligi  $l_{ocm} = \frac{A_{ocm}}{0,7 \cdot \delta_2} = \frac{11,2}{0,7 \cdot 1} = 16 \text{ см} = 16 \cdot 10^{-2} \text{ м}$

chokning uzunligi  $16 + 1 = 17 \cdot 10^{-2} \text{ м}$



**misol-4.28.** Ikkita №12 profillik shveller plan-kaga elimlangan. Har bir shvellerning kesim yuzasi  $A_{ues} = 13,7 \text{ см}^2$ , elim chokni qirqimiga ruxsat etilgan kuchlanish

$$[\tau] = 6 \frac{H}{\text{мм}^2}, \text{ shvellerni cho'zilishga ruxsat etilgan kuchlanish } [\sigma] = 160 \frac{H}{\text{мм}^2}.$$

Elim chokning uzunligi  $l_k$  -topilsin.

**echish.** Shveller uchun ruxsat etilgan yukni topamiz:

$$[Q]_p = [\sigma] \cdot 2A_{ues} = 160 \cdot 2 \cdot 1370 = 438 \cdot 10^3 H = 438 \text{ кН}.$$

Har bir chokga  $\frac{[Q]}{2}$  -kuch ta'sir qiladi. Chokning yuzasi  $A_{ues} = l_k \cdot n$ , chokning

mustahkamlik shartidan  $\tau = \frac{[Q]_k}{2A_{ues}} = \frac{[Q]_k}{2l_k n} \leq [\tau].$

$$[Q]_k = [Q]_p \text{ deb qabul qilinsak. } l_k \geq \frac{[Q]_p}{2n[\tau]} = \frac{438 \cdot 10^3}{2 \cdot 6 \cdot 120} = 305 \text{ мм}.$$

**misol-4.29. Shponkali birikmalar mustahkamligini hisoblash.**

Shponka materiali po'lat 45. Po'lat stupitsani ezilishga ruxsat etilgan kuchlanishi  $[\sigma_{\text{сж}}] = 100 \dots 120 \text{ МПа}$  va cho'yon stupitsa uchun  $[\sigma_{\text{сж}}] = 50 \dots 70 \text{ МПа}$

Ezilishga mustahkamlik sharti:  $\sigma_{\text{сж}}^{\text{max}} \approx \frac{2M_3}{d(h-t_1)(\ell-e)} \leq [\sigma_{\text{сж}}]$



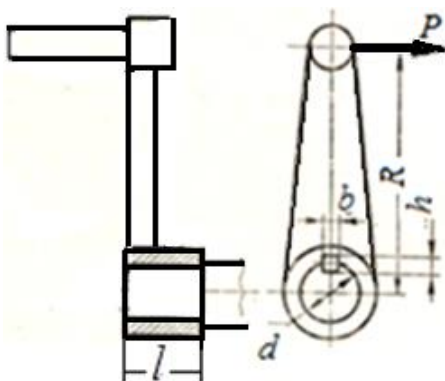
**Etaklovchi val:**  $d = 25\text{mm}$ ,  $b \cdot h = 8 \cdot 7\text{mm}$ ,  $t_1 = 4\text{mm}$  shponkani uzunligi  $l = 60\text{mm}$  va valdagi moment  $M_1 = 71,76 \cdot 10^3 \text{H} \cdot \text{mm}$

$$\sigma_{\text{эз}} = \frac{2 \cdot 71,76 \cdot 10^3}{25(7-4)(60-8)} = 30,9 \text{MPa}$$

**Etaklanuvchi val:**  $d = 55\text{mm}$ ,  $b \cdot h = 16 \cdot 10\text{mm}$ ,  $t_1 = 6\text{mm}$  shponkani uzunligi  $l = 74\text{mm}$  va valdagi moment  $M_3 = 430,6 \cdot 10^3 \text{H} \cdot \text{mm}$

$$\sigma_{\text{эз}} = \frac{2 \cdot 430,6 \cdot 10^3}{55(10-6)(74-16)} = 67,5 \text{MPa}$$

**misol-4.30.** Rukoyatka bilan valni birlashtiradigan shponkaning mustahkamlik shartidan rukoyatkaga qo'yilishi mumkin bo'lgan ruxsat etilgan  $R$  kuch aniqlansin.



Shponkaning o'lchamlari:  $h = 16\text{mm}$   
 $b = 20\text{mm}$ ,  $l = 60\text{mm}$ . Rukoyatkaning uzunligi  $R = 400\text{mm}$  val diametri  $d = 70\text{mm}$  shponkaning qirg'ilishiga ruxsat etilgan kuchlanish  $[\tau] = 80 \frac{\text{H}}{\text{mm}^2}$  ezilishga ruxsat etilgan kuchlanish

$$[\sigma_{\text{cm}}] = 180 \frac{\text{H}}{\text{mm}^2}$$

**echish.** Shponkadan uzatiladigan  $Q$  kuch rukoyatga qo'yilgan  $D$  kuch bilan valni aylanish o'qiga nisbatan momentlarning tengligiga shartiga asosan bog'liq.  $PR = \frac{Qd}{2}$  bu erdan,  $PR = \frac{Qd}{2R}$ . Shponkaga qo'yilishi mumkin bo'lgan  $Q$  kuchning ruxsat etilgan qiymati mustahkamlik shartlaridan topiladi.

Shponkani qirg'imiga mustahkamlik shartidan

$$[Q] = [\tau] \cdot A_{\kappa} = [\tau] \cdot bl = 80 \cdot 20 \cdot 60 = 96,0 \cdot 10^3 \text{H} = 96 \kappa \text{H}$$

Birikmani ezilishga mustahkamlik shartidan

$$[Q] = [\sigma_{\text{cm}}] \cdot A_{\text{cm}} = [\sigma_{\text{cm}}] \cdot \frac{hl}{2} = 180 \cdot 16 \cdot \frac{60}{2} = 86,4 \cdot 10^3 \text{H} = 86,4 \kappa \text{H}$$

Hisoblangan ruxsat etilgan kuchlardan kichikini qabul qilamiz. Unda

$$P = \frac{Qd}{2R} = \frac{86,4 \cdot 70}{2 \cdot 400} = 7,55 \kappa \text{H}$$

**misol-4.31.** Bolt sterjenida oquvchanlik chegarasidagi kuchlanishga teng kuchlanish  $\sigma_{OK} = 2200 \frac{\kappa \Gamma}{\text{cm}^2}$  hosil bo'lganicha gaykani burash uchun



$L = 15d$  uzunlikdagi standart M6 boltga qo'yilishi mumkin bo'lgan  $R$  kuch aniqlansin. Rezbani diametrlari : tashqi  $d = 6\text{mm}$ , o'rtacha  $d_{yp} = 5,35\text{mm}$ , ichki  $d_1 = 0,4918\text{mm}$ , ko'tarilish burchagi  $\beta = 3^0 24^1$ , ishqalanish koeffitsienti  $f = 0,15$ ,  $d_2 = \frac{D+6+0,5}{2} = 8,75\text{mm}$

**echish.** Tortish kuchini  $\sigma_{\hat{y}\hat{e}} = \frac{4 \cdot 1,3 \cdot Q}{\pi \cdot d_1^2} \leq [\sigma]$  formuladan

hisoblaymiz.  $Q = \frac{\pi}{4 \cdot 1,3} d_1^2 \sigma_{\text{OK}} = \frac{\pi}{5,2} (0,49)^2 \cdot 2200 \approx 320\text{kN}$

Gaykaga qo'yilgan moment  $M = Q \frac{d_{yp}}{2} \left[ f \frac{d_2}{d_{yp}} + \text{tg}(\beta + \rho^1) \right]$  va

$$M = 320 \frac{0,535}{2} \left[ 0,15 \frac{0,875}{0,535} + \text{tg}(3^0 24^1 + 9^0 50^1) \right] = 41\text{kN},$$

buerda  $\rho^1 = \text{arctg} \frac{f}{\cos 30^0}$ .

Klyuchga qo'yilgan kuch  $R = \frac{M}{L} = \frac{41}{15 \cdot 0,6} \approx 4,5\text{kN}$

### Metrik rezbalarning parametrlari [21]

| Rezbaning diametri |                                  |                               | Rezbaning qadami-S | profilning balandligi - h |
|--------------------|----------------------------------|-------------------------------|--------------------|---------------------------|
| Tashqi Diametr- d  | O'rtacha diametr- d <sub>2</sub> | Ichki diametr- d <sub>1</sub> |                    |                           |
| 6                  | 5,35                             | 4,918                         | 1                  | 0,541                     |
| 7                  | 6,35                             | 5,988                         | 1                  | 0,541                     |
| 8                  | 7,188                            | 6,647                         | 1,25               | 0,676                     |
| 9                  | 8,188                            | 7,647                         | 1,25               | 0,676                     |
| 10                 | 9,026                            | 8,376                         | 1,5                | 0,812                     |
| 11                 | 10,02                            | 9,376                         | 1,5                | 0,812                     |
| 12                 | 10,86                            | 10,10                         | 1,75               | 0,947                     |
| 14                 | 12,70                            | 11,83                         | 2                  | 1,082                     |
| 16                 | 14,70                            | 13,83                         | 2                  | 1,082                     |
| 18                 | 16,37                            | 15,29                         | 2,5                | 1,353                     |
| 20                 | 18,37                            | 17,29                         | 2,5                | 1,353                     |

| Rezbaning diametri |                                  |                               | Rezbaning qadami | profilning balandligi |
|--------------------|----------------------------------|-------------------------------|------------------|-----------------------|
| Tashqi Diametr- d  | O'rtacha diametr- d <sub>2</sub> | Ichki diametr- d <sub>1</sub> |                  |                       |
| 22                 | 20,37                            | 19,29                         | 2,5              | 1,353                 |
| 24                 | 22,05                            | 20,75                         | 3                | 1,624                 |
| 27                 | 25,05                            | 23,75                         | 3                | 1,624                 |
| 30                 | 27,73                            | 26,21                         | 3,5              | 1,894                 |
| 33                 | 30,73                            | 29,21                         | 3,5              | 1,894                 |
| 36                 | 33,40                            | 31,67                         | 4                | 2,165                 |
| 39                 | 36,40                            | 34,67                         | 4                | 2,165                 |
| 42                 | 39,08                            | 37,13                         | 4,5              | 2,435                 |
| 45                 | 42,08                            | 40,13                         | 4,5              | 2,435                 |
| 48                 | 44,75                            | 42,59                         | 5                | 2,7                   |
|                    |                                  |                               |                  |                       |

### TEST

## TECT

|                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>1. Mexanika nima?</b>                                      | <p>A) Mexanika moddiy jismlarni harakati va ta'sirlashuvi to'g'risidagi fan</p> <p>B) Mexanika moddiy jismlarni ta'sirlashuvi to'g'risidagi fan</p> <p>S) Mexanika moddiy jismlarni harakati to'g'risidagi fan</p> <p>D) mexanika moddiy jismlarning muvozanatini o'rganadi</p>                                                                                                                                      |
| <b>2. Texnika nima?</b>                                       | <p>A) ishlab chiqarishda tadbqiq etiladigan mehnat qurollari</p> <p>B) ishlab chiqarishda tadbqiq etiladigan jihozlari</p> <p>S) ishlab chiqarishni boshqarishda qatnashadigan mehnat qurollari, jihozlari</p> <p>D) ishlab chiqarishda tadbqiq etiladigan va uni boshqarishda qatnashadigan mehnat qurollari, jihozlari</p>                                                                                         |
| <b>3. Mexanik harakat nima?</b>                               | <p>A) vaqt o'tishi bilan fazoda moddiy jismlarning bir – biriga nisbatan vaziyatlarining o'zgarishligi</p> <p>B) vaqt o'zgarish bo'lganda fazoda moddiy jismlarning bir – biriga nisbatan vaziyatlarining o'zgarishidir</p> <p>S) vaqt o'tishi bilan fazoda moddiy jismlarning bir – biriga ta'siri</p> <p>D) – vaqt o'tishi bilan fazoda moddiy jismlarning bir – biriga nisbatan vaziyatlarining o'zgarishidir</p> |
| <b>4. Mexanizm va mashinalar nazariyasi nimani o'rganadi?</b> | <p>A) harakat qonunlari va xossalari hamda jismning muvozanat shartlarini o'rganadi</p> <p>B) mexanizmlarning tuzilishi, kinematikasi va dinamikasini analiz va sintez qilishni o'rganadi</p> <p>S) konstruktsiya va inshoot qismlarini mustaxkamlikka, birklikka va ustuvorlikka hisoblashni o'rganadi</p> <p>D) birikmalar, uzatmalarni hisoblash va loyixalash to'g'risidagi fan</p>                              |
| <b>5. Nazariy mexanika nimani o'rganadi?</b>                  | <p>A) harakat qonunlari va xossalari hamda jismning muvozanat shartlarini o'rganadi</p> <p>B) mexanizmlarning tuzilishi, kinematikasi va dinamikasini analiz va sintez qilishni o'rganadi</p> <p>S) konstruktsiya va inshoot qismlarini mustaxkamlikka, birklikka va ustuvorlikka hisoblashni o'rganadi</p> <p>D) birikmalar, uzatmalarni hisoblash va loyixalash to'g'risidagi fan</p>                              |
| <b>6. Materiallar qarshiligi nimani o'rganadi?</b>            | <p>A) harakat qonunlari va xossalari hamda jismning muvozanat shartlarini o'rganadi</p> <p>B) mexanizmlarning tuzilishi, kinematikasi va dinamikasini analiz va sintez qilishni o'rganadi</p> <p>S) konstruktsiya va inshoot qismlarini mustaxkamlikka, birklikka va ustuvorlikka hisoblashni o'rganadi</p> <p>D) birikmalar, uzatmalarni hisoblash va loyixalash</p>                                                |

|                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                     | to'g'risidagi fan                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>7. Mashina detallari nimani o'rganadi?</b>                       | <p>A) harakat qonunlari va xossalari hamda jismning muvozanat shartlarini o'rganadi</p> <p>B) mexanizmlarning tuzilishi, kinematikasi va dinamikasini analiz va sintez qilishni o'rganadi</p> <p>S) konstruktsiya va inshoot qismlarini mustaxkamlikka, birklikka va ustuvorlikka hisoblashni o'rganadi</p> <p>D) birikmalar, uzatmalarni hisoblash va loyixalash to'g'risidagi fan</p>                                                                                                                         |
| <b>8. Mashina nima?</b>                                             | <p>A) Energiya hosil qilish uchun harakatlanadigan, material va axborot to'playdigan yoki ishlab chiqadigan, odamni aqliy va jismoniy mehnatini engillashtiradigan mexanik qurilma</p> <p>B) Energiya hosil qilish uchun harakatlanmaydigan, material va axborot to'playdigan yoki ishlab chiqadigan, odamni aqliy va jismoniy mehnatini engillashtiradigan mexanik qurilma</p> <p>S) Energiya hosil qilish uchun harakatlanadigan va odamni aqliy va jismoniy mehnatini engillashtiradigan mexanik qurilma</p> |
| <b>9. Muxandislik inshootlariga qanday konstruktsiyalar kiradi?</b> | <p>A) ko'priklar, tonnellar, rezervuar</p> <p>B) binolar, ko'priklar, rezervuar</p> <p>S) binolar, ko'priklar, tonnellar, rezervuar</p> <p>D) binolar, ko'priklar, tonnellar</p>                                                                                                                                                                                                                                                                                                                                |
| <b>10. Detal nima?</b>                                              | <p>A) Energiya ishlab chiqaruvchi mashina, turli uzatish mexanizmlari va boshqarish apparatidan tashkil topgan qurilma</p> <p>B) burovchi momentni uzatadigan, buralish va egilish deformatsiyasiga uchraydigan brus</p> <p>S) yig'uv uslublari qo'llanilmasdan bir xil materialdan ishlab chiqilgan mashinaning qismidir</p> <p>D) mashina qismlarini aylanishiga yordam berib faqat eguvchi moment ta'siriga uchraydigan brus</p>                                                                             |
| <b>11. Val nima?</b>                                                | <p>A) Energiya ishlab chiqaruvchi mashina, turli uzatish mexanizmlari va boshqarish apparatidan tashkil topgan qurilma</p> <p>B) burovchi momentni uzatadigan, buralish va egilish deformatsiyasiga uchraydigan brus</p> <p>S) yig'uv uslublari qo'llanilmasdan bir xil materialdan ishlab chiqilgan mashinaning qismidir</p> <p>D) mashina qismlarini aylanishiga yordam berib faqat eguvchi moment ta'siriga uchraydigan brus</p>                                                                             |
| <b>12. O'q nima?</b>                                                | <p>A) Energiya ishlab chiqaruvchi mashina, turli uzatish mexanizmlari va boshqarish apparatidan tashkil topgan qurilma</p>                                                                                                                                                                                                                                                                                                                                                                                      |

|                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                         | <p>B) burovchi momentni uzatadigan, buralish va egilish deformatsiyasiga uchraydigan brus</p> <p>S) yig'uv uslublari qo'llanilmasdan bir xil materialdan ishlab chiqilgan mashinaning qismidir</p> <p>D) mashina qismlarini aylanishiga yordam berib faqat eguvchi moment ta'siriga uchraydigan brus</p>                                                                                                                                             |
| <b>13. Brus nima?</b>                   | <p>A) uzunligi boshqa o'lchamlaridan katta bo'lgan elementga</p> <p>B) Qalinligi boshqa o'lchamlaridan kichik bo'lgan element</p> <p>S) Ingichka brus</p> <p>D) yig'uv uslublari qo'llanilmasdan bir xil materialdan ishlab chiqilgan mashinaning qismidir</p>                                                                                                                                                                                       |
| <b>14. Sterjen nima?</b>                | <p>A) uzunligi boshqa o'lchamlaridan katta bo'lgan elementga</p> <p>B) Qalinligi boshqa o'lchamlaridan kichik bo'lgan element</p> <p>S) Ingichka brus</p> <p>D) yig'uv uslublari qo'llanilmasdan bir xil materialdan ishlab chiqilgan mashinaning qismidir</p>                                                                                                                                                                                       |
| <b>15. Plastinka nima?</b>              | <p>A) uzunligi boshqa o'lchamlaridan katta bo'lgan elementga</p> <p>B) Qalinligi boshqa o'lchamlaridan kichik bo'lgan element</p> <p>S) Ingichka brus</p> <p>D) yig'uv uslublari qo'llanilmasdan bir xil materialdan ishlab chiqilgan mashinaning qismidir</p>                                                                                                                                                                                       |
| <b>16. Qobiq nima?</b>                  | <p>A) uzunligi boshqa o'lchamlaridan katta bo'lgan elementga</p> <p>B) Qalinligi boshqa o'lchamlaridan kichik bo'lgan element</p> <p>S) Egri plastinka</p> <p>D) yig'uv uslublari qo'llanilmasdan bir xil materialdan ishlab chiqilgan mashinaning qismidir</p>                                                                                                                                                                                      |
| <b>17. Yuritma deb nimaga aytiladi?</b> | <p>A) Energiya ishlab chiqaruvchi mashina, turli uzatish mexanizmlari va boshqarish apparatidan tashkil topgan qurilma</p> <p>B) burovchi momentni uzatadigan, buralish va egilish deformatsiyasiga uchraydigan brus</p> <p>S) yig'uv uslublari qo'llanilmasdan bir xil materialdan ishlab chiqilgan mashinaning qismidir</p> <p>D) mashina qismlarini aylanishiga yordam berib faqat eguvchi moment ta'siriga uchraydigan brus</p>                  |
| <b>18. Statika nima?</b>                | <p>A). Moddiy jismlarning o'zaro ta'sirlashuvi va muvozanatini tekshiradigan nazariy mexanikaning bo'limi statika deyiladi.</p> <p>B) Kuch vektori yo'nalgan to'g'ri chiziq kuchning ta'sir chizig'ini o'rganuvchi bo'lim.</p> <p>S) Moddiy jismlarning o'zaro ta'sirlashuvi tekshiradigan nazariy mexanikaning bo'limi statika deyiladi.</p> <p>D) Moddiy jismlarning muvozanatini tekshiradigan nazariy mexanikaning bo'limi statika deyiladi.</p> |

|                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>19. Jismning muvozanati deb nimaga aytiladi?</b>                 | <p>A). Tinch yoki boshqa jismga nisbatan tekis to'g'ri chiziqli harakatdagi vaziyati</p> <p>B) Jismga nisbatan egri chiziqli harakatdagi vaziyati</p> <p>S) Jismga nisbatan yuqoriga harakatdagi vaziyati</p> <p>D) Ikki jism o'zaro to'qnashgan vaziyat</p>                                                                                                                                                                                                                                                                                                                              |
| <b>20. Kuch qanday elementlarga ega?</b>                            | <p>A) Son qiymati, yo'nalishi va qo'yilish nuqtasi.</p> <p>B) Son qiymati.</p> <p>S) Yo'nalishi.</p> <p>D) Qo'yilish nuqtasi.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>21. Kuchning ta'sir chizig'i deb nimaga aytiladi?</b>            | <p>A). Kuch vektori yo'nalgan to'g'ri chiziq kuchning ta'sir chizig'i deyiladi</p> <p>B) Ikki jism o'zaro to'qnashgan vaziyat</p> <p>S) Kuchni o'qdag proektsiyasi</p> <p>D) Juft elkasi</p>                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>22. Kuchlar sistemasi nima?</b>                                  | <p>A) Jismga qo'yilgan juft kuch.</p> <p>B) Bir qancha kuchlarning bosh vektori</p> <p>S) Jismga qo'yilgan <math>F_1, F_2, F_3</math> kuchlar to'plami</p> <p>D) Kuchlarning teng ta'sir etuvchisi</p>                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>23. Kuchlar sistemasining teng ta'sir etuvchisi nima?</b>        | <p>A) Juft kuch.</p> <p>B) Kuchlar sistemasini jismga ta'sirini yolg'iz bir o'zi bergan kuch.</p> <p>S) Muvozanatlashgan kuch.</p> <p>D) Harakatlantiruvchi kuch.</p>                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>24. Muvozanatlashgan kuchlar sistemasi qanday kuchlar?</b>       | <p>A) Tinch turgan jismga qo'yilgan <math>F_1, F_2, F_3</math> kuchlar sistemasi ta'sirida ham tinch holatda qoladi.</p> <p>B) Tinch turgan jismga qo'yilgan <math>F_1, F_2, F_3</math> kuchlar sistemasi ta'sirida ham harakat oladi qoladi</p> <p>S) Harakatlantiruvchi kuch.</p> <p>D) Juft kuch.</p>                                                                                                                                                                                                                                                                                  |
| <b>25. Kuch haqidagi birinchi aksiomaning ta'rifini ko'rsating?</b> | <p>A) Ikki kuch ta'siri ostidagi erkin qattik jism muvozanatda turishi uchun bu kuchlar moduli jixatdan bir-biriga teng va bitta to'g'ri chiziq bo'ylab qarama-qarshi tomonga yo'nalishi zarur</p> <p>B) Berilgan kuchlar ta'sirida deformatsiyalanadigan jism muvozanat holatida absolyut qattiq jismga aylansa, uning muvozanati o'zgarmaydi.</p> <p>S) Agar qattiq jismga muvozanatlashgan kuchlar sistemasi qo'yilsa yoki olinsa uning muvozanati buzilmaydi</p> <p>D) Jismlarning bir-biriga ta'siri o'zaro teng va bir to'g'ri chiziq bo'ylab qarama – qarshi tomonga yo'naladi</p> |
| <b>26. Kuch haqidagi ikkinchi aksiomaning ta'rifini</b>             | <p>A) Agar qattiq jismga muvozanatlashgan kuchlar sistemasi qo'yilsa yoki olinsa uning muvozanati buzilmaydi</p> <p>B) Jismlarning bir-biriga ta'siri o'zaro teng va bir to'g'ri chiziq bo'ylab qarama – qarshi tomonga yo'naladi</p>                                                                                                                                                                                                                                                                                                                                                     |

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| <b>ko'rsating?</b>                                                   | <p>S) Ikki kuch ta'siri ostidagi erkin qattik jism muvozanatda turishi uchun bu kuchlar moduli jixatdan bir-biriga teng va bitta to'g'ri chiziq bo'ylab qarama-qarshi tomonga yo'nalishi zarur</p> <p>D) Berilgan kuchlar ta'sirida deformatsiyalanadigan jism muvozanat holatida absolyut qattiq jismga aylansa, uning muvozanati o'zgarmaydi.</p>                                                                                                                                                                                                                                                                                                                                                          |
| <b>27.Kuch haqidagi uchinchi aksiomaning ta'rifini ko'rsating?</b>   | <p>A) Jismning biror nuqtasiga qo'yilgan turli yo'nalish-dagi ikki kuchning teng ta'sir etuvchisi, shu kuchlarning geometrik yig'indisiga teng bo'lib shu kuchlarga qurilgan parallelogrammning diagonalini bo'ylab yo'naladi.</p> <p>B) Ikki kuch ta'siri ostidagi erkin qattik jism muvozanatda turishi uchun bu kuchlar moduli jixatdan bir-biriga teng va bitta to'g'ri chiziq bo'ylab qarama-qarshi tomonga yo'nalishi zarur</p> <p>S) Berilgan kuchlar ta'sirida deformatsiyalanadigan jism muvozanat holatida absolyut qattiq jismga aylansa, uning muvozanati o'zgarmaydi.</p> <p>D) Jismlarning bir-biriga ta'siri o'zaro teng va bir to'g'ri chiziq bo'ylab qarama – qarshi tomonga yo'naladi</p>  |
| <b>28.Kuch haqidagi to'rtinchi aksiomaning ta'rifini ko'rsating?</b> | <p>A) Jismlarning bir-biriga ta'siri o'zaro teng va bir to'g'ri chiziq bo'ylab qarama – qarshi tomonga yo'naladi.</p> <p>B) Jismning biror nuqtasiga qo'yilgan turli yo'nalish-dagi ikki kuchning teng ta'sir etuvchisi, shu kuchlarning geometrik yig'indisiga teng bo'lib shu kuchlarga qurilgan parallelogrammning diagonalini bo'ylab yo'naladi.</p> <p>S) Ikki kuch ta'siri ostidagi erkin qattik jism muvozanatda turishi uchun bu kuchlar moduli jixatdan bir-biriga teng va bitta to'g'ri chiziq bo'ylab qarama-qarshi tomonga yo'nalishi zarur</p> <p>D) Berilgan kuchlar ta'sirida deformatsiyalanadigan jism muvozanat holatida absolyut qattiq jismga aylansa, uning muvozanati o'zgarmaydi.</p> |
| <b>29.Kuch haqidagi beshinchi aksiomaning ta'rifini ko'rsating?</b>  | <p>A) Jismlarning bir-biriga ta'siri o'zaro teng va bir to'g'ri chiziq bo'ylab qarama – qarshi tomonga yo'naladi.</p> <p>B) Jismning biror nuqtasiga qo'yilgan turli yo'nalishdagi ikki kuchning teng ta'sir etuvchisi, shu kuchlarning geometrik yig'indisiga teng bo'lib shu kuchlarga qurilgan parallelogrammning diagonalini bo'ylab yo'naladi.</p> <p>S) Ikki kuch ta'siri ostidagi erkin qattik jism muvozanatda turishi uchun bu kuchlar moduli jixatdan bir-biriga teng va bitta to'g'ri chiziq bo'ylab qarama-qarshi tomonga yo'nalishi zarur</p> <p>D) Berilgan kuchlar ta'sirida deformatsiyalanadigan jism muvozanat holatida absolyut qattiq jismga aylansa, uning muvozanati o'zgarmaydi.</p>  |
| <b>30.Tashqi kuch nima?</b>                                          | <p>A) Jismga ta'sir qiluvchi kuch yoki undagi temperaturani o'zgarishi</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

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|                                                   | <p>B) Inertsiya kuchlari</p> <p>S) Foydali qarshilik kuchi.</p> <p>D) Ishqalanish kuchi</p>                                                                                                                                                                                                                                                                                                              |
| <b>31. Statik kuch qanday kuch?</b>               | <p>A) Qiymati, yo'nalishi va qo'yiladigan nuqtalari o'zgarmaydigan yoki sekin va ozgina o'zgaradi</p> <p>B) Vakt oralig'ida qiymati, yo'nalishi va qo'yiladigan nuqtasi tez o'zgarishi bilan xarakterlanadi</p> <p>S) Inertsiya kuchlari</p> <p>D) Ishqalanish kuchi</p>                                                                                                                                 |
| <b>32. Dinamik kuch qanday kuch?</b>              | <p>A) Qiymati, yo'nalishi va qo'yiladigan nuqtalari o'zgarmaydigan yoki sekin va ozgina o'zgaradi</p> <p>B) Vakt oralig'ida qiymati, yo'nalishi va qo'yiladigan nuqtasi tez o'zgarishi bilan xarakterlanadi</p> <p>S) Inertsiya kuchlari</p> <p>D) Ishqalanish kuchi</p>                                                                                                                                 |
| <b>33. To'planma kuch qanday kuch?</b>            | <p>A) Jismga jism cheksiz kichik yuza orqali o'zaro ta'sirlashgan kuch</p> <p>B) yuklangan uchastkaning uzunlik birligiga to'g'ri keladigan kuch</p> <p>S) Qiymati, yo'nalishi va qo'yiladigan nuqtalari o'zgarmaydigan yoki sekin va ozgina o'zgaradi</p> <p>D) Vakt oralig'ida qiymati, yo'nalishi va qo'yiladigan nuqtasi tez o'zgarishi bilan xarakterlanadi</p>                                     |
| <b>34. Taqsimlangan kuch qanday kuch?</b>         | <p>A) Jismga jism cheksiz kichik yuza orqali o'zaro ta'sirlashgan kuch</p> <p>B) yuklangan uchastkaning uzunlik birligiga to'g'ri keladigan kuch</p> <p>S) Qiymati, yo'nalishi va qo'yiladigan nuqtalari o'zgarmaydigan yoki sekin va ozgina o'zgaradi</p> <p>D) Vakt oralig'ida qiymati, yo'nalishi va qo'yiladigan nuqtasi tez o'zgarishi bilan xarakterlanadi</p>                                     |
| <b>35. Bog'lanish deb nimaga aytiladi?</b>        | <p>A) Jismning harakat yoki holatini cheklovchi sabab bog'lanish deyiladi.</p> <p>B) Qo'zg'aluvchan sharnirli tayanch</p> <p>S) Qo'zg'almas sharnirli tayanch</p> <p>D) Birk mahkamlangan tayanch</p>                                                                                                                                                                                                    |
| <b>36. Erkin jism deb qanday jismga aytiladi?</b> | <p>A) Jism yoki jismlar muvozanatini o'zgartirmasdan, bog'lanishlarning berilgan jismga ta'sirini reaksiya kuchi bilan almashtirib, har qanday bog'lanishdagi jismni erkin jism deb qarash mumkin.</p> <p>B) Jism yoki jismlar muvozanatini o'zgartirib, bog'lanishlarning berilgan jismga ta'sirini reaksiya kuchi bilan almashtirib, har qanday bog'lanishdagi jismni erkin jism deb qarash mumkin</p> |

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|                                                                               | <p>S) Jism yoki jismlar muvozanatini o'zgartirmasdan, tashqi kuchlarni bog'lanishlarga ta'sirini reaksiya kuchi bilan almashtirib, har qanday bog'lanishdagi jism erkin jism</p> <p>D) Jism yoki jismlar muvozanatini o'zgartirmasdan, tashqi kuchlarni bog'lanishlarga ta'sirini bosim kuchi bilan almashtirib, har qanday bog'lanishdagi jism erkin jism</p>                                                                                                                                                                                           |
| <b>37.Bog'lanish reaksiyasi qanday yo'nalgan?</b>                             | <p>A) Bog'lanish reaksiyasi hamma vaqt bog'lanishning jism harakatiga ko'rsatadigan to'sqinligi yo'nalishiga qarama-qarshi yo'nalgan</p> <p>B) Bog'lanish reaksiyasi hamma vaqt bog'lanishning jism harakatiga ko'rsatadigan to'sqinligi yo'nalishi bo'yicha yo'nalgan</p> <p>S) Bog'lanish reaksiyasi hamma vaqt bog'lanishning jism harakatiga ko'rsatadigan to'sqinligi yo'nalishiga perpendikulyar yo'nalgan</p> <p>D) Bog'lanish reaksiyasi hamma vaqt bog'lanishning jism harakatiga ko'rsatadigan to'sqinligi yo'nalishiga parallel yo'nalgan</p> |
| <b>38.Qo'zg'aluvchan sharnirli tayanch nechta harakatni cheklaydi?</b>        | A) 1                      B) 2                      S) 3                      D) 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>39.Qo'zg'almas sharnirli tayanch nechta harakatni cheklaydi?</b>           | A) 1                      B) 2                      S) 3                      D) 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>40.Bikr qo'zg'almas tayanch nechta harakatni cheklaydi?</b>                | A) 1                      B) 2                      S) 3                      D) 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>41.Qo'zg'aluvchan sharnirli tayanchning erkinlik darajasi nimaga teng?</b> | A) 1                      B) 2                      S) 3                      D) 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>42.Qo'zg'almas sharnirli tayanchning erkinlik darajasi nimaga teng?</b>    | A) 1                      B) 2                      S) 3                      D) 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>43.Bikr qo'zg'almas tayanchnin erkin-</b>                                  | A) 0                      B) 1                      S) 2                      D) 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |



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| <b>lik darajasi nimaga teng?</b>                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>44. Bir nuqtada kesishuvchi kuchlar sistemasi deb nimaga deyiladi</b>                 | <p>A) Ta'sir chiziqlari bir nuqtada kesishmaydigan kuchlar sistemasi bir nuqtada kesishuvchi kuchlar sistemasi</p> <p>B) Ta'sir chiziqlari bir nuqtada kesishadigan kuchlar sistemasi bir nuqtada kesishuvchi kuchlar sistemasi</p> <p>S) Ta'sir chiziqlari parallel kuchlar sistemasi</p> <p>D) Ta'sir chiziqlari fazoda kesishmaydigan kuchlar sistemasi bir nuqtada kesishuvchi kuchlar sistemasi</p>                                                  |
| <b>45. Bir nuqtada kesishuvchi kuchlar sistemasining muvozanati qachon ta'minlanadi?</b> | <p>A) bu kuchlar sistemasining teng ta'sir etuvchisi nolga teng bo'lishi zarur</p> <p>B) bu kuchlar sistemasining teng ta'sir etuvchisi yoki bu kuchlarning koordinata o'qlardagi proektsiyalari nolga teng bo'lishi zarur va etarli</p> <p>S) bu kuchlar sistemasining teng ta'sir etuvchisi etarli</p> <p>D) bu kuchlar sistemasining teng ta'sir etuvchisi yoki bu kuchlarning koordinata o'qlardagi proektsiyalari nolga teng bo'lishi shart emas</p> |
| <b>46. Bir nuqtaga qo'yilgan kuchlar sistemasining analitik muvozanat shartlari?</b>     | <p>A). <math>\sum F_{kx} = 0 \quad \sum F_{ky} = 0</math>;      B). <math>\sum m(F) = 0</math></p> <p>C). <math>\sum m(F_{kx}) = 0</math>;      D). <math>\sum m(F_{ky}) = 0</math></p>                                                                                                                                                                                                                                                                   |
| <b>47. Tekislikda parallel joylashgan kuchlarning muvozanat shartlari.</b>               | <p>A) <math>\sum F_{kx} = 0 \quad \sum F_{ky} = 0</math></p> <p>B) <math>\sum F_k = 0 \quad \sum m_0(F_k) = 0</math></p> <p>S) <math>\sum m(F_{kx}) = 0</math>;      D) <math>\sum F = 0</math></p>                                                                                                                                                                                                                                                       |
| <b>48. Kuchning o'qdagi proektsiyasi deb nimaga aytiladi?</b>                            | <p>A) Juft kuchga.</p> <p>B) Kuch vektorining boshi oxiridan o'qqa tushirilgan ikkita perpendikulyar orasidagi o'q kesmasiga.</p> <p>S) Reaksiya kuchiga.</p> <p>D) <math>\alpha</math> burchak ostida joylashgan kuchga.</p>                                                                                                                                                                                                                             |
| <b>49. <math>F</math> kuchni <math>x</math>-o'qiga proektsiyasi nimaga teng?</b>         | <p>A) <math>F_x = F \cdot \sin \alpha</math>;      B) <math>F_y = F \cdot \sin \alpha</math>;</p> <p>S) <math>F_x = F \cdot \cos \alpha</math>;      D) <math>F_y = F \cdot \cos \alpha</math>;</p>                                                                                                                                                                                                                                                       |
| <b>50. <math>F</math> kuchni <math>y</math>-o'qiga proektsiyasi nimaga teng?</b>         | <p>A) <math>F_x = F \cdot \sin \alpha</math>;      B) <math>F_y = F \cdot \sin \alpha</math>;</p> <p>S) <math>F_x = F \cdot \cos \alpha</math>;      D) <math>F_y = F \cdot \cos \alpha</math>;</p>                                                                                                                                                                                                                                                       |
| <b>51. Kuchni nuqtaga nisbatan momenti deb nimaga aytiladi?</b>                          | <p>A) Kuch modulini uni elkasiga ko'paytmasiga.</p> <p>B) Juft kuchiga.</p> <p>S) Kuch modulini uni elkasiga bo'linmasiga.</p> <p>D) Kuchlar sistemasining bosh vektoriga.</p>                                                                                                                                                                                                                                                                            |
| <b>52. Moment</b>                                                                        | A) Kuch momenti qaysi nuqtaga nisbatan olinsa.                                                                                                                                                                                                                                                                                                                                                                                                            |

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| <b>markazi deb nimaga ataladi?</b>                                    | B) Kuchlarni qo'yilish nuqtasiga.<br>S) Bosh vektori qo'yilgan nuqtaga.<br>D) Koordinata boshiga.                                                                                                                                                                                                                                                 |
| <b>53 Kuchni nuqtaga nisbatan elkasi deb nimaga aytiladi?</b>         | A) Kuchni ta'sir chiziqiga.<br>B) Har qanday koordinataga.<br>S) Moment markazidan kuchning ta'sir chizig'igacha bo'lgan eng qisqa masofaga.<br>D) Ikkita parallel kuchlar orasidagi masofaga.                                                                                                                                                    |
| <b>54. Kuchni nuqtaga nisbatan momenti qachon nolga teng bo'ladi?</b> | A) Kuchning ta'sir chizig'i moment markazidan o'tsa<br>B) Kuchning miqdori va yo'nalishini o'zgartirmay ta'sir chizig'i bo'ylab istalgan nuqtaga ko'chirilsa.<br>S) Moment markazidan kuchning ta'sir chizig'igacha bo'lgan eng qisqa masofa kichiklashsa<br>D) Kuch maksimal qiymatga erishsa                                                    |
| <b>55. Juft kuch deb nimaga aytiladi?</b>                             | A) Bosh kuch vektoriga.<br>B) Muvozanatlovchi kuchga.<br>V) Moduli jihatdan bir-biriga teng va bir yunalishda aylanaetgan parallel kuchga.<br>D) Ta'sir chiziqlari kesishadigan ikkita kuchga.                                                                                                                                                    |
| <b>56. Juft momenti deb nimaga aytiladi?</b>                          | A) Moduli jihatdan bir-biriga teng va bir yo'nalishda aylanaetgan parallel kuchlarga.<br>B) Juftni tashkil etuvchi kuchlardan birining modulini elkaga ko'paytmasiga.<br>S) Kuch modulini uni elkasiga ko'paytmasiga.<br>D) Juftni tashkil etuvchi kuchlardan birining modulini elkaga bo'linmasiga.                                              |
| <b>57. Kuchni o'qqa nisbatan momenti deb nimaga aytiladi?</b>         | A) Kuchni o'qqa perpendikulyar tekislikdagi proektsiya-sidan o'q bilan tekislikning kesishgan nuqtasiga nisbatan olingan momentga.<br>B) Juftni tashkil etuvchi kuchlardan birining modulini elkaga ko'paytmasiga.<br>S) Kuch modulini uni elkasiga ko'paytmasiga.<br>D) Juftni tashkil etuvchi kuchlardan birining modulini elkaga bo'linmasiga. |
| <b>58. Kuchni o'qqa nisbatan momenti qachon nolga teng bo'ladi?</b>   | A) Kuchning ta'sir chizig'i o'qni kesib o'tsa yoki o'qqa parallel bo'lsa<br>B) Kuchning miqdori va yo'nalishini o'zgartirmay ta'sir chizig'i bo'ylab istalgan nuqtaga ko'chirilsa.<br>S) Moment markazidan kuchning ta'sir chizig'igacha bo'lgan eng qisqa masofa kichiklashsa<br>D) Kuch maksimal qiymatga erishsa                               |
| <b>59. Kuch momenti qachon musbat ishorali bo'ladi?</b>               | A) kuch moment markazi atrofida jismni soat strelkasi-ning harakat yo'nalishiga mos aylantirishga intilganda<br>B) kuch moment markazi atrofida jismni soat strelkasi-ning                                                                                                                                                                        |

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|                                                                         | <p>harakat yo'nalishiga teskari tomonga aylantira olmasa</p> <p>S) kuch moment markazi atrofida jismni soat strelkasi-ning harakat yo'nalishiga teskari tomonga aylantirishga intilganda</p> <p>D) jism kuchni moment markazi atrofida soat strelka-sining harakat yo'nalishiga teskari tomonga aylantirish-ga intilganda</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>60.Kuchning o'qdagi proektsiyasi qachon musbat ishorali bo'ladi?</b> | <p>A) kuchning o'qdagi proektsiyasining yo'nalishi o'q yo'nalishi bilan mos tushsa</p> <p>B) kuchning o'qdagi proektsiyasining yo'nalishi o'q yo'nalishi bilan mos tushmasa</p> <p>S) kuchning yo'nalishi o'q yo'nalishiga tik yo'nalsa</p> <p>D) kuchning yo'nalishi o'q yo'nalishiga parallel yo'nalsa</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>61.Jismning og'irlik markazi deb nimaga aytiladi?</b>                | <p>A) Jismga tegishli bo'lmagan elementar zarrachalarning parallel og'irlik kuchlari markaziga aytiladi</p> <p>B) Jismga tegishli barcha elementar zarrachalarning kesishuvchi og'irlik kuchlari markaziga aytiladi</p> <p>S) Jismga tegishli barcha elementar zarrachalarning parallel og'irlik kuchlari markaziga aytiladi</p> <p>D) Hamma javob to'g'ri</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>62.Fazodagi kuchlar sistemasi deb nimaga aytiladi?</b>               | <p>A) Ta'sir chiziqlari tekislikda ixtiyoriy ravishda joylashgan kuchlardan tashkil topgan sistema</p> <p>B) Ta'sir chiziqlari parallel joylashgan kuchlardan tashkil topgan sistema</p> <p>S) Ta'sir chiziqlari fazoda ixtiyoriy ravishda joylashgan kuchlardan tashkil topgan sistema</p> <p>D) Ta'sir chiziqlari kesishuvchi kuchlardan tashkil topgan sistema</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>63.Fazodagi kuchlar sistemasi kachon muvozanatda buladi?</b>         | <p>A) Jismga ta'sir etuvchi fazodagi kuchlar sistemasi muvozanatda bo'lishi uchun barcha kuchlarning uchta Dekart koordinata o'qlarining har biridagi proektsiyalarining yig'indilari nolga teng bo'lishi zarur va etarli</p> <p>B) Jismga ta'sir etuvchi fazodagi kuchlar sistemasi muvozanatda bo'lishi uchun barcha kuchlarning uchta koordinata o'qlarining har biriga nisbatan momentlarining yig'indilari ham nolga teng bo'lishi zarur va etarli</p> <p>S) Jismga ta'sir etuvchi fazodagi kuchlar sistemasi muvozanatda bo'lishi uchun barcha kuchlarning uchta Dekart koordinata o'qlarining har biridagi proektsiyalarining yig'indilari nolga teng bo'lishi va kuchlarning uchta koordinata o'qlarining har biriga nisbatan momentlarining yig'indilari ham nolga teng bo'lishi zarur va etarli</p> <p>D) Hamma javob to'g'ri</p> |
| <b>64. Kuchlar sistemasining bosh vektori nima?</b>                     | <p>A)Kuchlar sistemasining bosh vektori – mazkur kuchlarning geometrik yig'indisi.</p> <p>B)Kuchlar sistemasining bosh vektori – mazkur kuchlarning</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |



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| ishqalanish kuchi formulasini ko'rsating?                                 | S) $\vec{R} = \vec{F} + \vec{N}$ D) $F = F_{\max} / N$                                                                                                                                                                                                                                                                                                                                     |
| 72.Sirpanib ishqalanish koeffitsienti-ning formulasini ko'rsating?        | A) $f = \frac{F_{\max}}{N}$ B) $F_{\max} = fN$<br>S) $F = F_{\max} / N$ D) Hamma javob to'g'ri                                                                                                                                                                                                                                                                                             |
| 73.Sirpanib ishqalanish koeffitsienti- ning o'lchov birligini ko'rsating? | A) o'lchovsiz son<br>B) sm<br>S) $\text{sek}^{-1}$<br>D) $\text{sm/s}$                                                                                                                                                                                                                                                                                                                     |
| 74.Dumalanib ishqalanish kuchi formulasini ko'rsating?                    | A) $M_c = \delta \cdot N$ B) $F = f \cdot N$<br>S) $M = \frac{\delta}{N}$ D) $M = \frac{N}{\delta}$                                                                                                                                                                                                                                                                                        |
| 75.Dumalanib ishqalanish koeffitsientining o'lchov birligini ko'rsating?  | A) sm B) $\text{sm/s}$<br>S) $\text{sek}^{-1}$ D) o'lchovsiz                                                                                                                                                                                                                                                                                                                               |
| 76. Kinematikada nima o'rganiladi?                                        | A) Moddiy jismni massasi aniqlanadi.<br>B) Moddiy jismga ta'sir qiluvchi kuchlar o'rganiladi.<br>S) Moddiy jism massasi va unga ta'sir qiladigan kuchlarni e'tiborga olmasdan, uning harakati va harakat xarakteristikalarini o'rganiladi.<br>D) Jismlarni fazoda bir-biriga nisbatan siljishi o'rganiladi.                                                                                |
| 77.Harakat nima?                                                          | A) nuqtaning boshlang'ich holatdan oxirgi holatga vaqtga bog'liq holda aniq bir usulda o'ta olmasligiga aytiladi.<br>B) nuqtaning boshlang'ich holatdan oxirgi holatga vaqtga bog'liq holda aniq bir usulda o'tishiga aytiladi.<br>S) nuqtaning boshlang'ich holatdan oxirgi holatga vaqtga bog'liq bo'lmaga holda o'tishiga aytiladi.<br>D) Hamma javob to'g'ri                           |
| 78. ko'chish nima?                                                        | A) biror sanoq sistemasiga nisbatan nuqtaning ma'lum vaqt ichida fazoda bir holatdan boshqa holatga o'ta olmasligi<br>B) biror sanoq sistemasiga nisbatan nuqtaning bir holatdan boshqa holatga ixtiyoriy ravishda o'tishiga<br>S) biror sanoq sistemasiga nisbatan nuqtaning ma'lum vaqt ichida fazoda bir holatdan boshqa holatga ixtiyoriy ravishda o'tishiga<br>D) Hamma javob to'g'ri |

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| <b>79. Tezlik qanday kattalik?</b>                   | <p>A) tezlikning moduli va yo'nalishi jihatidan o'zgarishini xarakterlovchi skalyar kattalik</p> <p>B) harakatni xarakterlovchi vektor kattalik, jismning tez yoki sekin va qaysi tomonga qarab harakat qilayotganligini ko'rsatadi.</p> <p>S) tezlikning moduli va yo'nalishi jihatidan o'zgarishini xarakterlovchi vektor kattalik</p> <p>D) harakatni xarakterlovchi skalyar kattalik, jismning tez yoki sekin va qaysi tomonga qarab harakat qilayotganligini ko'rsatadi</p> |
| <b>80. Tezlanish qanday kattalik?</b>                | <p>A) tezlikning moduli va yo'nalishi jihatidan o'zgarishini xarakterlovchi skalyar kattalik</p> <p>B) harakatni xarakterlovchi vektor kattalik, jismning tez yoki sekin va qaysi tomonga qarab harakat qilayotganligini ko'rsatadi.</p> <p>S) tezlikning moduli va yo'nalishi jihatidan o'zgarishini xarakterlovchi vektor kattalik</p> <p>D) harakatni xarakterlovchi skalyar kattalik, jismning tez yoki sekin va qaysi tomonga qarab harakat qilayotganligini ko'rsatadi</p> |
| <b>81. Nuqta traekto - riyasi nima?</b>              | <p>A).Moddiy nuqtani harakat vaqtida fazoda qoldirgan izi</p> <p>B) .Jismlarni fazoda bir-biriga nisbatan siljishi.</p> <p>V) .Bir jismni ikkinchi jism sirtida harakatlanishida hosil bo'lgan chiziq.</p> <p>D). Har qanday to'g'ri chiziq.</p>                                                                                                                                                                                                                                 |
| <b>82. Nuqta harakati- ning vektor usuli nima?</b>   | <p>A) Harakatlanayotgan nuqtaning har bir ondagi holatini uning radius vektori belgilaydi.</p> <p>B) Fazoda harakatlanayotgan nuqtaning har bir vaqtdagi holatini uning uchta Dekart koordinatalari belgilaydi.</p> <p>S) Harakatlanayotgan nuqtaning har bir ondagi holati berilgan traektoriyadagi qo'zg'almas sanoq boshi O nuqtadan hisoblangan koordinata bilan aniqlanadi.</p> <p>D) Formula bilan aniqlanadi</p>                                                          |
| <b>83. Nuqta harakatining koordinata usuli nima?</b> | <p>A) Harakatlanayotgan nuqtaning har bir ondagi holatini uning radius vektori belgilaydi.</p> <p>B) Fazoda harakatlanayotgan nuqtaning har bir vaqtdagi holatini uning uchta Dekart koordinatalari belgilaydi.</p> <p>S) Harakatlanayotgan guqtaning har bir ondagi holati berilgan traektoriyadagi qo'zg'almas sanoq boshi O nuqtadan hisoblangan koordinata bilan aniqlanadi.</p> <p>D) Formula bilan aniqlanadi</p>                                                          |

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| <b>84. Nuqta harakatining tabiiy usuli nima?</b>                 | <p>A) Harakatlanayotgan nuqtaning har bir ondagi holatini uning radius vektori belgilaydi.</p> <p>B) Fazoda harakatlanayotgan nuqtaning har bir vaqtdagi holatini uning uchta Dekart koordinatalari belgilaydi.</p> <p>S) Harakatlanayotgan nuqtaning har bir ondagi holati berilgan traektoriyadagi qo'zg'almas sanoq boshi O nuqtadan hisoblangan koordinata bilan aniqlanadi.</p> <p>D) Formula bilan aniqlanadi</p> |                                                                           |
| <b>85. Tezlik nima?</b>                                          | <p>A) Nuqtaning holatini yoki harakatining o'zgarishini xarakterlovchi kinematik o'lchov.</p> <p>B) Nuqta harakatining matematik ifodasi.</p> <p>S) Bosib o'tilgan masofani vaqtga ko'paytmasi.</p> <p>D) Vaqtni bosib o'tilgan masofaga bo'linmasi.</p>                                                                                                                                                                |                                                                           |
| <b>86. Tezlanish nima?</b>                                       | <p>A) Vaqtni bosib o'tilgan masofaga bo'linmasi.</p> <p>B) Vaqtni harakat tezligiga ko'paytmasi.</p> <p>S) Nuqtaning tezlik vektorini o'zgarishini xarakterlovchi kinematik o'lchov.</p> <p>D) Vaqtni bosib o'tilgan masofaga ko'paytmasi.</p>                                                                                                                                                                          |                                                                           |
| <b>87. Nuqta harakatining tenglamasi qanday usulda berilgan?</b> | $\vec{r} = \vec{r}(t)$                                                                                                                                                                                                                                                                                                                                                                                                  | <p>A) Vektor</p> <p>B) Koordinata</p> <p>S) Tabiiy</p> <p>D) Murakkab</p> |
| <b>88. Nuqta harakatining tenglamasi qanday usulda berilgan?</b> | $\left. \begin{aligned} x &= f_1(t) \\ y &= f_2(t) \\ z &= f_3(t) \end{aligned} \right\}$                                                                                                                                                                                                                                                                                                                               | <p>A) Vektor</p> <p>B) Koordinata</p> <p>S) Tabiiy</p> <p>D) Murakkab</p> |
| <b>89. Nuqta harakatining tenglamasi qanday usulda berilgan?</b> | $S = f(t)$                                                                                                                                                                                                                                                                                                                                                                                                              | <p>A) Vektor</p> <p>B) Koordinata</p> <p>S) Tabiiy</p> <p>D) Murakkab</p> |
| <b>90. Nuqtaning tezligi qanday usulda berilgan?</b>             | $\vec{v} = \frac{d\vec{r}}{dt}$                                                                                                                                                                                                                                                                                                                                                                                         | <p>A) Vektor</p> <p>D) Murakkab</p> <p>B) Koordinata</p> <p>S) Tabiiy</p> |
| <b>91. Nuqtaning tezligi qanday usulda berilgan?</b>             | $v_x = \frac{dx}{dt}; v_y = \frac{dy}{dt}; v_z = \frac{dz}{dt}$                                                                                                                                                                                                                                                                                                                                                         | <p>A) Vektor</p> <p>B) Koordinata</p> <p>S) Tabiiy</p> <p>D) Murakkab</p> |
| <b>92. Nuqtaning tezligi qanday usulda berilgan?</b>             | $v = \left  \frac{dS}{dt} \right $                                                                                                                                                                                                                                                                                                                                                                                      | <p>A) Vektor</p> <p>B) Koordinata</p> <p>S) Tabiiy</p> <p>D) Murakkab</p> |

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| <b>93. Nuqtaning tezlanishi qanday sulda berilgan?</b>                                      | $\bar{a} = \frac{d^2 \bar{r}}{dt^2}$                                                                                                                                                                                                                                      | A) Vektor<br>B) Koordinata<br>S) Tabiiy<br>D) Murakkab |
| <b>94. Nuqtaning tezlanishi qanday sulda berilgan?</b>                                      | $\dot{a}_x = \frac{d^2 x}{dt^2}; \dot{a}_y = \frac{d^2 y}{dt^2}; \dot{a}_z = \frac{d^2 z}{dt^2}$                                                                                                                                                                          | A) Vektor<br>B) Koordinata<br>S) Tabiiy<br>D) Murakkab |
| <b>95. Qattiq jismning ilgarilanma harakati deb nimaga aytiladi?</b>                        | A). Jismdan olingan har qanday kesma jism harakatlanganda hamma vaqt o'z - o'ziga parallel qoladi<br>B). Jism harakatlanganda uning ixtiyoriy ikki nuqtasi hamma vaqt qo'zg'almasdan qoladi<br>S). Jismni to'g'ri chiziqli harakati<br>D). Jismni tekis parallel harakati |                                                        |
| <b>96. Qattiq jismning qo'zg'almas o'q atrofidagi aylanma harakati deb nimaga aytiladi?</b> | A). Jism harakatlanganda uning ixtiyoriy ikki nuqtasi hamma vaqt qo'zg'almasdan qoladi<br>B). Jismdan olingan har qanday kesma jism harakatlanganda hamma vaqt o'z - o'ziga parallel qoladi<br>S). Jismni to'g'ri chiziqli harakati<br>D). Jismni tekis parallel harakati |                                                        |
| <b>97. Jismning qo'zg'almas o'q atrofida aylanma harakat tenglamasini ko'rsating?</b>       | A) $\varphi = \varphi(t)$ B) $s = s(t)$<br>S) $\bar{r} = \bar{r}(t)$ D) $x = s_1(t), y = s_2(t)$                                                                                                                                                                          |                                                        |
| <b>98. Burchak tezlik formulasini ko'rsating?</b>                                           | A). $\omega = \frac{\pi n}{30}$ B). $\omega = \frac{d\varepsilon}{dt}$ S). $\omega = v \cdot h$ D). $\omega = \varepsilon \cdot h$                                                                                                                                        |                                                        |
| <b>99. Burchak tezlanish formulasini ko'rsating?</b>                                        | A). $\varepsilon = \frac{d\omega}{dt}$ B). $\varepsilon = \frac{\pi n}{30}$ S). $\varepsilon = v \cdot h$ D). $\varepsilon = a_t \cdot h$                                                                                                                                 |                                                        |
| <b>100. Aylanma harakatdagi jism nuqtasining doiraviy tezligi?</b>                          | A). $V = \omega \cdot h$ B). $V = \frac{\omega}{h}$ S). $V = \frac{h}{\omega}$ D). $V = \varepsilon \cdot h$                                                                                                                                                              |                                                        |
| <b>101. Aylanma harakatdagi jism nuqtasi-ning normal tezlanishi?</b>                        | A). $a_n = \omega^2 \cdot h$ B). $a_n = \frac{\omega}{h}$ S). $a_n = \frac{\omega^2}{h}$ D). $\dot{a}_n = \varepsilon \cdot h$                                                                                                                                            |                                                        |
| <b>102. Aylanma harakatdagi jism nuqtasi-ning</b>                                           | A) $\dot{a}_t = \varepsilon \cdot h$ B) $\dot{a}_t = \varepsilon^2 \cdot h$ S) $\dot{a}_t = \frac{\varepsilon}{h}$ D) $\dot{a}_t = \frac{h}{\varepsilon}$                                                                                                                 |                                                        |



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| <b>tangentsial<br/>tezlanishi?</b>                                                 |                                                                                                                                                                                                                                                                                                                             |
| <b>103. Nuqtaning qanday harakatiga murakkab (absolyut) harakat deyiladi?</b>      | <p>A) nuqtaning qo'zg'almas koordinatalar sistemasiga nisbatan qilgan harakatiga</p> <p>B) nuqtaning qo'zg'aluvchi koordinatalar sistemi bilan birgalikdagi harakatiga</p> <p>S) nuqtaning fazoda qilgan harakatiga</p> <p>D) nuqtaning qo'zg'aluvchi koordinata sistemasiga nisbatan qilgan harakatiga</p>                 |
| <b>104. Nuqtaning qanday harakatiga nisbiy harakat deyiladi?</b>                   | <p>A) nuqtaning qo'zg'aluvchi koordinata sistemasiga nisbatan qilgan harakatiga</p> <p>B) nuqtaning qo'zg'almas koordinatalar sistemasiga nisbatan qilgan harakatiga</p> <p>S) nuqtaning fazoda qilgan harakatiga</p> <p>D) nuqtaning qo'zg'aluvchi koordinatalar sistemi bilan birgalikdagi harakatiga</p>                 |
| <b>105. Qattiq jismning tekis parallel harakati deb qanday harakatga aytiladi?</b> | <p>A) jismning har bir nuqtasi doimo biror qo'zg'almas tekislikka parallel tekislikda harakatlansa</p> <p>B) jism harakati davomida fazoda qandaydir iz qoldirsa</p> <p>S) jism butun harakati davomida o'zgarmas tezlik bilan harakatlansa</p> <p>D) jismning har bir nuqtasi doimo biror qonun bo'yicha harakat qilsa</p> |
| <b>106. Tezliklar oniy markazi deb nimaga aytiladi?</b>                            | <p>A) berilgan onda tezligi nolga teng bo'lgan tekis shakl nuqtasiga</p> <p>B) jismning tezligiga teng bo'lgan nuqtaga</p> <p>S) berilgan onda o'zgarmas tezlik bilan harakatlanadigan nuqtaga</p> <p>D) berilgan onda tezligi ma'lum bo'lgan nuqtaga</p>                                                                   |
| <b>107. Dinamik kuch qanday kuch?</b>                                              | <p>A) Qiymati, yo'nalishi va qo'yiladigan nuqtalari o'zgarmaydigan yoki sekin va ozgina o'zgaradi</p> <p>B) Vakt oralig'ida qiymati, yo'nalishi va qo'yiladigan nuqtasi tez o'zgarishi bilan xarakterlanadi</p> <p>S) Inertsia kuchlari</p> <p>D) Ishqalanish kuchi</p>                                                     |
| <b>108. Dinamika nimani o'rganadi?</b>                                             | <p>A) Kuch ta'sirida sodir bo'lgan mexanik harakatni.</p> <p>B) Jismni og'irligi bilan massasi orasidagi bog'lanishni</p> <p>S) Moddiy nuqtaning tezlanishini.</p> <p>D) Jismlarning mexanik harakatini ularning massasiga va harakatni vujudga keltiruvchi kuchlarga bog'liq ravishda o'rganadi</p>                        |
| <b>109. Dinamika-ning qonunlari-ni kim yaratgan?</b>                               | <p>A) N'yuton B) Dalamber S) Eyler D) Lomonosov</p>                                                                                                                                                                                                                                                                         |

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| <b>110. Dinamika-ning birinchi qonunini ta'riflang?</b>   | <p>A) Tashqi muhit ta'sirida bo'lmagan moddiy nuqta biror kuch ta'sir etmaguncha o'zining tinch holatini yoki to'g'ri chiziqli harakatini saqlaydi.</p> <p>B) Moddiy nuqtaning kuch ta'sirida olgan tezlanishi bilan massasining ko'paytmasi miqdor jihatdan shu kuchga teng bo'lib, tezlanishi kuch bilan bir xil yo'nalishda bo'ladi</p> <p>S) Ikkita moddiy nuqta bir-biriga miqdorlari teng bo'lgan va shu nuq talarni tutashtiruvchi to'g'ri chiziq bo'ylab qarama-qarshi tomonga yo'nalgan kuchlar bilan ta'sir etadi</p> <p>D) Tashqi muhit ta'siridagi bo'lgan moddiy nuqta biror kuch ta'sir etmsa o'zining tinch holatini yoki to'g'ri chiziqli harakatini saqlaydi</p> |
| <b>111. Dinamika-ning ikkinchi qonunini ta'riflang?</b>   | <p>A) Tashqi muhit ta'sirida bo'lmagan moddiy nuqta biror kuch ta'sir etmaguncha o'zining tinch holatini yoki to'g'ri chiziqli harakatini saqlaydi.</p> <p>B) Moddiy nuqtaning kuch ta'sirida olgan tezlanishi bilan massasining ko'paytmasi miqdor jihatdan shu kuchga teng bo'lib, tezlanishi kuch bilan bir xil yo'nalishda bo'ladi</p> <p>S) Ikkita moddiy nuqta bir-biriga miqdorlari teng bo'lgan va shu nuq talarni tutashtiruvchi to'g'ri chiziq bo'ylab qarama-qarshi tomonga yo'nalgan kuchlar bilan ta'sir etadi</p> <p>D) Tashqi muhit ta'siridagi bo'lgan moddiy nuqta biror kuch ta'sir etmsa o'zining tinch holatini yoki to'g'ri chiziqli harakatini saqlaydi</p> |
| <b>112. Dinamika-ning uchinchi qonunini ta'riflang?</b>   | <p>A) Tashqi muhit ta'sirida bo'lmagan moddiy nuqta biror kuch ta'sir etmaguncha o'zining tinch holatini yoki to'g'ri chiziqli harakatini saqlaydi.</p> <p>B) Moddiy nuqtaning kuch ta'sirida olgan tezlanishi bilan massasining ko'paytmasi miqdor jihatdan shu kuchga teng bo'lib, tezlanishi kuch bilan bir xil yo'nalishda bo'ladi</p> <p>S) Ikkita moddiy nuqta bir-biriga miqdorlari teng bo'lgan va shu nuq talarni tutashtiruvchi to'g'ri chiziq bo'ylab qarama-qarshi tomonga yo'nalgan kuchlar bilan ta'sir etadi</p> <p>D) Tashqi muhit ta'siridagi bo'lgan moddiy nuqta biror kuch ta'sir etmsa o'zining tinch holatini yoki to'g'ri chiziqli harakatini saqlaydi</p> |
| <b>113. Dinamika-ning birinchi masalasini ta'riflang?</b> | <p>A) Nuqtaning massasi va uning harakatining tenglamalari berilgan. Nuqtaga ta'sir kiluvchi kuchni topish kerak</p> <p>B) Nuqtaning massasi va shu nuqtaga ta'sir etuvchi kuch berilgan. Nuqta harakatining tenglamalarini aniqlash kerak</p> <p>S) Nuqtaning massasi berilgan. Nuqta harakatining tenglamalarini aniqlash kerak</p> <p>D) Nuqtaning massasi berilgan. Nuqtaga ta'sir kiluvchi kuchni topish kerak</p>                                                                                                                                                                                                                                                           |

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| <b>114. Dinamika-ning ikkinchi masalasini ta'riflang?</b> | <p>A) Nuqtaning massasi va uning harakatining tenglamalari berilgan. Nuqtaga ta'sir kiluvchi kuchni topish kerak</p> <p>B) Nuqtaning massasi va shu nuqtaga ta'sir etuvchi kuch berilgan. Nuqta harakatining tenglamalarini aniqlash kerak</p> <p>S) Nuqtaning massasi berilgan. Nuqta harakatining tenglamalarini aniqlash kerak</p> <p>D) Nuqtaning massasi berilgan. Nuqtaga ta'sir kiluvchi kuchni topish kerak</p>                                                                                                         |
| <b>115. Dalamber tenglamasini ko'rsating?</b>             | <p>A) <math>\overline{F} + \overline{N} + \overline{F}_u = 0</math>                      B). <math>\sum \overline{F} = 0</math></p> <p>S) <math>F_1 + F_2 = N</math>                                      D). <math>\sum M_0(F_k) = 0</math></p>                                                                                                                                                                                                                                                                                |
| <b>116. Dalamber printsini ta'riflang?</b>                | <p>A) Aktiv kuch va bog'lanish reaksiya kuchi ta'siridagi nuqtaga har onda uning inertsia kuchini qo'ysak, bu kuchlar o'zaro muvozanatlashadi.</p> <p>B) Miqdor jihatdan nuqtaning massasi bilan tezlanishining ko'paytmasiga teng va uning tezlanishiga qarama-qarshi yo'nalgan kuch</p> <p>S) dinamikaning asosiy qonunini formal ravishda statikaning muvozanat tenglamasiga o'xshash tenglamalarga keltirib, dinamika masalalariga statikadagi muvozanat shartlarini qo'llash usuli</p> <p>D) Barcha kuchlarni qo'shish</p> |
| <b>117. Inertsia kuchini ta'riflang?</b>                  | <p>A) Aktiv kuch va bog'lanish reaksiya kuchi ta'siridagi nuqtaga har onda uning inertsia kuchini qo'ysak, bu kuchlar o'zaro muvozanatlashadi.</p> <p>B) Miqdor jihatdan nuqtaning massasi bilan tezlanishining ko'paytmasiga teng va tezlanishga qarama-qarshi yo'nalgan kuch</p> <p>S) dinamikaning asosiy qonunini formal ravishda statikaning muvozanat tenglamasiga o'xshash tenglamalarga keltirib, dinamika masalalariga statikadagi muvozanat shartlarini qo'llash</p> <p>D) Barcha kuchlarni qo'shish</p>              |
| <b>118. Kinetosta-tika nima?</b>                          | <p>A) Aktiv kuch va bog'lanish reaksiya kuchi ta'siridagi nuqtaga har onda uning inertsia kuchini qo'ysak, bu kuchlar o'zaro muvozanatlashadi.</p> <p>B) Miqdor jihatdan nuqtaning massasi bilan tezlanishining ko'paytmasiga teng va tezlanishga qarama-qarshi yo'nalgan kuch</p> <p>S) dinamikaning asosiy qonunini formal ravishda statikaning muvozanat tenglamasiga o'xshash tenglamalarga keltirib, dinamika masalalariga statikadagi muvozanat shartlarini qo'llash</p> <p>D) Barcha kuchlarni qo'shish</p>              |

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| <b>119. Jismning inertligi deb nimaga aytiladi?</b>  | <p>A) Jismning qo'yilgan kuchlar ta'sirida o'z tezligini tez o'zgartirish xususiyati</p> <p>B) Jismning qo'yilgan kuchlar ta'sirida o'z tezligini sekin o'zgartirish xususiyati</p> <p>S) Jismning qo'yilgan kuchlar ta'sirida o'z tezligini tez yoki sekin o'zgartirish xususiyati</p> <p>D) Hamma javob to'g'ri</p>                                                                                                                                                  |
| <b>120. Jismning massasi deb nimaga aytiladi?</b>    | <p>A) Jismning inertligini miqdor jihatdan ifodalovchi vektor kattalik</p> <p>B) Jismning inertligini miqdor jihatdan ifodalovchi fizik kattalik</p> <p>S) Jismning inertligini sifat jihatdan ifodalovchi fizik kattalik</p> <p>D) Jismning inertligini sifat jihatdan ifodalovchi vektor kattalik</p>                                                                                                                                                                |
| <b>121. Ish deb nimaga aytiladi?</b>                 | <p>A) kuch moduli bilan yo'l hamda kuch va siljish yo'nalishlari orsidagi burchakning kosinusiga bo'linmasiga</p> <p>B) kuch moduli bilan yo'l hamda kuch va siljish yo'nalishlari orsidagi burchakning kosinusiga ko'paytmasiga</p> <p>S) kuch moduli bilan yo'l hamda kuch va siljish yo'nalishlari orsidagi burchakning kosinusiga yig'indisiga</p> <p>D) kuch moduli bilan yo'l hamda kuch va siljish yo'nalishlari orsidagi burchakning kosinusiga ayirmasiga</p> |
| <b>122. Quvvat nima?</b>                             | <p>A) quvvat kuch moduli bilan <math>u</math> qo'yilgan nuqta tezligining bo'linmasi</p> <p>B) quvvat kuch moduli bilan <math>u</math> qo'yilgan nuqta tezligining ko'paytmasi</p> <p>S) quvvat kuch moduli bilan <math>u</math> qo'yilgan nuqta tezligining yig'indisi</p> <p>D) quvvat kuch moduli bilan <math>u</math> qo'yilgan nuqta tezligining ayirmasi</p>                                                                                                     |
| <b>123. Foydali ish koeffitsienti nima?</b>          | <p>A) Foydali ishni sarflangan ishdan ayirmasi</p> <p>B) Foydali ishni sarflangan ishga nisbati</p> <p>S) Foydali ishni sarflangan ish bilan ko'paytmasi</p> <p>D) Hamma javob to'g'ri</p>                                                                                                                                                                                                                                                                             |
| <b>124. Statik moment deb nimaga aytiladi?</b>       | <p>A) elementar yuza <math>dA</math> ni tegishli o'q orasidagi masofa kvadratiga ko'paytmasining integraliga aytiladi</p> <p>B) elementar yuza <math>dA</math> bilan ikkala o'q orasidagi masofa ko'paytmalarining integraliga aytiladi</p> <p>S) elementar yuza <math>dA</math> bilan tegishli o'q orasidagi masofa ko'paytmasining integraliga teng</p> <p>D) Hamma javob to'g'ri</p>                                                                                |
| <b>125. Uklarga nisbatan kesim yuzaning inertiya</b> | <p>A) elementar yuza <math>dA</math> ni tegishli o'q orasidagi masofa kvadratiga ko'paytmasining integraliga aytiladi</p> <p>B) elementar yuza <math>dA</math> bilan ikkala o'q orasidagi masofa</p>                                                                                                                                                                                                                                                                   |

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| <b>momenti deb nimaga aytiladi?</b>                                                            | ko'paytmalarining integraliga aytiladi<br>S) elementar yuza $dA$ bilan tegishli o'q orasidagi masofa<br>ko'paytmasining integraliga teng<br>D) Hamma javob to'g'ri                                                                                                                                                    |
| <b>126. Kesim yuzani markazdan qochma inertsia momentini kursating?</b>                        | A) $I_x = \int_A y^2 dA$ B) $I_\rho = \int_A \rho^2 dA$<br>S) $I_{xy} = \int_A xy dA$ D) $I_{x1} = I_x + a^2 A$ ;                                                                                                                                                                                                     |
| <b>127. Kesimning markazdan qochma inertsia momenti qachon nolga teng bo'ladi?</b>             | A) Kesimning kamida bitta simmetriya o'qi bo'lsa<br>B) Kesimning kamida ikkita o'qi parallel bo'lsa<br>S) Kesimning kamida ikkita o'qi kesishsa<br>D) Kesimning kamida ikkita o'qi ayqashsa                                                                                                                           |
| <b>128. Kesimning markazdan qochma inertsia momenti qachon manfiy ishorali bo'ladi?</b>        | A) Bitta koordinata manfiy ishorali bo'lsa<br>B) Ikkita koordinata manfiy ishorali bo'lsa<br>S) Ikkita koordinata musbat ishorali bo'lsa<br>D) Kesimning kamida ikkita o'qi ayqashsa                                                                                                                                  |
| <b>129. Kutb inertsia momentini kursating?</b>                                                 | A) $I_x = \int_A y^2 dA$ B) $I_\rho = \int_A \rho^2 dA$<br>S) $I_{xy} = \int_A xy dA$ D) $I_{x1} = I_x + a^2 A$ ;                                                                                                                                                                                                     |
| <b>130. Parallel uklarga nisbatan inertsia momenti formulasini kursating?</b>                  | A) $I_x = \int_A y^2 dA$ B) $I_\rho = \int_A \rho^2 dA$<br>S) $I_{xy} = \int_A xy dA$ D) $I_{x1} = I_x + a^2 A$ ;                                                                                                                                                                                                     |
| <b>131. Ogishgan uklarga nisbatan markazdan qochma inertsia momenti formulasini kursating?</b> | A) $I_x = \int_A y^2 dA$ B) $I_\rho = \int_A \rho^2 dA$<br>S) $I_{xy} = \int_A xy dA$ D) $I_{x1y1} = \frac{I_x - I_y}{2} \cdot \sin 2\alpha + I_{xy} \cos 2\alpha$                                                                                                                                                    |
| <b>132. Bosh inertsia o'qlari deb qanday uklarga aytiladi?</b>                                 | A) Markazdan qochma inertsia momentlari nolga teng bo'lgan vaziyatga to'g'ri keluvchi o'qga<br>B) Markazdan qochma inertsia momentlari nolga teng bo'lmagan vaziyatga to'g'ri keluvchi o'qga<br>S) Markazdan qochma inertsia momentlari birga teng bo'lgan vaziyatga to'g'ri keluvchi o'qga<br>D) Hamma javob to'g'ri |

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| <b>133.Bosh inertsia momentlarining ekstremal kiymatlarini kursating?</b>                    | <p>A) <math>I_{\max \min} = \frac{1}{2} \left[ (I_x + I_y) \pm \sqrt{(I_x - I_y)^2 + 4 \cdot I_{xy}^2} \right]</math></p> <p>B) <math>I_{x1y1} = \frac{I_x - I_y}{2} \cdot \sin 2\alpha + I_{xy} \cos 2\alpha</math></p> <p>S) <math>tg 2\alpha_0 = -\frac{2I_{xy}}{I_x - I_y}</math></p> <p>D) <math>I_{x1} = I_x + a^2 A;</math></p>                      |
| <b>134.Bosh inertsia uklarining yunalishi kaysi formuladan topiladi?</b>                     | <p>A) <math>tg 2\alpha_0 = -\frac{2I_{xy}}{I_x - I_y}</math></p> <p>B) <math>I_{\max \min} = \frac{1}{2} \left[ (I_x + I_y) \pm \sqrt{(I_x - I_y)^2 + 4 \cdot I_{xy}^2} \right]</math></p> <p>S) <math>I_{x1y1} = \frac{I_x - I_y}{2} \cdot \sin 2\alpha + I_{xy} \cos 2\alpha</math></p> <p>D) <math>I_{x1} = I_x + a^2 A;</math></p>                      |
| <b>135.Tashqi faktor nima?</b>                                                               | <p>A) Jismga ta'sir qiluvchi kuch</p> <p>B) Jismga ta'sir qiluvchi kuch yoki undagi temperaturani o'zgarishi</p> <p>S) Jismdagi temperaturani o'zgarishi</p> <p>D) Jismni tinch holati</p>                                                                                                                                                                  |
| <b>136.Xavfli holatni kelib chiqishi nimalarga bog'liq?</b>                                  | <p>A) tashqi faktorga, material va geometrik o'lchamlar hamda kesim yuzalarning ratsional shakliga</p> <p>B) tashqi faktorga</p> <p>S) material va geometrik o'lchamlarga</p> <p>D) kesim yuzalarning ratsional shakliga</p>                                                                                                                                |
| <b>137.Mustahkamlik nima?</b>                                                                | <p>A) Sistemani xavfli holatda emirilishi</p> <p>B) Sistemani xavfli holatga emirilmasdan qarshilik ko'rsata olish qobiliyati</p> <p>S) Sistemada qoldiq deformatsiya hosil bo'lishi</p> <p>D) ) Sistemani parchalanib ketishi</p>                                                                                                                          |
| <b>138. Bkrlik deb nimaga aytiladi?</b>                                                      | <p>A) Sterjenlarni tashqi kuch ta'siridan boshlang'ich shakl va o'lchamlarini saqlab bilish qobiliyati;</p> <p>B) Tashqi kuch ta'siridan sterjen shaklini o'zgarishi;</p> <p>S) Tashqi kuch ta'siridan sterjen o'qini egrilanishi;</p> <p>D) Tashqi kuch ta'siridan sterjen o'qini to'g'rilanishi</p>                                                       |
| <b>139.Tashqi kuchni qo'yilish nuqtasini real ob'ektning deformatsiyasiga ta'siri bormi?</b> | <p>A) Kuchlarni ularni ta'sir chizig'i bo'ylab ko'chirib bo'lmaydi</p> <p>B) Kuchlar sistemasini teng ta'sir etuvchi bilan almashtirib bo'lmaydi.</p> <p>S) Kuchlar sistemasini teng ta'sir etuvchi bilan almashtirib bo'ladi</p> <p>D) Kuchlarni ularni ta'sir chizig'i bo'ylab ko'chirib va kuchlar sistemasini teng ta'sir etuvchi bilan almashtirib</p> |

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|                                                         | bo'lmaydi,                                                                                                                                                                                                                                                                                                                                                    |
| <b>140. Tashqi kuch nima?</b>                           | A) Jismga ta'sir qiluvchi kuch yoki undagi temperaturani o'zgarishi<br>B) Inertsia kuchlari<br>S) Foydali qarshilik kuchi.<br>D) Ishqalanish kuchi                                                                                                                                                                                                            |
| <b>141. Ichki kuch deb nimaga aytiladi?</b>             | A) Tashqi kuch ta'siridan jism materialining zarrachalaridagi o'zaro tortishish kuchlarining faollashuvi<br>B) Tashqi kuch ta'siridan inshoot qismini muvozanatda bo'lishi<br>S) Tashqi kuch ta'siridan inshoot qismida qoldiq deformatsiya hosil bo'lmasligi;<br>D) Konstruktsiya yoki inshoot qismini tashqi kuch ta'siriga qarshilik ko'rsata olmasligi    |
| <b>142. dinamik kuchlanishni ta'riflang?</b>            | A) Miqdorini davriy o'zgartiradigan kuchlanishga o'zgaruvchan kuchlanish deyiladi<br>B) Zarb ta'siridagi kuchlanish<br>S) Pozunni harakatida hosil bo'lgan kuchlanish<br>D) Miqdorini va kuyilish nuqtasini kiska vakt oraligida o'zgartiradigan kuchlanishga aytiladi                                                                                        |
| <b>143. mustahkamlik kanday faktorlarga bog'liq?</b>    | A) tashqi kuchga<br>B) ichki kuchga<br>S) tashqi kuchga, materialga, kesimni ulchamlariga<br>D) kesimni ulchamlariga                                                                                                                                                                                                                                          |
| <b>144. Burchakli deformatsiya deb nimaga aytiladi?</b> | A) Tashqi kuch ta'siridan sterjenning burchakli o'lchamini o'zgarishiga;<br>B) Sterjen mustahkamligini yo'qolishiga;<br>S) Sterjenni tashqi kuch ta'siridan muvozanatini buzilishiga;<br>D) Sterjenni tashqi kuch ta'siridan muvozanatini tiklanishiga.                                                                                                       |
| <b>145. Chiziqli deformatsiya deb nimaga aytiladi?</b>  | A) tashqi kuch ta'siridan jism zarrachalarining kuch yo'nalishiga qarshi ko'chishiga<br>B) tashqi kuch ta'siridan jism zarrachalarining kuch yo'nalishidagi ko'cha olmasligi<br>S) tashqi kuch ta'siridan jism zarrachalarining kuch yo'nalishiga qarshi ko'chia olmasligi<br>D) tashqi kuch ta'siridan jism zarrachalarining kuch yo'nalishidagi ko'chishiga |
| <b>146. Elastik deformatsiya deb nimaga aytiladi?</b>   | A) Yuksizlantirish natijasida to'liq yo'qolgan deformatsiya elastik deformatsiya<br>B) Yuksizlantirish natijasida to'liq yo'qolmagan deformatsiya elastik deformatsiya<br>S) Yuklantirish natijasida to'liq yo'qolgan deformatsiya elastik deformatsiya<br>D) Yuklantirish natijasida to'liq yo'qolmagan deformatsiya elastik deformatsiya                    |

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| <b>147.Ko'ndalang deformatsiya nima?</b>                            | A) Tashqi kuch ta'siridan brus ko'ndalang kesim yuzasining o'zgarishini absolyut (nisbiy) miqdori<br>B) Bir birlik uzunlikka to'g'ri keluvchi absolyut uzayish<br>S) Jism o'lchamlarini o'zgarishiga<br>D) Jism shaklini o'zgarishiga          |
| <b>148.Siljishdagi xosil bo'lgan deformatsiya kanday nomlanadi?</b> | A) siljish burchagi<br>S) ilashish burchagi<br>B) buralish burchagi<br>D) qirqim burchagi                                                                                                                                                      |
| <b>149.Buralishda xosil bo'ladigan ichki kuch faktorni kaysi?</b>   | A) burovchi moment<br>S) eguvchi moment<br>B) eguvchi kuch<br>D) cho'zuvi kuch                                                                                                                                                                 |
| <b>150.Valda xosil bo'ladigan deformatsiya kaysi?</b>               | A) burchakli deformatsiya<br>S) egilish burchagi<br>B) chizikli deformatsiya<br>D) cho'zuvchi kuch                                                                                                                                             |
| <b>151.Egilishda kanday deformatsiya sodir bo'ladi?</b>             | A) chizikli va burchakli deformatsiya<br>B) puanson deformatsiya<br>S) burchak deformatsiya<br>D) buralish deformatsiya                                                                                                                        |
| <b>152. Burovchi moment ning o'lchov birligi kaysi?</b>             | A) $[Hm]$<br>B) $[Pa]$<br>S) $[kH]$<br>D) $[MPa]$                                                                                                                                                                                              |
| <b>153.Chizikli deformatsiyaning o'lchov birligi kaysi?</b>         | A) $[mm]$<br>B) $[pad]$<br>S) $[pad]$<br>D) $[H]$                                                                                                                                                                                              |
| <b>154.Oddiy deformatsiyalar-ning turlarini ayting?</b>             | A) cho'zilish<br>B) siqilish<br>S) siljish bilan buralishni birgalikdagi ta'siri<br>D) cho'zilish (siqilish), siljish, buralish, egilish                                                                                                       |
| <b>155.Murakkab deformatsiyalar-ning turini ko'rsating?</b>         | A) siljish bilan buralishni birgalikdagi ta'siri<br>B) cho'zilish (siqilish), siljish, buralish, egilish<br>S) qiyshif egilish, markazlashmagan cho'zilish (siqilish), buralish bilan egilishni birgalikdagi ta'siri<br>D) hamma javob to'g'ri |
| <b>156.Kuchlanish deb nimaga aytiladi?</b>                          | A) bir birlik yuzaga to'g'ri keluvchi kuchning miqdoriga aytiladi<br>B) hosil bo'lishi bilan emirilash yoki plastik deformatsiya sodir bo'ladi<br>S) konstruktsiya xavfsiz, ishonchli va uzoq muddat                                           |



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|                                                                                    | ishlashini ta'minlovchi eng katta kuchlanish<br>D) konstruktsiyaning elementiga qo'yilgan kuch ta'sirida hosil bo'ladi                                                                                                                                                                                                                                                                                                                                                            |
| <b>157.Kanday kuchlanishlar mavjud?</b>                                            | A) normal va urinma                      B) urunma<br>S) maksimal                                  D) normal                                                                                                                                                                                                                                                                                                                                                                      |
| <b>158.Hisobiy kuchlanish nima?</b>                                                | A) konstruktsiyaning elementiga qo'yilgan kuch ta'sirida hosil bo'ladi<br>B) hosil bo'lishi bilan emirilash yoki plastik deformatsiya sodir bo'ladi<br>S) bir birlik yuzaga to'g'ri keluvchi kuchlanish<br>D) konstruktsiya xavfsiz, ishonchli va uzoq muddat ishlashini ta'minlovchi eng katta kuchlanish                                                                                                                                                                        |
| <b>159.Mustahkamlik ga ruxsat etilgan yukni hisoblash nima?</b>                    | A) brusga qo'yilgan yuk, materiali va o'lchamlari aniq, eng katta hisobiy kuchlanish topiladi va ruxsat etilgan kuchlanish bilan taqqoslanadi<br>B) brusga qo'yilgan yuk va materiali aniq, ko'ndalang kesim yuza hisoblanadi.<br>S) brusning o'lchamlari va materiali aniq, konstruktsiyaga qo'yilishi mumkin bo'lgan yukning qiymati topiladi<br>D) Hamma javob to'g'ri                                                                                                         |
| <b>160.Materiallar qarshiligida qabul qilingan birinchi gepotezani ta'riflang?</b> | A) Konstruktsiya materiali bir jinsli va g'ovaksiz, ya'ni uning xossasi elementning shakli va o'lchamlariga bog'liq emas<br>B) Konstruktsiya materiali izotrop, ya'ni uning xossasi barcha yo'nalishda bir xil<br>S) Konstruktsiya materiali elastiklik xossasiga ega. Elastik jism deformatsiyasi faqat kuchga bog'liq bo'lib, kuchlarning quyilish tartibiga bog'liq emas<br>D) Yuk qo'yilishigacha tekis bo'lgan brusning kesimi, yuk ta'siridan keyin xam tekisligicha qoladi |
| <b>161.Materiallar qarshiligida qabul qilingan birinchi gepotezani ta'riflang?</b> | A) Konstruktsiya materiali bir jinsli va g'ovaksiz, ya'ni uning xossasi elementning shakli va o'lchamlariga bog'liq emas<br>B) Konstruktsiya materiali izotrop, ya'ni uning xossasi barcha yo'nalishda bir xil<br>S) Konstruktsiya materiali elastiklik xossasiga ega. Elastik jism deformatsiyasi faqat kuchga bog'liq bo'lib, kuchlarning quyilish tartibiga bog'liq emas<br>D) Yuk qo'yilishigacha tekis bo'lgan brusning kesimi, yuk ta'siridan keyin xam tekisligicha qoladi |
| <b>162.Materiallar qarshiligida qabul qilingan ikkinchi gepotezani ta'riflang?</b> | A) Konstruktsiya materiali bir jinsli va g'ovaksiz, ya'ni uning xossasi elementning shakli va o'lchamlariga bog'liq emas<br>B) Konstruktsiya materiali izotrop, ya'ni uning xossasi barcha yo'nalishda bir xil<br>S) Konstruktsiya materiali elastiklik xossasiga ega. Elastik jism                                                                                                                                                                                               |

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|                                                                                             | <p>deformatsiyasi faqat kuchga bog'liq bo'lib, kuchlarning quyilish tartibiga bog'liq emas</p> <p>D) Yuk qo'yilishigacha tekis bo'lgan brusning kesimi, yuk ta'siridan keyin xam tekisligicha qoladi</p>                                                                                                                                                                                                                                                                                             |
| <p><b>163.Materiallar qarshiligida qabul qilingan to'rtinchi gepotezani ta'riflang?</b></p> | <p>A) Konstruktsiya materiali bir jinsli va g'ovaksiz, ya'ni uning xossasi elementning shakli va o'lchamlariga bog'liq emas</p> <p>B) Konstruktsiya materiali izotrop, ya'ni uning xossasi barcha yo'nalishda bir xil</p> <p>S) Konstruktsiya materialining har bir nuqtasidagi deformatsiya shu nuqtadagi kuchlanishga to'g'ri proportsional</p> <p>D) Yuk qo'yilishigacha tekis bo'lgan brusning kesimi, yuk ta'siridan keyin xam tekisligicha qoladi</p>                                          |
| <p><b>164.Materiallar qarshiligida qabul qilingan ikkinchi gepotezani ta'riflang?</b></p>   | <p>A) Konstruktsiya materiali bir jinsli va g'ovaksiz, ya'ni uning xossasi elementning shakli va o'lchamlariga bog'liq emas</p> <p>B) Konstruktsiya materiali izotrop, ya'ni uning xossasi barcha yo'nalishda bir xil</p> <p>S) Konstruktsiya materiali elastiklik xossasiga ega. Elastik jism deformatsiyasi faqat kuchga bog'liq bo'lib, kuchlarning quyilish tartibiga bog'liq emas</p> <p>D) Yuk qo'yilishigacha tekis bo'lgan brusning kesimi, yuk ta'siridan keyin xam tekisligicha qoladi</p> |
| <p><b>165.Materiallar qarshiligida qabul qilingan to'rtinchi gepotezani ta'riflang?</b></p> | <p>A) Konstruktsiya materiali bir jinsli va g'ovaksiz, ya'ni uning xossasi elementning shakli va o'lchamlariga bog'liq emas</p> <p>B) Konstruktsiya materiali izotrop, ya'ni uning xossasi barcha yo'nalishda bir xil</p> <p>S) Konstruktsiya materialining har bir nuqtasidagi deformatsiya shu nuqtadagi kuchlanishga to'g'ri proportsional</p> <p>D) Yuk qo'yilishigacha tekis bo'lgan brusning kesimi, yuk ta'siridan keyin xam tekisligicha qoladi</p>                                          |
| <p><b>166.Materiallar qarshiligida qabul qilingan uchinchi gepotezani ta'riflang?</b></p>   | <p>A) Konstruktsiya materiali bir jinsli va g'ovaksiz, ya'ni uning xossasi elementning shakli va o'lchamlariga bog'liq emas</p> <p>B) Konstruktsiya materiali izotrop, ya'ni uning xossasi barcha yo'nalishda bir xil</p> <p>S) Konstruktsiya materiali elastiklik xossasiga ega. Elastik jism deformatsiyasi faqat kuchga bog'liq bo'lib, kuchlarning quyilish tartibiga bog'liq emas</p> <p>D) Yuk qo'yilishigacha tekis bo'lgan brusning kesimi, yuk ta'siridan keyin xam tekisligicha qoladi</p> |
| <p><b>167.Materiallar qarshiligida qabul qilingan beshinchi gepotezani ta'riflang?</b></p>  | <p>A) Konstruktsiya materiali bir jinsli va g'ovaksiz, ya'ni uning xossasi elementning shakli va o'lchamlariga bog'liq emas</p> <p>B) Konstruktsiya materiali izotrop, ya'ni uning xossasi barcha yo'nalishda bir xil</p> <p>S) Konstruktsiya materialining har bir nuqtasidagi deformatsiya shu nuqtadagi kuchlanishga to'g'ri proportsional</p>                                                                                                                                                    |

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|                                                                                           | D) Konstruktsiyaning deformatsiyasi uning geometrik o'lchamlariga nisbatan kichik miqdor                                                                                                                                                                                                                    |
| <b>168.Qanday materiallar izotrop deb ataladi?</b>                                        | A) hamma yo'nalishda hossasi bir hil bo'lgan materiallar<br>B) har hil yo'nalishda hossasi har hil bo'lgan materiallar<br>S) sintetik materiallar<br>D) yog'och materiallar                                                                                                                                 |
| <b>169. Qanday materiallar anizotrop deb ataladi?</b>                                     | A) Har hil yo'nalishda hossasi har hil bo'lgan materiallar<br>B) po'lat<br>S) hamma yo'nalishda hossasi bir hil bo'lgan materiallar<br>D) Cho'yan                                                                                                                                                           |
| <b>170. Cho'zilish va siqilishda Guk qonunini ko'rsating?</b>                             | A) $\Delta\ell = \ell_1 - \ell_0$ B) $\Delta\ell = \frac{EF}{\ell A}$ ; S) $\Delta\ell = \frac{F\ell}{EA}$ D) $\Delta\ell = \frac{FA}{E\ell}$                                                                                                                                                               |
| <b>171. <math>\mu</math> kim topgan?</b>                                                  | A) Juravskiy B) Timoshenko<br>S) Puasson D) Jukovskiy                                                                                                                                                                                                                                                       |
| <b>172. F kuch va xususiy og'irlik ta'siridagi sterjenning deformatsiyasini aniqlang?</b> | A) $\Delta\ell = \frac{F\ell}{EA}$ ; B) $\Delta\ell = \frac{F\ell}{EA} + \frac{\gamma\ell^2}{2E}$<br>S) $\Delta\ell = \frac{\gamma\ell^2}{2E}$ ; D) $\Delta\ell = \frac{F\ell}{EA} - \frac{\gamma\ell^2}{2E}$                                                                                               |
| <b>173.Temperatura ta'sirida deformatsiyani aniqlang?</b>                                 | A) $\Delta\ell_t = \alpha \cdot \ell$ B) $\Delta\ell_t = \alpha \cdot \Delta t \cdot \ell$<br>S) $\Delta\ell_t = \Delta t \cdot \ell$ D) $\Delta\ell_t = \frac{\Delta t \cdot \ell}{EA}$                                                                                                                    |
| <b>174. Chuyon materiali uchun ruxsat etilgan kuchlanishni aniqlang?</b>                  | A) $[\sigma] = \frac{\sigma_{\partial}}{n}$ B) $[\sigma] = \frac{\sigma_{o\kappa}}{n}$ S) $[\sigma] = \frac{\sigma_{\epsilon}}{n}$ D) $[\sigma] = \frac{\sigma_n}{n}$                                                                                                                                       |
| <b>175.Mahalliy uzayish nima?</b>                                                         | A) Deformatsiyani namunaning ma'lum bir qismida sodir bo'lishi<br>B) Namuna deformatsiyasini o'sishiga<br>S) Namunada qoldiq deformatsiya hosil bo'lishiga<br>D) Namunada uzilish bo'lishiga                                                                                                                |
| <b>176.Puxtalanish nima?</b>                                                              | A) plastiklik deformatsiyasining o'sishi natijasida kuchlanish ning kamayish hodisasi<br>B) plastik deformatsiya ta'sirida material elastiklik xossasining yaxshilanishi<br>S) Material cheksiz kichik deformatsiyada emiriladi<br>D) Materialni emirilmadan katta deformatsiya hosil qila olish qobiliyati |

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| <b>177. Cho'zilish va siqilishda Guk qonunini ta'riflang?</b>      | <p>A) elastik bo'ylama uzayish, ichki bo'ylama kuch va sterjenning uzunligiga to'g'ri va bikrligiga teskari proportsional</p> <p>B) elastik bo'ylama uzayish, ichki bo'ylama kuch va sterjenning uzunligi va bikrligiga teskari proportsional</p> <p>S) elastik bo'ylama uzayish, ichki bo'ylama kuch va sterjenning uzunligiga teskari va bikrligiga tugri proportsional</p> <p>D) Hamma javob to'g'ri</p>                                                                       |
| <b>178. Materialni elastiklik chegarasi deb nimaga aytiladi?</b>   | <p>A) Guk qonuniga bo'ysunadigan kuchlanishga</p> <p>B) So'nuvchan deformatsiya hosil qiladigan kuchlanishga</p> <p>S) Y'zgarmas kuchda namuna deformatsiya sini o'sishi</p> <p>D Eng katta kuch <math>F_{max}</math> ta'sirida hosil bo'lgan kuchlanish</p>                                                                                                                                                                                                                      |
| <b>179. Materialni mustahkamlik chegarasi deb nimaga aytiladi?</b> | <p>A) Guk qonuniga bo'ysunadigan kuchlanishga</p> <p>B) So'nuvchan deformatsiya hosil qiladigan kuchlanishga</p> <p>S) Y'zgarmas kuchda namuna deformatsiya sini o'sishi</p> <p>D) Eng katta kuch <math>F_{max}</math> ta'sirida hosil bo'lgan kuchlanish</p>                                                                                                                                                                                                                     |
| <b>180. Jismni emirilishi nimaga boglik?</b>                       | <p>A) jismning o'lchami shunday qiymatga erishadiki, natijada jism bir butunligini saqlab qoladi</p> <p>B) jismning o'lchami shunday qiymatga erishadiki, natijada jism parchalanib ketmaydi</p> <p>S) jismning o'lchami shunday qiymatga erishadiki, natijada jism bir butunligini saqlab qola olmaydi va parchalanib ketadi.</p> <p>D) Jismni muvozanat holati</p>                                                                                                              |
| <b>181. Ustuvorlik deb nimaga aytiladi?</b>                        | <p>A) Sterjenlarni tashqi kuch ta'siridan to'g'ri chiziqli muvozanat holatini saqlab bilish qobiliyati;</p> <p>B) Tashqi kuch ta'siridan sterjen shaklini o'zgarishi;</p> <p>S) Tashqi kuch ta'siridan sterjen o'qini egrilanishi;</p> <p>D) Tashqi kuch ta'siridan sterjen o'qini to'g'rilanishi</p>                                                                                                                                                                             |
| <b>182. Kesish usuli nima uchun kerak?</b>                         | <p>A) Ichki kuchlarni ko'rish va aniqlash uchun;</p> <p>B) Tashqi va ichki kuchlarni muvozanatlashtirish uchun;</p> <p>S) Sterjen deformatsiyasini aniqlash uchun;</p> <p>D) Sterjen kesimidagi kuchlanishni aniqlash uchun.</p>                                                                                                                                                                                                                                                  |
| <b>183. Materialni elastikligi nima?</b>                           | <p>A) Tashqi faktor ta'siri yo'qotilmasdan jism zarrachalarining boshlang'ich vaziyatini tiklanishini ta'minlovchi materialning xossasi</p> <p>B) Tashqi faktor ta'siri yo'qotilgandan keyin jism zarrachalarining boshlang'ich vaziyatini tiklanishini ta'minlamaydigan materialning xossasi</p> <p>S) Tashqi faktor ta'siri yo'qotilgandan keyin jism zarrachalarining boshlang'ich vaziyatini tiklanishini ta'minlovchi materialning xossasi</p> <p>D) Hamma javob to'g'ri</p> |

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| <b>184.Nisbiy deformatsiya nima?</b>                               | <p>A) Bir birlik uzunlikka to'g'ri keluvchi absolyut uzayish</p> <p>B) Tashqi kuch ta'siri yo'qotilgandan keyin jismning boshlang'ich o'lcham va shaklini tiklanishi</p> <p>S) Jism o'lchamlarini o'zgarishiga</p> <p>D) Jism shaklini o'zgarishiga</p>                                                                                                                                                       |
| <b>185. Plastiklik nima?</b>                                       | <p>A) plastik deformatsiya ta'sirida material elastiklik xossasining yaxshilanishi</p> <p>B) plastiklik deformatsiyasining o'sishi natijasida kuchlanishning kamayish hodisasi</p> <p>S) Materialni emirilmasdan katta deformatsiya hosil qila olish qobiliyati</p> <p>D) Material cheksiz kichik deformatsiyada emiriladi</p>                                                                                |
| <b>186.Kattiklik deb nimaga aytiladi?</b>                          | <p>A) materialni sirtiga mexanik tarzda singdirilgan detalga qarshilik ko'rsatish olmaslik qobiliyati</p> <p>B) materialni sirtiga mexanik tarzda singdirilgan detalga qarshilik ko'rsatish qobiliyati</p> <p>S) materialga plastik tarzda singdirilgan detalga qarshilik ko'rsatish qobiliyati</p> <p>D) materialni sirtiga plastik tarzda singdirilgan detalga qarshilik ko'rsatish olmaslik qobiliyati</p> |
| <b>187.Plastik deformatsiya nima?</b>                              | <p>A) Jism shaklini o'zgarishiga</p> <p>B) Jism o'lchamlarini o'zgarishiga</p> <p>S) jismni plastik deformatsiyani qabul qilish qobiliyati</p> <p>D) Yuksizlantirishdan keyin jismda qolgan deformatsiya</p>                                                                                                                                                                                                  |
| <b>188.Chegaraviy kuchlanish nima?</b>                             | <p>A) konstruktsiya xavfsiz, ishonchli va uzoq muddat ishlashini ta'minlovchi eng katta kuchlanish</p> <p>B) hosil bo'lishi bilan emirilash yoki plastik deformatsiya sodir bo'ladi</p> <p>S) konstruktsiyaning elementiga qo'yilgan kuch ta'sirida hosil bo'ladi</p> <p>D) Hamma javob to'g'ri</p>                                                                                                           |
| <b>189.Mustahkamlik ka tekshirish hisoblashi nima?</b>             | <p>A) brusga qo'yilgan yuk, material va o'lchamlari aniq, eng katta hisobiy kuchlanish topiladi va ruxsat etilgan kuchlanish bilan taqqoslanadi</p> <p>B) brusga qo'yilgan yuk va material aniq, ko'ndalang kesim yuza hisoblanadi.</p> <p>S) brusning o'lchamlari va material aniq, konstruktsiyaga qo'yilishi mumkin bo'lgan yukning qiymati topiladi</p> <p>D) Hamma javob to'g'ri</p>                     |
| <b>190. Markaziy cho'zilish yoki siqilish deb nimaga aytiladi?</b> | <p>A) Y'zaro teng va bo'ylama o'qida qarama – qarshi tomonlarga yo'nalgan kuchlar ta'siridagi sterjenni deformatsiyasiga aytiladi.</p> <p>B) Sterjenni tashqi kuch ta'siridan emirilishiga;</p> <p>S) Sterjenni elastik deformatsiyasiga;</p>                                                                                                                                                                 |

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|                                                                                                     | D) Sterjenni bikrligini kichiklashishiga.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 191. Guk qonuni-ning ikkinchi ko'rinishini ko'rsating?                                              | A) $\varepsilon = \frac{\Delta \ell}{\ell}$ B) $\varepsilon = \frac{\sigma}{E}$ S) $\varepsilon = \ell_1 - \ell_0$ D) $\varepsilon = \frac{\sigma}{A}$                                                                                                                                                                                                                                                                                                                                                                                         |
| 192. Cho'zilish va siqilishda normal kuchlanish formulasini ko'rsating?                             | A) $\sigma = NA$ ; B) $\sigma = \frac{N}{A}$ S) $\sigma = \frac{A}{N}$ D) $\sigma = \sqrt{\rho^2 - \tau^2}$                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 193. F kuch va xususiy og'irlik ta'siridagi ster-jenning kesimi-ni tanlang?                         | A) $A \geq \frac{F}{[\sigma]}$ B) $A = A_0 \ell \left[ \frac{\gamma}{[\sigma]} \right]^y$ S) $A \geq F[\sigma]$ D) $A = \frac{\pi d^2}{4}$                                                                                                                                                                                                                                                                                                                                                                                                     |
| 194. Material-larni cho'zilish yoki siqilishga sinashdan maqsad nima?                               | A) Namunani cho'zilishda uzish<br>B) Materialni mexanik va plastiklik xossalarini aniqlash<br>S) Namunalarni shaklini o'zgartirish<br>D) Guk qonunini tekshirish.                                                                                                                                                                                                                                                                                                                                                                              |
| 195. Mo'rtlik deb nimaga aytiladi?                                                                  | A) Katta deformatsiya hosil qilib emirilish xususiyatiga ega bo'lgan material;<br>B) Kichik deformatsiya hosil qilib emiriladigan materialni xossasiga<br>S) Kichik deformatsiya hosil qilib emirilmaydigan materialni xossasiga<br>D) Oquvchanlik chegarasi bor bo'lgan materialga.                                                                                                                                                                                                                                                           |
| 196. Cho'zilish va siqilish defor-matsiyasining potentsial energiyasi qaysi formula bilan topiladi? | A) $U = \frac{2E}{\sigma^2}$ ; B) $U = \frac{\sigma^2}{2E}$ ; S) $U = \frac{2\sigma}{\varepsilon}$ ; D) $U = \frac{2}{\sigma\varepsilon}$                                                                                                                                                                                                                                                                                                                                                                                                      |
| 197. Cho'zilish va siqilishda ichki bo'ylama kuch qanday topiladi                                   | A) brusning kesilgan ko'ndalang kesimidan bir tomonda olib qolingani tashqi kuchlarni ushbu kesimning bo'ylama o'qiga proektsiyalarining algebraik yig'indisiga teng<br>B) brusning kesilgan ko'ndalang kesimidan bir tomonda olib qolingani tashqi kuchlarni ushbu kesimning kesim markaziga proektsiyalarining algebraik yig'indisiga teng<br>S) brusning kesilgan ko'ndalang kesimidan bir tomonda olib qolingani tashqi kuchlarni ushbu kesimning kesim markaziga kuch momentlarining algebraik yig'indisiga teng<br>D) Hamma javobto'g'ri |

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| <b>198.Cho'zilish va siqilishga sinashning maksadi nima?</b>          | A) nazariy bilimlar tajribada tekshiriladi; materialning emirilish xarakteri, mexanik xossalari, plastiklik xossalari o'rganiladi va ruxsat etilgan kuchlanish tanlanadi<br>B) materialning emirilish xarakteri o'rganiladi<br>S) plastiklik xossalari o'rganiladi<br>D) mexanik xossalari o'rganiladi                                                       |
| <b>199.Materialni proportsionallik chegarasi deb nimaga aytiladi?</b> | A) Guk qonuniga bo'ysunadigan kuchlanishga<br>B) So'nuvchan deformatsiya hosil qiladigan kuchlanishga<br>S) Y'zgarmas kuchda namuna deformatsiya sini o'sishi<br>D Eng katta kuch Fmax ta'sirida hosil bo'lgan kuchlanish                                                                                                                                    |
| <b>200. nisbiy uzayish formulasi?</b>                                 | A) $\psi = \frac{A_0 - A_1}{A_0} \cdot 100\%$ B) $\delta = \frac{\Delta \ell_{\kappa}}{\ell_0} \cdot 100$<br>S) $\delta = 28...33 \%$ D) $\psi = 55...65 \%$                                                                                                                                                                                                 |
| <b>1.Jismni xavfli holati nima?</b>                                   | A) Jismni muvozanat holati    B) Jismni tinch holati<br>S) elementni emirilishi    D) Hamma javob to'g'ri                                                                                                                                                                                                                                                    |
| <b>202.Konstruktsiya ni hisoblash sxemasi nima?</b>                   | A) Muhim bo'lgan faktorlardan ozod bo'lgan real ob'ekt<br>B) Muhim bo'lmagan faktorlardan ozod bo'lgan real ob'ekt<br>S) Muhim bo'lmagan faktorlardan ozod bo'lmagan real ob'ekt<br>D) Muhim bo'lgan faktorlardan ozod bo'lmagan real ob'ekt                                                                                                                 |
| <b>203.Deformatsiya deb nimaga aytiladi?</b>                          | A) ) Jism chiziqli o'lchamlarining o'zgarishi<br>B) Jism burchakli o'lchamlarining o'zgarishi<br>S) jism zarrachalarining orasidagi masofani o'zgarishi<br>D) jism zarrachalarining orasidagi masofa o'zgarmaydi                                                                                                                                             |
| <b>204. Elastik deformatsiya deb nimaga aytiladi?</b>                 | A) Tashqi kuch ta'siri yo'qotilgandan keyin jismning boshlang'ich o'lcham va shaklini tiklanishi<br>B) Bir birlik uzunlikka to'g'ri keluvchi absolyut uzayish<br>S) Jism o'lchamlarini o'zgarishiga<br>D) Jism shaklini o'zgarishiga                                                                                                                         |
| <b>205. Bo'ylama deformatsiya nima?</b>                               | A) Tashqi kuch ta'siridan brus uzunligini o'q bo'ylab chiziqli uzayishini nisbiy (absolyut) miqdori<br>B) Bir birlik uzunlikka to'g'ri keluvchi absolyut uzayish<br>S) Jism o'lchamlarini o'zgarishiga<br>D) Jism shaklini o'zgarishiga                                                                                                                      |
| <b>206.Kuchlanish nimani aniqlaydi?</b>                               | A) konstruktsiya xavfsiz, ishonchli va uzoq muddat ishlashini ta'minlovchi eng katta kuchlanish<br>B) hosil bo'lishi bilan emirilash yoki plastik deformatsiya sodir bo'ladi<br>S) konstruktsiyaning elementiga qo'yilgan kuch ta'sirida hosil bo'ladi<br>D) kesim yuzaning ma'lum nuqtasidagi yoki kesim yuza bo'ylab ichki kuchning tarqalish qonuniyatini |
| <b>207.Ruxsat etilgan kuchlanish nima?</b>                            | A) bir birlik yuzaga to'g'ri keluvchi kuchlanish<br>B) hosil bo'lishi bilan emirilash yoki plastik deformatsiya sodir bo'ladi                                                                                                                                                                                                                                |

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|                                                                                          | <p>S) konstruktsiya xavfsiz, ishonchli va uzoq muddat ishlashini ta'minlovchi eng katta kuchlanish</p> <p>D) konstruktsiyaning elementiga qo'yilgan kuchlanish</p>                                                                                                                                                                                                                           |
| <b>208. Mustahkamlik ka loyihaviy hisoblashi nima?</b>                                   | <p>A) brusga qo'yilgan yuk, materiali va o'lchamlari aniq, eng katta hisobiy kuchlanish topiladi va ruxsat etilgan kuchlanish bilan taqqoslanadi</p> <p>B) brusga qo'yilgan yuk va materiali aniq, ko'ndalang kesim yuza hisoblanadi.</p> <p>S) brusning o'lchamlari va materiali aniq, konstruktsiyaga qo'yilishi mumkin bo'lgan yukning qiymati topiladi</p> <p>D) Hamma javob to'g'ri</p> |
| <b>209. Cho'zilish va siqilishda sterjenni kesim yuzasida qanday kuch hosil bo'ladi?</b> | <p>A) tashqi;</p> <p>B) ichki bo'ylama kuch;</p> <p>S) ko'ndalang kuch;</p> <p>D) moment</p>                                                                                                                                                                                                                                                                                                 |
| <b>210. Puasson koeffitsienti qaysi formula bilan topiladi?</b>                          | <p>A) <math>\mu = 0,3</math>; B) <math>\mu = \frac{\varepsilon}{\varepsilon'}</math>; S) <math>\mu = \frac{\varepsilon^1}{\varepsilon}</math>; D) <math>\mu = \frac{\Delta \ell}{\ell}</math></p>                                                                                                                                                                                            |
| <b>211. Teng qarshilik ko'rsatuvchi brus kesimining yuzasi?</b>                          | <p>A) <math>A \geq \frac{F}{[\sigma]}</math> B) <math>A = A_0 \ell^{\frac{\gamma}{[\sigma]}}</math> S) <math>A = F[\sigma]</math> D) <math>A = h \ell</math></p>                                                                                                                                                                                                                             |
| <b>212. Yumshoq po'lot materiali uchun ruxsat etilgan kuchlanishni ko'rsating?</b>       | <p>A) <math>[\sigma] = \frac{\sigma_{ok}}{n}</math> B) <math>[\sigma] = \frac{\sigma_{\vartheta}}{n}</math> S) <math>[\sigma] = \frac{\sigma_n}{n}</math> D) <math>[\sigma] = \frac{\sigma_e}{n}</math></p>                                                                                                                                                                                  |
| <b>213. Cho'zilish va siqilishda mustahkamlik shart formulasini ko'rsating?</b>          | <p>A) <math>\sigma = \frac{N}{A} \leq [\sigma]</math> B) <math>\sigma_{\max} = \frac{N}{A} \leq [\sigma]</math></p> <p>S) <math>\sigma = \frac{F}{A} \leq [\sigma]</math> D) <math>\tau = \frac{N}{A} \leq [\sigma]</math></p>                                                                                                                                                               |
| <b>214. E nima?</b>                                                                      | <p>A) materialni xarakterlovchi kattalik</p> <p>B) materialning mexanik xossasini xarakterlovchi fizik kattalik</p> <p>S) materialni turiga bog'liq emas</p> <p>D) hamma javob to'g'ri</p>                                                                                                                                                                                                   |
| <b>215. Cho'zilish va siqilishda Guk qonunini ta'riflang?</b>                            | <p>A) elastik jismlarda, normal kuchlanish nisbiy deformatsiyaga teskari proportsional</p> <p>B) elastik jismlarda, normal kuchlanish nisbiy deformatsiyaga to'g'ri proportsional</p> <p>S) elastik jismlarda, normal kuchlanish kundalang deformatsiyaga to'g'ri proportsional</p>                                                                                                          |



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|                                                                                                              | D) plastik jismlarda, normal kuchlanish nisbiy deformatsiyaga to'g'ri proporsional                                                                                                                                                                                                                          |
| <b>216. Material-ning mexanik xossalari nima bilan xarakterlanadi?</b>                                       | A) Namunani sinash jarayonida bir holatdan ikkinchi holatga o'tish<br>B) Namunani sinash jarayonida bir holatdan ikkinchi holatga o'tishini ko'rinmasligi<br>S) Namunani uzayishi<br>D) Namunani sinash jarayonida bir holatdan ikkinchi holatga o'tish chegaralaridagi kuchlanishlar bilan                 |
| <b>217. Materialni oquvchanlik chegarasi deb nimaga aytiladi?</b>                                            | A) Guk qonuniga bo'ysunadigan kuchlanishga<br>B) So'nuvchan deformatsiya hosil qiladigan kuchlanishga<br>S) Y'zgarmas kuchda namuna deformatsiya sini o'sishi<br>D) Eng katta kuch $F_{max}$ ta'sirida hosil bo'lgan kuchlanish                                                                             |
| <b>218. Relaksatsiya hodisasi nima?</b>                                                                      | A) plastiklik deformatsiyasining o'sishi natijasida kuchlanishning kamayish hodisasi<br>B) plastik deformatsiya ta'sirida material elastiklik xossasining yaxshilanishi<br>S) Material cheksiz kichik deformatsiyada emiriladi<br>D) Materialni emirilmasdan katta deformatsiya hosil qila olish qobiliyati |
| <b>219. Cho'zilish diagrammasidagi mustahkamlik chegarasi qanday kattalik?</b>                               | A) material bardosh beradigan eng katta kuchlanish<br>B) oquvchanlik zonasining boshlang'ich nuqtasi<br>S) kuchlanish va deformatsiya proporsional eng katta kuchlanish<br>D) deformatsiya elastik bo'lgan eng katta kuchlanish                                                                             |
| <b>220. Cho'zilish, siqilishda normal kuchlanish qaysi ichki kuchlar ta'siridan hosil bo'ladi?</b>           | A) bo'ylama kuch<br>B) eguvchi moment<br>S) burovchi moment<br>D) ko'ndalang kuch                                                                                                                                                                                                                           |
| <b>221. Egilishda urinma kuchlanish qaysi ichki kuch ta'siridan hosil bo'ladi?</b>                           | A) ko'ndalang kuch<br>B) bo'ylama kuch<br>S) burovchi moment<br>D) eguvchi moment                                                                                                                                                                                                                           |
| <b>222. Cho'zilish diagrammasining qaysi zonasida namunaning kesimida qoldiq deformatsiya xosil bo'ladi?</b> | A) oquvchanlik zonasida<br>B) proporsionallik zonasida<br>S) mustahkamlik zonasida<br>D) elastiklik zonasida                                                                                                                                                                                                |

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| 223. Buralishda urinma kuchlanish qanday ichki kuch taʼsiridan hosil boʻladi?                      | A) Burovchi moment<br>B) Koʻndalang kuch<br>S) Boʻylama kuch<br>D) Eguvchi moment                                                                                                                                                                                                                                                                                                                                                                                             |
| 224. Kuchlanganlik xolati nazariyalarining vazifasi nima?                                          | A) Turli kesim yuzalarida kuchlanganlik holatlarining nazariyalari deyiladi.<br>B) Turli kesim yuzalarida hosil boʻladigan kuchlanishlarning tahlili kuchlanganlik holatlarining nazariyalari deyiladi.<br>S) Turli kesim yuzalarida hosil boʻladigan normal kuchlanishlarning tahlili kuchlanganlik holatlarining nazariyalari deyiladi.<br>D) ) Turli kesim yuzalarida hosil boʻladigan urinma kuchlanishlarning tahlili kuchlanganlik holatlarining nazariyalari deyiladi. |
| 225. Chiziqli kuchlanganlik holatida qiya kesimni normal kuchlanishi qaysi formula bilan topiladi? | A) $\sigma_{\alpha} = P_{\alpha} \sin \alpha$ ;      B) $\sigma_{\alpha} = \sigma_0 \cos^2 \alpha$<br>S) $\sigma_{\alpha} = \frac{\sigma_0}{2} \sin 2\alpha$ D) $\sigma_{\alpha} = \frac{F}{A}$                                                                                                                                                                                                                                                                               |
| 226. Tekis kuchlanganlik holatida qiya kesimni normal kuchlanishini aniqlang?                      | A) $\sigma_{\alpha} = \sigma_1 \cos^2 \alpha$ ;    B) $\sigma_{\alpha} = \sigma_1 \cos^2 \alpha + \sigma_3 \cos^2 \alpha_1$<br>S) $\sigma_{\alpha} = \frac{\sigma_1 - \sigma_3}{2} \sin^2 \alpha$ ;    D) $\sigma_{\alpha} = \sigma_3 \cos^2 \alpha$                                                                                                                                                                                                                          |
| 227. Bosh yuza deb nimaga aytiladi?                                                                | A) normal va urinma kuchlanishlar nolga teng boʻlgan yuzalar bosh yuzalar deyiladi<br>B) urinma kuchlanishlar nolga teng boʻlgan yuzalar bosh yuzalar deyiladi<br>S) normal kuchlanishlar nolga teng boʻlgan yuzalar bosh yuzalar deyiladi<br>D) xamma javob tugri                                                                                                                                                                                                            |
| 228. Chiziqli kuchlanganlik holatida qiya kesimni urinma kuchlanishi qaysi formula bilan topiladi? | A) $\tau_{\alpha} = \frac{F}{A}$ B) $\tau_{\alpha} = P_{\alpha} \cos \alpha$ ;<br>S) $\tau_{\alpha} = \frac{\sigma_0}{2} \sin 2\alpha$ D) $\tau_{\alpha} = \sigma_0 \cos \alpha$                                                                                                                                                                                                                                                                                              |
| 229. Tekis kuchlanganlik                                                                           | A) $\tau_{\alpha} = \frac{\sigma_1}{2} \sin 2\alpha$ ;      B) $\tau_{\alpha} = \frac{\sigma_3}{2} \sin 2\alpha$                                                                                                                                                                                                                                                                                                                                                              |

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| holatida qiya kesimni urinma kuchlanishini aniqlang?                                             | S) $\tau_{\alpha} = \frac{\sigma_1 - \sigma_3}{2} \sin 2\alpha$ D) $\tau_{\alpha} = \frac{\sigma_1 + \sigma_3}{2}$                                                                                                                                                                                                                                                                                    |
| 230. Urinma kuchlanishlar-ning juftlik alomati deb nimaga aytiladi?                              | A) O'zaro perpendikulyar joylashgan qiya kesimlardagi urinma kuchlanishlar bir-biriga teng emas va ishorasi har xil<br>B) O'zaro perpendikulyar joylashgan qiya kesimlardagi urinma kuchlanishlar bir-biriga teng va ishorasi bir xil<br>S) O'zaro perpendikulyar joylashgan qiya kesimlardagi urinma kuchlanishlar bir-biriga teng va ishorasi har xil<br>D) xamma javob tugri                       |
| 231. Bosh kuchlanishlarning yo'nalishi qaysi formula bilan topiladi?                             | A) $tg 2\alpha_0 = -\frac{2I_{xy}}{I_x - I_y}$ ; B) $tg 2\alpha_0 = -\frac{2\tau_{xy}}{\sigma_x - \sigma_y}$<br>S) $tg 2\alpha_0 = -\frac{\sigma_x - \sigma_y}{2I_{xy}}$ D) $tg \alpha_0 = -\frac{\tau_{xy}}{\sigma_1 - \sigma_3}$                                                                                                                                                                    |
| 232. Gukning hajmiy qonuni?                                                                      | A) $\varepsilon_0 = \frac{\sigma_{yp}}{K}$ B) $\varepsilon_0 \geq \frac{\sigma_{yp}}{K}$ S) $\varepsilon_0 \leq \frac{\sigma_{yp}}{K}$ D) $\varepsilon_0 \neq \frac{\sigma_{yp}}{K}$                                                                                                                                                                                                                  |
| 233. Hajmiy deformatsiyada $\varepsilon_1$ ni aniqlay-digan formula-sini ko'rsating?             | A) $\varepsilon_1 = 2E[\sigma_1 - \mu\sigma_3]$ ; B) $\varepsilon_1 = \frac{1}{E}[\sigma_1 - \mu(\sigma_2 + \sigma_3)]$<br>S) $\varepsilon_1 = \frac{\sigma_1}{E}$ D) $\varepsilon_1 = \sigma_1 - \frac{\mu}{E}(\sigma_2 + \sigma_3)$                                                                                                                                                                 |
| 234. Hajmiy deformatsiyani to'liq potentsiyal energiyasi formulasini ko'rsating?                 | A) $U = U_x - U_{uu}$<br>B) $U = \frac{1}{E}[\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - 2(\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_1\sigma_3)]$<br>S) $U = \frac{1}{2E}[\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - 2\mu(\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_1\sigma_3)]$<br>D) $U = \frac{1}{2E}[\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - \sigma_1\sigma_2 - \sigma_2\sigma_3 - \sigma_1\sigma_3]$ |
| 235. Hajm o'zgari-shidagi deformatsiya potentsial energiyasining to'g'ri formulasini ko'rsating? | A) $U_x = \frac{3\sigma_1\varepsilon_1}{2}$ ; B) $U_x = \frac{1-2\mu}{6E}(\sigma_1 + \sigma_2 + \sigma_3)^2$<br>S) $U_x = \frac{1-2\mu}{6E}(\sigma_1^2 + \sigma_2^2 + \sigma_3^2)$ D) $U_x = U + U_{uu}$                                                                                                                                                                                              |
| 236. Mustahkamlik nazariyalari-ning vazifalari-ni to'g'ri ta'riflang?                            | A) Turli kuchlanganlik holatida kubikni deformatsiyasini aniqlash<br>B) Mor doirasini qurish<br>S) Turli kuchlanganlik holatida kubikni mustahkamlik shartini tuzish                                                                                                                                                                                                                                  |

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|                                                                                         | D) Kesimni tanlash                                                                                                                                                                                                              |
| <b>237.Birinchi mustahkamlik nazariyasining to'g'ri nomini toping?</b>                  | A). Eng katta bosh normal kuchlanishlar nazariyasi<br>B) Eng katta nisbiy deformatsiyalar nazariyasi<br>S) Eng katta urinma kuchlanishlar nazariyasi<br>D) Energetik nazariya                                                   |
| <b>238.Ikkinchi mustahkamlik nazariyasining to'g'ri nomini toping?</b>                  | A). Eng katta bosh normal kuchlanishlar nazariyasi<br>B) Eng katta nisbiy deformatsiyalar nazariyasi<br>S) Eng katta urinma kuchlanishlar nazariyasi<br>D) Energetik nazariya                                                   |
| <b>239.Uchinchi mustahkamlik nazariyasining to'g'ri nomini toping?</b>                  | A). Eng katta bosh normal kuchlanishlar nazariyasi<br>B) Eng katta nisbiy deformatsiyalar nazariyasi<br>S) Eng katta urinma kuchlanishlar nazariyasi<br>D) Energetik nazariya                                                   |
| <b>240. To'rtinchi mustahkamlik nazariyasining to'g'ri nomini toping?</b>               | A). Eng katta bosh normal kuchlanishlar nazariyasi<br>B) Eng katta nisbiy deformatsiyalar nazariyasi<br>S) Eng katta urinma kuchlanishlar nazariyasi<br>D) Energetik nazariya                                                   |
| <b>241.Birinchi mustahkamlik nazariyasi bo'yicha mustahkamlik shartni ko'rsating?</b>   | A) $\sigma_{\max} = \sigma_1 \leq [\sigma]$ B) $\sigma_1 - \mu(\sigma_2 + \sigma_3) \leq [\sigma]$<br>S) $\sigma_{\max} = \sqrt{\sigma^2 + 4\tau^2} \leq [\sigma]$ D) $\sigma_{\max} = \sqrt{\sigma^2 + 3\tau^2} \leq [\sigma]$ |
| <b>242.Ikkinchi mustahkamlik nazariyasi bo'yicha mustahkamlik shartni ko'rsating?</b>   | A) $\sigma_{\max} = \sigma_1 \leq [\sigma]$ B) $\sigma_1 - \mu(\sigma_2 + \sigma_3) \leq [\sigma]$<br>S) $\sigma_{\max} = \sqrt{\sigma^2 + 4\tau^2} \leq [\sigma]$ D) $\sigma_{\max} = \sqrt{\sigma^2 + 3\tau^2} \leq [\sigma]$ |
| <b>243. Uchinchi mustahkamlik nazariyasi bo'yicha mustahkamlik shartni ko'rsating?</b>  | A) $\sigma_{\max} = \sigma_1 \leq [\sigma]$ B) $\sigma_1 - \mu(\sigma_2 + \sigma_3) \leq [\sigma]$<br>S) $\sigma_{\max} = \sqrt{\sigma^2 + 4\tau^2} \leq [\sigma]$ D) $\sigma_{\max} = \sqrt{\sigma^2 + 3\tau^2} \leq [\sigma]$ |
| <b>244.To'rtinchi mustahkamlik nazariyasi bo'yicha mustahkamlik shartni ko'rsating?</b> | A) $\sigma_{\max} = \sigma_1 \leq [\sigma]$ B) $\sigma_1 - \mu(\sigma_2 + \sigma_3) \leq [\sigma]$<br>S) $\sigma_{\max} = \sqrt{\sigma^2 + 4\tau^2} \leq [\sigma]$ D) $\sigma_{\max} = \sqrt{\sigma^2 + 3\tau^2} \leq [\sigma]$ |
| <b>245.Sof siljish deb nimaga aytiladi?</b>                                             | A) Fakat normal kuchlanish ta'siridagi kubikning deformatsiyasi<br>B) Fakat urinma kuchlanish ta'siridagi kubikning                                                                                                             |

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|                                                                         | <p>deformatsiyasi</p> <p>S) normal va urinma kuchlanishlar ta'siridagi kubikning deformatsiyasi</p> <p>D) xamma javob tugri</p>                                                                                                                                                                                                                                                                                                                                                         |
| <b>246. Siljishda Guk qonuni ?</b>                                      | <p>A) <math>\tau = \frac{F}{A}</math>    B) <math>\tau = \gamma G</math>    S) <math>\tau = \frac{\gamma}{G}</math>    D) <math>\tau_{\alpha} = \sigma_1</math></p>                                                                                                                                                                                                                                                                                                                     |
| <b>247. Siljish modulini ko'rsating?</b>                                | <p>A) <math>k = \frac{E}{2(1-\mu)}</math>    B) <math>G = \frac{E}{2(1+\mu)}</math></p> <p>S) <math>k = \frac{\sigma_{yp}}{\varepsilon_{yp}}</math>    D) <math>G = \frac{(\mu+1)2}{E}</math></p>                                                                                                                                                                                                                                                                                       |
| <b>248. Buralish deb nimaga aytiladi?</b>                               | <p>A) Buylama ukiga perpendikulyar tekislikda aylanti-ruvchi moment bilan yuklangan sterjenning deformatsiya-siga aytiladi</p> <p>B) Buylama ukiga parallel tekislikda aylantiruvchi moment bilan yuklangan sterjenning deformatsiyasiga aytiladi</p> <p>S) Buylama ukiga parallel tekislikda tashki kuch bilan yuklangan sterjenning deformatsiyasiga aytiladi</p> <p>D) Buylama ukiga perpendikulyar tekislikda tashki kuch bilan yuklangan sterjenning deformatsiyasiga aytiladi</p> |
| <b>249. Buralish burchagi formulasini ko'rsating?</b>                   | <p>A) <math>\varphi = \frac{F\ell}{EA}</math>    B) <math>\varphi = \frac{M_{\delta}\ell}{GI_{\rho}}</math></p> <p>C) <math>\varphi = \frac{4FR^3n}{Gr^4}</math>    D) <math>\varphi = \frac{M_c}{EA}</math></p>                                                                                                                                                                                                                                                                        |
| <b>250. Buralishda bikrlilik shartni ko'rsating?</b>                    | <p>A) <math>\varphi_{\max} = \frac{M_{\delta} \cdot \ell}{G \cdot I_{\rho}} \leq [\varphi]</math>    B) <math>\varphi = \frac{F\ell}{EA}</math></p> <p>S) <math>\lambda = \frac{4FR^3n}{Gr^4}</math>    D) <math>\varphi = \frac{M_c}{EA}</math></p>                                                                                                                                                                                                                                    |
| <b>251. Doiraviy kesimli sterjenning buralishida kuchlanish?</b>        | <p>A) <math>\tau_{\rho} = \frac{M_{\delta}}{I_{\rho}}</math>    B) <math>\tau_{\rho} = \frac{M_{\delta} \cdot \rho}{I_{\rho}}</math></p> <p>S) <math>\tau_{\rho} = \frac{M}{W}</math>    D) <math>\tau_{\rho} = \frac{I_{\delta} \cdot \rho}{M_{\rho}}</math></p>                                                                                                                                                                                                                       |
| <b>252. Buralishda urinma kuchlanish kesim yuzada qanday tarqaladi?</b> | <p>A) Kesim yuzada notekis tarkalgan</p> <p>B) Kesim yuzada tekis tarkalgan</p> <p>S) Kesim yuzaning markazida nolga teng va kesimning sirtida eng katta kiymatga erishadi</p> <p>D) Kesim yuzaning sirtida markazida eng katta kiymatga erishadi</p>                                                                                                                                                                                                                                   |
| <b>253. Vintsimon prujinaning deformatsiyasi?</b>                       | <p>A) <math>\lambda = \frac{4FR^3n}{Gr^4}</math>    B) <math>\lambda = \frac{FR^3n}{Gr^4}</math></p>                                                                                                                                                                                                                                                                                                                                                                                    |

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|                                                                | <p>S) <math>\lambda = \frac{4FRn}{Gr^4}</math></p> <p>D) <math>\lambda = \frac{4FR^2n}{Gr^4}</math></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 254. Vintsimon prujinaning kesim yuzasidagi to'liq kuchlanish? | <p>A) <math>\tau = \frac{F}{\pi \cdot r^2}</math></p> <p>B) <math>\tau = \frac{F}{\pi \cdot r^2} + \frac{2FR}{\pi \cdot r^3}</math></p> <p>S) <math>\tau = \frac{2FR}{\pi \cdot r^3}</math></p> <p>D) <math>\tau = \frac{F}{r^2}</math></p>                                                                                                                                                                                                                                                                                                                                                                                                        |
| 255. Egilish deb nimaga aytiladi?                              | <p>A) Kesim yuzasida ikkita ichki kuch faktori – ko'ndalang kuch va eguvchi moment hosil bo'ladigan hamda bo'ylama o'qi kuchni ta'sir chiziqi bo'yicha egrilanadigan brusning deformatsiyasi - egilish deyiladi</p> <p>B) Kesim yuzasida ikkita bitta kuch faktori – ko'ndalang kuch hosil bo'ladigan hamda bo'ylama o'qi kuchni ta'sir chiziqi bo'yicha egrilanadigan brusning deformatsiyasi - egilish deyiladi</p> <p>S) Kesim yuzasida ikkita bitta kuch faktori – eguvchi moment hosil bo'ladigan hamda bo'ylama o'qi kuchni ta'sir chiziqi bo'yicha egrilanadigan brusning deformatsiyasi - egilish deyiladi</p> <p>D) Xamma javob tugri</p> |
| 256. Balka deb nimaga aytiladi?                                | <p>A) kamida uchta tayagchga tayanuvchi va oraliq sharnirlar bo'lmagan balkaga deyiladi</p> <p>B) Ikki tayanchga tayangan va egilish deformatsiyasiga uchraydigan brus</p> <p>S) to'rtta tayanchga tayanuvchi va oraliq sharniri bo'lgan balka</p> <p>D) Xamma javob tugri</p>                                                                                                                                                                                                                                                                                                                                                                     |
| 257. Uzluksiz balka deb nimaga aytiladi?                       | <p>A) kamida uchta tayagchga tayanuvchi va oraliq sharnirlar bo'lmagan balkaga deyiladi</p> <p>B) Ikki tayanchga tayangan va egilish deformatsiyasiga uchraydigan brus</p> <p>S) to'rtta tayanch tayanuvchi va oraliq sharniri bo'lgan balka</p> <p>D) Xamma javob tugri</p>                                                                                                                                                                                                                                                                                                                                                                       |
| 258. Eguvchi moment deb nimaga aytiladi?                       | <p>A) Eguvchi moment brusni ajratib olingan qismidagi barcha kuchlarning, balka kesilgan yuzasining kesim markaziga nisbatan kuch momentlarining algebraik yig'in-disiga teng.</p> <p>B) Eguvchi moment brusni ajratib olingan qismidagi barcha kuchlarning, balka kesilgan yuzasining kesim markaziga nisbatan proektsiyalarining algebraik yig'in-disiga teng.</p> <p>S) Eguvchi moment brusni ajratib olingan qismidagi barcha kuchlarning, balka urinma yuzasiga nisbatan kuch momentlarining algebraik yig'indisiga teng.</p> <p>D) Xamma javob to'g'ri</p>                                                                                   |

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| <p><b>259. Kundalang kuch deb nimga aytiladi?</b></p>            | <p>A) Ko'ndalang kuch balkaning ajratib olingan qismidagi barcha kuchlarni balkani kesilgan yuzasidagi kuch chiziqiga proektsiyalarining algebraik yig'indisiga teng</p> <p>B) ) Ko'ndalang kuch balkaning ajratib olingan qismidagi barcha kuchlarni balkani kesilgan yuzasidagi kuch chiziqiga perpendikulyar proektsiyalarining algebraik yig'indisiga teng</p> <p>S) ) Ko'ndalang kuch balkaning ajratib olingan qismidagi barcha kuchlarni balkani urinma yuzasidagi kuch chiziqiga proektsiyalarining algebraik yig'indisiga teng</p> <p>D) Xamma javob to'g'ri</p> |
| <p><b>260. Kundalang kuch kachon musbat ishorali buladi?</b></p> | <p>A) Brusning kesilgan kesimiga nisbatan balka kesimining siljish yo'nalishi soat strelkasining harakat yo'nalishi bilan mos tushsa</p> <p>B) Brusning urinma kesimiga nisbatan balka kesimining siljish yo'nalishi soat strelkasining harakat yo'nalishi bilan mos tushsa</p> <p>S) Brusning kesilgan kesimiga nisbatan balka kesimining siljish yo'nalishi soat strelkasining harakat yo'nalishi bilan mos tushmasa</p> <p>D) Xamma javob tugri</p>                                                                                                                    |
| <p><b>261. Eguvchi moment kachon musbat ishorali buladi?</b></p> | <p>A) Brusning kesilgan kesimiga nisbatan balka kesimining siljish yo'nalishi soat strelkasining harakat yo'nalishi bilan mos tushsa</p> <p>B) Brusni egilishida kesim markazi qabariq chiziqda qolsa eguvchi moment manfiy va botiq chiziqda qolsa musbat ishorali .</p> <p>S) Brusning kesilgan kesimiga nisbatan balka kesimining siljish yo'nalishi soat strelkasining harakat yo'nalishi bilan mos tushmasa</p> <p>D) Xamma javob tugri</p>                                                                                                                          |
| <p><b>262. Cof egilish deb nimaga aytiladi</b></p>               | <p>A) Faqat urinma kuchlanish ta'siridagi balkani deformatsiyasiga</p> <p>B) Urinma va normal kuchlanishlar ta'siridagi balkani deformatsiyasiga</p> <p>S) Faqat normal kuchlanish ta'siridagi balkani deformatsiyasiga</p> <p>D) Bosh kuchlanishlar ta'siridagi balkani deformatsiya-siga</p>                                                                                                                                                                                                                                                                            |
| <p><b>263. Neytral katlam deb nimaga aytiladi?</b></p>           | <p>A) Balkani egilishda o'zining boshlang'ich uzunligini o'zgartirmaydigan material qatlami neytral qatlam deyiladi.</p> <p>B) Balkaning ko'ndalang kesim yuzasi bilan neytral qatlamning kesishish chiziqi neytral katlam deyiladi</p> <p>S) Balkani egilishda o'zining boshlang'ich uzunligini o'zgartiradigan material qatlami neytral qatlam deyiladi</p> <p>D) Xamma javob tugri</p>                                                                                                                                                                                 |

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| <p><b>264.Neytral uk deb nimaga aytiladi?</b></p>                                                  | <p>A) Balkani egilishda o'zining boshlang'ich uzunligini o'zgartirmaydigan material qatlami neytral qatlam deyiladi.<br/> B) Balkaning ko'ndalang kesim yuzasi bilan neytral qatlamning kesishish chiziqli neytral katlam deyiladi<br/> S) Balkani egilishda o'zining boshlang'ich uzunligini o'zgartiradigan material qatlami neytral qatlam deyiladi<br/> D) Xamma javob tugri</p>                                                                                                                        |
| <p><b>265. Kesim markazi deb nimaga aytiladi?</b></p>                                              | <p>A) Balkani bo'ylama o'qi bilan kesish tekisligini kesishish nuqtasi kesim markazi deyiladi<br/> B) Balkani bo'ylama o'qiga parallel joylashgan tekisligini kesishish nuqtasi kesim markazi deyiladi<br/> S) Balkani ko'ndalang o'qi bilan kesish tekisligini kesishish nuqtasi kesim markazi deyiladi<br/> D) Hamma javob to'g'ri</p>                                                                                                                                                                    |
| <p><b>266.Ko'ndalang kuch va yoyilgan kuch intensivligi orasidagi differentsial bog'lanish</b></p> | <p><math>q = \frac{dQ}{dx}</math> , B) <math>Q = \frac{dM_x}{dx}</math> S) <math>q = -\frac{d^2M_x}{dx^2}</math><br/> A) D) Hamma javob to'g'ri</p>                                                                                                                                                                                                                                                                                                                                                         |
| <p><b>267.Ko'ndalang kuch va kuch momenti orasidagi differentsial bog'lanish</b></p>               | <p><math>q = \frac{dQ}{dx}</math> , B) <math>Q = \frac{dM_x}{dx}</math> S) <math>q = -\frac{d^2M_x}{dx^2}</math><br/> A) D) Hamma javob to'g'ri</p>                                                                                                                                                                                                                                                                                                                                                         |
| <p><b>268.Eguvchi moment va yoyilgan kuch intensivligi orasidagi differentsial bog'lanish</b></p>  | <p><math>q = \frac{dQ}{dx}</math> , B) <math>Q = \frac{dM_x}{dx}</math> S) <math>q = -\frac{d^2M_x}{dx^2}</math><br/> A) D) Hamma javob to'g'ri</p>                                                                                                                                                                                                                                                                                                                                                         |
| <p><b>269.Ko'ndalang kuch va yoyilgan kuch intensivligi orasidagi differentsial bog'lanish</b></p> | <p>A) balkaning ixtiyoriy kesimidagi ko'ndalang kuchning abstsissa bo'ylab birinchi tartibli hosilasi shu kesimdagi taqsimlangan kuch intensivligiga teng<br/> B) balkaning ixtiyoriy kesimidagi ko'ndalang kuch, shu kesimdagi eguvchi momentdan abstsissa bo'yicha olingan birinchi tartibli hosilasiga teng<br/> S) balkani biror nuqtasidagi taqsimlangan kuch intensivligi shu kesimdagi eguvchi momentdan abstsissa bo'ylab olingan ikkinchi tartibli hosilasiga teng<br/> D) Hamma javob to'g'ri</p> |
| <p><b>270.Ko'ndalang kuch va kuch momenti orasidagi</b></p>                                        | <p>A) balkaning ixtiyoriy kesimidagi ko'ndalang kuchning abstsissa bo'ylab birinchi tartibli hosilasi shu kesimdagi taqsimlangan kuch intensivligiga teng</p>                                                                                                                                                                                                                                                                                                                                               |



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| <b>differentzial bog'lanish</b>                                                            | <p>B) balkaning ixtiyoriy kesimidagi ko'ndalang kuch, shu kesimdagi eguvchi momentdan abstsissa bo'yicha olingan birinchi tartibli hosilasiga teng</p> <p>S) balkani biror nuqtasidagi taqsimlangan kuch intensivligi shu kesimdagi eguvchi momentdan abstsissa bo'ylab olingan ikkinchi tartibli hosilasiga teng</p> <p>D) Hamma javob to'g'ri</p>                                                                                                                                                               |
| <b>271.Eguvchi moment va yoyilgan kuch intensivligi orasidagi differentzial bog'lanish</b> | <p>A) balkaning ixtiyoriy kesimidagi ko'ndalang kuchning abstsissa bo'ylab birinchi tartibli hosilasi shu kesimdagi taqsimlangan kuch intensivligiga teng</p> <p>B) balkaning ixtiyoriy kesimidagi ko'ndalang kuch, shu kesimdagi eguvchi momentdan abstsissa bo'yicha olingan birinchi tartibli hosilasiga teng</p> <p>S) balkani biror nuqtasidagi taqsimlangan kuch intensivligi shu kesimdagi eguvchi momentdan abstsissa bo'ylab olingan ikkinchi tartibli hosilasiga teng</p> <p>D) Hamma javob to'g'ri</p> |
| <b>272. Egilishda normal kuchlanish formulasini ko'rsating?</b>                            | <p>A) <math>\sigma = \frac{F}{A}</math> S) <math>\sigma = \frac{Mz}{I_x}</math> B) <math>\sigma = \frac{Q \cdot S}{I \cdot b}</math> D) <math>\sigma = \frac{Mz}{S\rho}</math></p>                                                                                                                                                                                                                                                                                                                                |
| <b>273.Egilishda normal kuchlanish kanday tarkaladi?</b>                                   | <p>A) normal kuchlanish balka kesimining neytral o'qida nolga teng va neytral o'qdan eng uzoqda joylashgan nuqtasida maksimumga erishadi</p> <p>B) normal kuchlanish balka kesimining neytral o'qida maksimumga teng va neytral o'qdan eng uzoqda joylashgan nuqtasida nolga erishadi</p> <p>S) Kesimning neytral o'qidan bir xil masofada joylashgan yuzalardagi urinma kuchlanishlar o'zaro tengdir .</p> <p>D) Hamma javob to'g'ri</p>                                                                         |
| <b>274.Egilishda urinma kuchlanish kanday tarkaladi?</b>                                   | <p>A)Urinma kuchlanish balka kesimining neytral o'qida nolga teng va neytral o'qdan eng uzoqda joylashgan nuqtasida maksimumga erishadi</p> <p>B) Urinma kuchlanish to'g'ri to'rtburchakning balandligi bo'ylab parabola qonuniyati bilan o'zgaradi, kesimning chetki nuqtalarida nolga teng va neytral qatlamda eng katta qiymatga erishadi</p> <p>Kesimning neytral o'qidan bir xil masofada joylashgan yuzalardagi urinma kuchlanishlar o'zaro tengdir .</p> <p>D) Hamma javob to'g'ri</p>                     |
| <b>275. Egilishda urinma kuchlanish formulasini ko'rsating?</b>                            | <p>A) <math>\sigma = \frac{Mz}{I_x}</math> B) <math>\tau = \frac{Mz}{I}</math> S) <math>\tau = \frac{Q \cdot S_y}{I_y \cdot b}</math> D) <math>\tau = \frac{F}{A}</math></p>                                                                                                                                                                                                                                                                                                                                      |

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| <b>276. Egilishda urinma kuchlanish formulasini kim keltirib chiqardi?</b>                             | A) Juravskiy    B) Timoshenko    S) Puasson    D) Jukovskiy                                                                                                                                                                                                                                                                                                                  |
| <b>277. Egilishda normal kuchlanish bo'yicha mustahkamlik shartni ko'rsating?</b>                      | $A) \sigma = \frac{F}{A} \leq [\sigma];$ $B) \sigma = \frac{Mz_y}{S_y \rho} \leq [\sigma];$ $S) \sigma = \frac{M}{W_x} \leq [\sigma]$ $D) \sigma = \frac{Q \cdot S_y}{I_y \cdot d} \leq [\sigma]$                                                                                                                                                                            |
| <b>278. Egilishda normal kuchlanish bo'yicha mustahkamlik shartidan ruxsat etilgan yukni aniqlang?</b> | $A) F = W[\sigma];$ $B) M = W[\sigma];$ $S) F = W[\sigma]$ $D) Q = A[\tau]$                                                                                                                                                                                                                                                                                                  |
| <b>279. Egilishda normal kuchlanish bo'yicha mustahkamlik shartidan foydalanib kesimni tanlang?</b>    | $A) W \geq \frac{F}{[\sigma]};$ $B) A \geq \frac{F}{[\sigma]};$ $S) W \geq \frac{M}{[\sigma]};$ $D) \frac{I_y}{S_y} \geq \frac{Q}{b[\tau]}$                                                                                                                                                                                                                                  |
| <b>280. Egilishda urinma kuchlanish bo'yicha mustahkamlik shartni ko'rsating?</b>                      | $A) \tau = \frac{F}{A} \leq [\tau]$ $B) \tau = \frac{Q \cdot S_y}{I_y \cdot d} \leq [\tau]$ $S) \tau = \frac{M}{W_x} \leq [\tau]$ $D) \tau = \frac{Q}{A} \leq [\tau]$                                                                                                                                                                                                        |
| <b>281. Teng qarshilik ko'rsatuvchi balka deb nimaga aytiladi?</b>                                     | <p>A) Uzunligi bo'ylab kesim yuzasi o'zgarmaydigan balkaga.</p> <p>B) Uzunligi bo'ylab barcha kesim yuzalarida normal kuchlanish bir xil qiymatga ega bo'lgan balkaga.</p> <p>S) Uzunligi bo'ylab kesim yuzasi to'g'ri chiziqli qonuniyat asosida tanlangan balkaga.</p> <p>D) Uzunligi bo'ylab kesim yuzasida normal kuchlanish bir xil qiymatga ega bo'lmagan balkaga.</p> |
| <b>282. Teng qarshilik ko'rsatuvchi balka kesimining eni nimaga teng?</b>                              | $A) b_x = b \frac{x}{l}$ $B) b_x = b \frac{l}{x}$ $S) b_x = \frac{3Q}{2A}$ $D) b_x = \frac{3A}{2AQ}$                                                                                                                                                                                                                                                                         |
| <b>283. Balkaning salqiligi nima?</b>                                                                  | <p>A) Balka nuqtasini tashqi kuch ta'siridan ushbu kuchning ta'sir chiziki yunalishida kuchishi</p> <p>B) Balka nuqtasini tashqi kuch ta'siridan ushbu kuchning ta'sir chiziki yunalishiga teskari kuchishi</p> <p>S) Balka nuqtasini tashqi kuch ta'siridan ushbu kuchning ta'sir chizikiga perpendikulyar yunalishda kuchishi</p>                                          |

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|                                                                             | D) salqilik balka kesimining yon sirtida minimumga teng                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>284.Balka kesimining aylanish burchagi nima?</b>                         | <p>A) Balka nuqtasini tashki kuch ta'siridan ushbu kuchning ta'sir chiziki yunalishida kuchishi</p> <p>B) Balka kesimini tashki kuch ta'siridan boshlang'ich vaziyatiga nisbatan neytral uk atrofida ma'lum burchakka aylanishi</p> <p>S) Balka nuqtasini tashki kuch ta'siridan ushbu kuchning ta'sir chizikiga perpendikulyar yunalishda kuchishi</p> <p>D) Balka kesimini tashki kuch ta'siridan boshlang'ich vaziyatiga nisbatan ma'lum burchakka aylanishi</p>                                                                                                                                         |
| <b>285.Balka egilgan o'qining taqribiy differentsial tenglamasi qani?</b>   | <p>A) <math>y = \frac{M_c}{EI}</math>;</p> <p>B) <math>EIy'' = M_x</math>;</p> <p><math>\theta = \frac{Q_c}{EI}</math></p> <p>D) <math>y = \int \frac{\overline{M} \overline{M}_1 dx}{EI}</math></p> <p>S)</p>                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>286.Egilishda salqilikni grafoanalitik usul bilan aniqlang?</b>          | <p>A) <math>y = \frac{M_c}{EI}</math>;</p> <p>B) <math>EIy'' = M_x</math>;</p> <p><math>\theta = \frac{Q_c}{EI}</math></p> <p>D) <math>y = \int \frac{\overline{M} \overline{M}_1 dx}{EI}</math></p> <p>S)</p>                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>287. Qiyshiq egilish deb nimaga aytiladi?</b>                            | <p>A) Tashqi kuchning ta'sir chizig'i bo'ylama o'qiga perpendikulyar joylashib, ko'ndalang kesimi ning birorta ham bosh inertsia o'qlari tekisligidan o'tmaydigan sterjen-ning egilishi qiyshiq egilish deyiladi.</p> <p>B) bo'ylama o'qiga parallel kuch ta'sirida cho'zilish (siqilish) ga uchraydigan va ko'ndalang kesimining birorta ham bosh inertsia o'qlari tekisligida egilmay-digan brusning deformatsiyasi</p> <p>S) Kesim yuzasida buralishdagi urinma va egilishdagi normal kuchlanishlar hosil bo'ladigan brusning deformatsiyasiga qiyshiq egilish deyiladi</p> <p>D) Hamma jvob to'g'ri</p> |
| <b>288.Markaziy bo'lmagan cho'zilish yoki siqilish deb nimaga aytiladi?</b> | <p>A) Tashqi kuchning ta'sir chizig'i bo'ylama o'qiga perpendikulyar joylashib, ko'ndalang kesimining birorta ham bosh inertsia o'qlari tekisligidan o'tmaydigan sterjen-ning egilishi markazlashmagan egilish deyiladi.</p> <p>B) bo'ylama o'qiga parallel kuch ta'sirida cho'zilish (siqilish) ga uchraydigan va ko'ndalang kesimining birorta ham bosh inertsia o'qlari tekisligida egilmay-digan brusning deformatsiyasi</p> <p>S) Kesim yuzasida buralishdagi urinma va egilishdagi normal kuchlanishlar hosil bo'ladigan brusning deformatsiyasiga egilish deyiladi</p> <p>D) Hamma jvob to'g'ri</p>  |

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| <b>289. Buralish bilan egilishni birgalikdagi ta'siri nima?</b>                       | <p>A) Tashqi kuchning ta'sir chizig'i bo'ylama o'qiga perpendikulyar joylashib, ko'ndalang kesimining birorta ham bosh inertsia o'qlari tekisligidan o'tmaydigan sterjen egilish bilan buralishda bo'ladi.</p> <p>B) bo'ylama o'qiga parallel kuch ta'sirida cho'zilish (siqilish) ga uchraydigan va ko'ndalang kesimining birorta ham bosh inertsia o'qlari tekisligida egilmay-digan brusning deformatsiyasi</p> <p>S) Kesim yuzasida buralishdagi urinma va egilishdagi normal kuchlanishlar hosil bo'ladigan brusning deformatsiyasi</p> <p>D) Hamma javob to'g'ri</p> |
| <b>290. Qiyshik egilishda normal kuchlanish formulasini ko'rsating?</b>               | <p>A) <math>\sigma = \frac{F}{A} \left( 1 + \frac{y_0 y_F}{i_x^2} + \frac{x_0 x_F}{i_y^2} \right);</math>      B) <math>\sigma = \pm M \left( \frac{\cos \varphi}{W_y} + \frac{\sin \varphi}{W_z} \right)</math></p> <p>S) <math>\sigma = \frac{M_y \cdot y_c}{I_y} + \frac{M_z \cdot z_c}{I_z}</math>      D) <math>\sigma = \frac{F_z}{A} + \frac{F_y}{A}</math></p>                                                                                                                                                                                                     |
| <b>291. Qiyshiq egilishda neytral o'q tenglamasini ko'rsating?</b>                    | <p>A) <math>\frac{x^2}{a^2} + \frac{y^2}{b^2}</math>      B) <math>1 + \frac{y_0 y_F}{i_x^2} + \frac{x_0 x_F}{i_y^2} = 0;</math></p> <p>S) <math>\frac{\cos \varphi \cdot z_0}{I_y} + \frac{\sin \varphi \cdot y_0}{I_z} = 0</math>      D) <math>r = \frac{A}{\int_0^A \frac{dA}{\rho}}</math></p>                                                                                                                                                                                                                                                                        |
| <b>292. Qiyshiq egilishda mustahamlik shartni ko'rsating?</b>                         | <p>A) <math>\sigma = \frac{M_y \cdot y_c}{I_y} + \frac{M_z \cdot y_z}{I_z} \leq [\sigma]</math></p> <p>B) <math>\sigma = \frac{F_z}{A} + \frac{F_y}{A} \leq [\sigma]</math></p> <p>S) <math>\sigma = \frac{M}{W_y} \left( \cos \varphi + \frac{W_z}{W_y} \sin \varphi \right) \leq [\sigma]</math></p> <p>D) <math>\frac{F}{A} \left( 1 + \frac{y_0 y_F}{i_x^2} + \frac{x_0 x_F}{i_y^2} \right) \leq [\sigma]</math></p>                                                                                                                                                   |
| <b>293. Qiyshiq egilishda to'liq ko'chish formulasini ko'rsating?</b>                 | <p>A) <math>f = \frac{F \ell}{A}</math>      B) <math>f = \frac{M_{\delta} \ell}{G I_{\rho}}</math></p> <p>S) <math>f = \sqrt{f_z^2 + f_y^2}</math>      D) <math>f = \frac{M_c}{EI}</math></p>                                                                                                                                                                                                                                                                                                                                                                            |
| <b>294. Markaziy bo'lmagan cho'zilish va siqilishda normal kuchlanish formulasini</b> | <p>A) <math>\sigma = \frac{F}{A}</math>      B) <math>\sigma = \frac{M_x y}{I_x}</math></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

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| <b>kursating?</b>                                                                                                | $\sigma = \pm \frac{F_z x \cdot z_c}{I_y} \pm \frac{F_y x \cdot y_c}{I_z};$ <p>S) <math display="block">\sigma = \pm \frac{F}{A} + \frac{F \cdot y_F \cdot y}{I_x} \pm \frac{F \cdot x_F \cdot x}{I_y};</math></p>                                                  |
| <b>295. Markaziy bo'lmagan cho'zilish va siqilishda neytral o'q tenglamasi</b>                                   | <p>A) <math>\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1</math>      B) <math>1 + \frac{y_0 y_F}{i_x^2} + \frac{x_0 x_F}{i_y^2} = 0;</math></p> <p>S) <math>r = \frac{A}{\int_0^A \frac{dA}{\rho}}</math>      D) <math>tg \alpha = tg \varphi \frac{I_y}{I_z}</math></p>  |
| <b>296. Eyler formulasini ko'rsating?</b>                                                                        | <p>A) <math>F_k = [\sigma]A</math>      B) <math>F_k = [\tau]A</math></p> <p>S) <math>F_k = a - b\lambda</math>      D) <math>F_k = \frac{n^2 \pi^2 EI_{\min}}{(\mu \ell)^2}</math></p>                                                                             |
| <b>297. <math>\lambda \geq 100</math> sterjenlarda kritik kuchlanish qaysi formula bilan topiladi?</b>           | <p>A) <math>\sigma = \frac{F_k}{A}</math>      B) <math>\sigma_k = a - b\lambda</math></p> <p>V) <math>\sigma_k = \frac{\pi^2 E}{\lambda^2}</math>      G) <math>\sigma_k = \sigma_{ok}</math></p>                                                                  |
| <b>298. <math>40 \leq \lambda \leq 100</math> : sterjenlarda kritik kuchlanish qaysi formula bilan topiladi?</b> | <p>A) <math>\sigma = \frac{F_k}{A}</math>      B) <math>\sigma_k = a - b\lambda</math></p> <p>S) <math>\sigma_k = \frac{\pi^2 E}{\lambda^2}</math>      D) <math>\sigma_k = \sigma_{ok}</math></p>                                                                  |
| <b>299. Kritik kuch formulasini kim keltirib chiqardi?</b>                                                       | A) Yasinskiy   B) Dalamber   S) Eyler   D) Lomonosov                                                                                                                                                                                                                |
| <b>300. Eyler formulasini ko'rsating?</b>                                                                        | <p>A) <math>F_k = [\sigma]A</math>      B) <math>F_k = [\tau]A</math></p> <p>S) <math>F_k = a - b\lambda</math>      D) <math>F_k = \frac{n^2 \pi^2 EI_{\min}}{(\mu \ell)^2}</math></p>                                                                             |
| <b>301. Egiluvchanlik qaysi formula bilan topiladi?</b>                                                          | <p>A) <math>\lambda = \frac{4FR^3 n}{Gr^4}</math>      S) <math>\lambda = \mu \frac{\ell}{i_{\min}}</math></p> <p>B) <math>\lambda = \frac{F\ell}{EI}</math>      D) <math>\lambda = \frac{M_c}{EI}</math></p>                                                      |
| <b>302. Siqilgan sterjenlarni ustuvorlik shartini ko'rsating?</b>                                                | <p>A) <math>\sigma_k = \frac{F_k}{A} \leq [\sigma]</math>      B) <math>\sigma_k = \frac{F_k}{A \cdot \varphi} \leq [\sigma]</math></p> <p>S) <math>\sigma_k = \frac{\varphi \cdot F_k}{A \cdot \varphi} \leq [\sigma]</math>      D) V va S javoblari to'g'ri.</p> |

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| <b>303. Tekis tezlanishli ilgari-lanma harakatda dinamik kuchlanish?</b>       | <p>A) <math>\sigma_g = \sigma_{ct}(1 + \frac{a}{g})</math>      B) <math>\sigma_g = K_g \frac{q\ell^2}{8W}</math></p> <p>S) <math>\sigma_g = \frac{\gamma \varpi^2 D^2}{4g}</math>      D) <math>\sigma_g = \frac{\gamma F \varpi^2 r \ell^2}{9g\sqrt{3} \cdot W}</math></p>                                                                                                    |
| <b>304. Berilgan tezlanishli ilgarilanma harakatda dinamik koeffitsient?</b>   | <p>A) <math>K_g = 1 + \sqrt{1 + \frac{v^2}{g\delta_c}}</math>      B) <math>K_g = 1 + \frac{\delta_H}{\delta_c}</math></p> <p>S) <math>K_g = 1 + \frac{a}{g}</math>      D) <math>K_g = 1 + \frac{\omega^2 r}{\delta}</math></p>                                                                                                                                                |
| <b>305. Zarb ta'sirida kuchlanish formulasi?</b>                               | <p>A) <math>\sigma_g = \frac{Q}{A} K_g</math>      B) <math>\sigma_g = \sigma_c \left(1 + \frac{A}{\delta_c}\right)</math></p> <p>S) <math>\sigma_g = \frac{Q}{A} \left(1 + \sqrt{1 + \frac{2h}{\delta_c}}\right)</math>      D) <math>\sigma_g = K_g \frac{q\ell^2}{8W}</math></p>                                                                                             |
| <b>306. Zarb ta'sirida dinamik koeffitsient formulasi?</b>                     | <p>A) <math>K_g = 1 + \frac{\delta_H}{\delta_c} \beta</math>      B) <math>K_g = 1 + \frac{\omega^2 r}{g}</math></p> <p>S) <math>K_g = 1 + \sqrt{1 + \frac{2h}{\delta_c}}</math>      D) <math>K_g = 1 + \frac{a}{g}</math></p>                                                                                                                                                 |
| <b>307. O'zgaruvchan kuchlanishni ta'riflang?</b>                              | <p>A) Miqdorini davriy o'zgartiradigan kuchlanishga o'zgaruvchan kuchlanish deyiladi</p> <p>B) Zarb ta'siridagi kuchlanish</p> <p>S) Pozunni harakatida hosil bo'lgan kuchlanish</p> <p>D) Miqdorini davriy o'zgartirmaydigan kuchlanishga o'zgaruvchan kuchlanish deyiladi</p>                                                                                                 |
| <b>308. Materialni chidamlilik chegarasi nima?</b>                             | <p>A) Shunday tsikllar soni-ki, agar namuna ma'lum tsikllar soniga kadar emirilmasa, keyingi tsikllarda emirilmaydi</p> <p>B) Shunday tsikllar soni-ki, agar namuna ma'lum tsikllar sonida emirilsa, keyin ishlamaydi</p> <p>S) Shunday tsikllar soni-ki, agar namuna ma'lum tsikllar soniga kadar emirilmasa, keyin tsikllar takrorlanmaydi</p> <p>D) Val cheksiz aylanadi</p> |
| <b>309. Qiyshiq egilishda neytral o'q qanday chiziq?</b>                       | <p>A) Neytral o'q koordinata boshidan o'tmaydigan to'g'ri chiziq</p> <p>B) Neytral o'q koordinata boshidan o'tuvchi to'g'ri chiziq</p> <p>S) Neytral o'q kesimni sirtidan o'tuvchi to'g'ri chiziq</p> <p>D) kesimni neytral o'qi yo'q</p>                                                                                                                                       |
| <b>310 markazlashmagan cho'zilish ( siqilishda) neytral o'q qanday chiziq?</b> | <p>A) Neytral o'q koordinata boshidan o'tmaydigan to'g'ri chiziq</p> <p>B) Neytral o'q koordinata boshidan o'tuvchi to'g'ri chiziq</p> <p>S) Neytral o'q kesimni sirtidan o'tuvchi to'g'ri chiziq</p> <p>D) kesimni neytral o'qi yo'q</p>                                                                                                                                       |
| <b>311. Mexanizm nima?</b>                                                     | <p>A) Mashina detallarining majmuasi.</p> <p>B) Bir eki bir nechta jism harakatini boshqa jismlarning aniq qonuniyatdagi harakatiga aylantirib beruvchi qurilma.</p> <p>S) Moddiy nuqtalar majmuasi.</p>                                                                                                                                                                        |

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|                                                                | D) Xossasini va o'lchamini o'zgartiradigan buyum.                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>312.Richagli mexanizmlar deb nimaga aytiladi?</b>           | A) aylanma harakatni aylanma harakatga o'zgartirib beruvchi mexanizmlarga aytiladi<br>B) ilgarilanma-qaytma xarakatni ilgarilanma - qaytma harakatga o'zgartirib beruvchi mexanizmlarga aytiladi<br>S) tebranma harakatni tebranmaharakatga o'zgartirib beruvchi mexanizmlarga aytiladi<br>D) aylanma harakatni ilgarilanma-qaytma yoki ilgarilanma - qaytma harakatni aylanma harakatga o'zgartirib beruvchi mexanizmlarga aytiladi                                                               |
| <b>313.Richagli mexanizmlar turini to'g'ri tanlang?</b>        | A) Krivoship- polzunli, krivoship kormisloli, kulisali<br>B) Kulachokli va tishli mexanizmlar<br>S) Vintli va friksion mexanizmlar<br>D) Gidravlik va pnevmatik mexanizmlar, elektrik mexanizmlar.                                                                                                                                                                                                                                                                                                 |
| <b>314.Aksial mexanizm deb qanday mexanizmga aytiladi?</b>     | A) Polzun harakat tekisligining chiziqi etaklovchi bo'g'in bilan quyi kinematik juft hosil qilgan qo'zg'almas bo'g'indan o'tsa.<br>B) Polzun harakat tekisligining chiziqi etaklovchi bo'g'in bilan quyi kinematik juft hosil qilgan qo'zg'almas bo'g'indan o'tmasa.<br>S) Polzun harakat tekisligining chiziqi etaklovchi bo'g'in bilan quyi kinematik juft hosil qilgan qo'zg'almas bo'g'inga tik joylashsa.<br>D) Polzun bilan etaklovchi bo'g'in bir biriga tik joylashsa                      |
| <b>315. Dezaksial mexanizm deb qanday mexanizmga aytiladi?</b> | A) Polzun harakat tekisligining chiziqi etaklovchi bo'g'in bilan quyi kinematik juft hosil qilgan qo'zg'almas bo'g'indan o'tsa.<br>B) Polzun harakat tekisligining chiziqi etaklovchi bo'g'in bilan quyi kinematik juft hosil qilgan qo'zg'almas bo'g'indan pastda yoki yo'qoridan o'tsa.<br>S) Polzun harakat tekisligining chiziqi etaklovchi bo'g'in bilan quyi kinematik juft hosil qilgan qo'zg'almas bo'g'inga tik joylashsa.<br>B) Polzun bilan etaklovchi bo'g'in bir biriga tik joylashsa |
| <b>316.Bo'g'in deb nimaga aytiladi?</b>                        | A) Bir yoki bir nechta detallarning qo'zg'almas birikmasi.<br>B) Mexanizmni bir qismi.<br>S) Bir yoki bir nechta detallarning qo'zg'aluvchan birikmasi.<br>D) Bir-biriga nisbatan harakat qiladigan ikkita bo'g'inning birikmasi.                                                                                                                                                                                                                                                                  |
| <b>317.Kinematik juft deb nimaga aytiladi?</b>                 | A) Bir yoki bir nechta detallarning qo'zg'almas birikmasi.<br>B) Mexanizmni bir qismi.<br>S) Bir yoki bir nechta detallarning qo'zg'aluvchan birikmasi.<br>D) Bir-biriga nisbatan harakat qiladigan ikkita bo'g'inning                                                                                                                                                                                                                                                                             |

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|                                                                                      | birikmasi.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>318. Kulisali mexanizm deb qanday mexanizmga aytiladi?</b>                        | <p>A) to'rt bo'g'inli sharnirli mexanizmdagi polzunning qo'zg'almas yo'naltiruvchisi qo'zg'aluvchan bo'lsa</p> <p>B) to'rt bo'g'inli sharnirli mexanizmdagi polzunning qo'zg'almas yo'naltiruvchisi qo'zg'almas bo'lsa</p> <p>S) Sharnirli to'rt bo'g'inli mexanizmdagi koromislo o'rniga polzun o'rnatib, uni qo'zg'almas yo'naltiruvchi bo'ylab harakatga keltirsa</p> <p>D) Sharnirli to'rt bo'g'inli mexanizmdagi koromislo o'rniga polzun o'rnatib, uni qo'zg'almas yo'naltiruvchi bo'ylab harakatga keltirmasa</p>                                                                                                                                          |
| <b>319. Mashina mexanikasi nimani o'rganadi?</b>                                     | <p>A) mexanizm va mashinalar harakatini eksperimental o'rganib, ularning ish organlarini boshqa ish organlari bilan aloqasidagi harakat qonuniyatlarini topish</p> <p>B) mexanizm va mashinalar harakatini nazariy o'rganib, ularning ish organlarini boshqa ish organlari bilan aloqasidagi harakat qonuniyatlarini topish</p> <p>S) mexanizm va mashinalar harakatini nazariy va eksperimental o'rganib, ularning ish organlarini boshqa ish organlari bilan aloqasidagi harakat qonuniyatlarini topish</p> <p>D) mexanizm va mashinalar harakatini nazariy va eksperimental o'rganib, ularning ish organlarini boshqa ish organlari bilan aloqasini topish</p> |
| <b>320. Mexanizm qanday ishni bajaradi?</b>                                          | <p>A) mexanizm foydali ish bajaradi</p> <p>B) mexanizm energiyani bir turdan boshqa turga aylantira</p> <p>S) mexanizm foydali ish bajarmaydi va energiyani bir turdan boshqa turga aylantirmaydi</p> <p>D) ma'lum tartibda harakat qilish yoki harakatni uzatishdan iborat</p>                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>321. Sterjenli mexanizm deb qanday mexanizmga aytiladi?</b>                       | <p>A) aylanma harakatni ilgarilanma-qaytma yoki ilgarilanma - qaytma harakatni aylanma harakatga o'zgartirib beruvchi mexanizmlarga aytiladi</p> <p>B) aylanma harakatni ilgarilanma-qaytma harakatga o'zgartirib beruvchi mexanizmlarga aytiladi</p> <p>S) aylanma harakatni aylanma harakatga o'zgartirib beruvchi mexanizmlarga aytiladi</p> <p>D) tebranma harakatni aylanma harakatga o'zgartirib beruvchi mexanizmlarga aytiladi</p>                                                                                                                                                                                                                        |
| <b>322. Mexanizmlar nazariyasini o'rganishda bo'g'inlarning qanday ko'rinishidan</b> | <p>A) konstruktiv shaklidan</p> <p>B) kinematik sxemadan</p> <p>S) kinematik shaklidan</p> <p>D) konstruktiv sxemasidan</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |



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| <b>foydalaniladi?</b>                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>323.Krivoship nima?</b>                                           | A) Qo'zg'almas o'q atrofida aylanma harakat etadigan bug'in<br>B) Qo'zg'almas o'q atrofida tebranma harakat etadigan bug'in<br>S) Biror tekislikda murakkab harakat etadigan bug'in<br>D) Ilgarilanma – qaytma harakat etadigan bug'in                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>324.Koromislo nima?</b>                                           | A) Qo'zg'almas o'q atrofida aylanma harakat etadigan bug'in<br>B) Qo'zg'almas o'q atrofida tebranma harakat etadigan bug'in<br>S) Biror tekislikda murakkab harakat etadigan bug'in<br>D) Ilgarilanma – qaytma harakat etadigan bug'in                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>325.Shatun nima?</b>                                              | A) Qo'zg'almas o'q atrofida aylanma harakat etadigan bug'in<br>B) Qo'zg'almas o'q atrofida tebranma harakat etadigan bug'in<br>S) Biror tekislikda murakkab harakat etadigan bug'in<br>D) Ilgarilanma – qaytma harakat etadigan bug'in                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>326.Polzun nima?</b>                                              | A) Qo'zg'almas o'q atrofida aylanma harakat etadigan bug'in<br>B) Qo'zg'almas o'q atrofida tebranma harakat etadigan bug'in<br>S) Biror tekislikda murakkab harakat etadigan bug'in<br>D) Ilgarilanma – qaytma harakat etadigan bug'in                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>327.Polzun kanday xarakatlanadi</b>                               | A) Aylanma<br>B) Kuzgalmas<br>S) Ilgarilanma<br>D) Tebranma                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>328.Assur guruhi deb nimaga aytiladi?</b>                         | A) Harakatchanlik darajasi nolga teng bo'lgan strukturaviy guruh.<br>B) Quyi kinematik juft.<br>S) Oliy kinematik juft.<br>D) Harakatchanlik drajasi noldan farqli bo'lgan strukturaviy guruh                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>329.Mexanizm xosil kilishning Assur-Artobolev-skiy printsiipi</b> | A) Har qanday mexanizm etaklovchi bo'g'in bilan qo'zg'almas bo'g'inga harakatlanuvchanlik darajasi birga teng bo'lgan kinematik zanjirlarni ketma-ket qo'sha borib hosil qilinishi mumkin.<br>B) Har qanday mexanizm etaklovchi bo'g'in bilan qo'zg'almas bo'g'inga harakatlanmaydigan kinematik zanjirlarni ketma-ket qo'sha borib hosil qilinishi mumkin.<br>S) Har qanday mexanizm etaklovchi bo'g'in bilan qo'zg'almas bo'g'inga harakatlanuvchanlik darajasi nolga teng bo'lgan kinematik zanjirlarni ketma-ket qo'sha borib hosil qilinishi mumkin.<br>D) Har qanday mexanizm etaklovchi bo'g'in bilan qo'zg'almas bo'g'inga harakatlanuvchanlik darajasi ikkiga teng bo'lgan kinematik zanjirlarni ketma-ket qo'sha borib hosil qilinishi mumkin. |
| <b>330.Mexanizmlar analizi nima?</b>                                 | A) mexanizmlar kinematik va dinamik jihatdan tekshiriladi.<br>B) mexanizm bo'g'inlarining berilgan harakat qonunini amalga oshiruvchi mexanizm yaratish talab etiladi.<br>S) mexanizmlar kinematik jihatdan tekshiriladi.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

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|                                                             | D0 mexanizmlar dinamik jihatdan tekshiriladi.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>331.Mexanizmlar sintezi nima?</b>                        | A) mexanizmlar kinematik va dinamik jihatdan tekshiriladi.<br>B) mexanizm bo'g'inlarining berilgan harakat qonunini amalga oshiruvchi mexanizm yaratish talab etiladi.<br>S) mexanizmlar kinematik jihatdan tekshiriladi.<br>D) mexanizmlar dinamik jihatdan tekshiriladi.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>332.Mashinaning asosiy belgilari nimalardan niborat?</b> | A) mashina ma'lum tartibda tuzilgan bo'lishi; uning qismlari ma'lum tartibda harakatlanishi; mashina tegishli foydali mexanik ish bajarishi<br>B) uning qismlari ma'lum tartibda harakatlanishi;<br>S) mashina tegishli foydali mexanik ish bajarishi<br>D) mashina ma'lum tartibda tuzilgan bo'lishikerak                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>333.Mashinani mexanizmdan farki nimada?</b>              | A) uchta belgisidan birinchisi bulmaydi<br>B) uchta belgisidan ikkinchisi bulmaydi<br>S) uchta belgisidan xammasi buladi<br>D) uchta belgisidan oxirgisi bulmaydi                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>334.Mexanizm deb nimaga aytiladi?</b>                    | A) Kinematik zanjir tarkibiga kiruvchi qo'zg'almas bo'g'inga nisbatan bir yoki bir necha bo'g'in muayyan tartibda harakatlangan vaqtda zanjirning qolgan bo'g'inlari ham ma'lum tartibda harakat qilsa, bunday kinematik zanjir<br>B) Kinematik zanjir tarkibiga kiruvchi qo'zg'almas bo'g'inga nisbatan bir yoki bir necha bo'g'in muayyan tartibda harakatlangan vaqtda zanjirning qolgan bo'g'inlari harakat qilsa, bunday kinematik zanjir<br>S) Kinematik zanjir tarkibiga kiruvchi qo'zg'almas bo'g'inga nisbatan bir yoki bir necha bo'g'in harakatlangan vaqtda zanjirning qolgan bo'g'inlari ham ma'lum tartibda harakat qilsa, bunday kinematik zanjir<br>D) Kinematik zanjir tarkibiga kiruvchi qo'zg'aluvchan bo'g'inga nisbatan bir bo'g'in harakatlangan vaqtda zanjirning qolgan bo'g'inlari ham ma'lum tartibda harakat qilsa, bunday kinematik zanjir |
| <b>335.Kinematik zanjir deb nimaga aytiladi?</b>            | A) Bir necha bo'g'inning kinematik juftlar vositasi bilan birikishidan hosil bo'lgan qo'zg'aluvchi sistema kinematik zanjir deb ataladi.<br>B) kinematik zanjir tarkibiga kiruvchi bo'g'inlarning biri fakat ikkitadan kinematik juftga kirs<br>S) Kinematik zanjirlar tarkibiga kiruvchi har bir bo'g'in eng kamida ikkita kinematik juftga qo'shilsa<br>D) ikkitadan ortiq kinematik juftga qo'shilsa                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>336.Oddiy kinematik zanjir deb nimaga aytiladi?</b>      | A) kinematik zanjir tarkibiga kiruvchi bo'g'inlarning biri fakat ikkitadan kinematik juftga kirs<br>B) Bir necha bo'g'inning kinematik juftlar vositasi bilan birikishidan hosil bo'lgan qo'zg'aluvchi sistema kinematik                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

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|                                                                 | <p>zanjir deb ataladi.</p> <p>S) Kinematik zanjirlar tarkibiga kiruvchi har bir bo'g'in eng kamida ikkita kinematik juftga qo'shilsa</p> <p>D) ikkitadan ortiq kinematik juftga qo'shilsa</p>                                                                                                                                                                                                                                                                                     |
| <b>337.Murakkab kinematik zanjir deb nimaga aytiladi?</b>       | <p>A) Kinematik zanjirlar tarkibiga kiruvchi har bir bo'g'in ikkitadan ortiq kinematik juftga qo'shilsa</p> <p>B) Bir necha bo'g'inning kinematik juftlar vositasi bilan birikishidan hosil bo'lgan qo'zg'aluvchi sistema kinematik zanjir deb ataladi.</p> <p>S) kinematik zanjir tarkibiga kiruvchi bo'g'inlarning biri fakat ikkitadan kinematik juftga kirs</p> <p>D) Kinematik zanjirlar tarkibiga kiruvchi har bir bo'g'in eng kamida ikkita kinematik juftga qo'shilsa</p> |
| <b>338.Ochik kinematik zanjir deb nimaga aytiladi?</b>          | <p>A) kinematik zanjir tarkibiga kiruvchi bo'g'inlarning biri fakat ikkitadan kinematik juftga kirs</p> <p>B) Bir necha bo'g'inning kinematik juftlar vositasi bilan birikishidan hosil bo'lgan qo'zg'aluvchi sistema kinematik zanjir deb ataladi.</p> <p>S) Kinematik zanjirlar tarkibiga kiruvchi har bir bo'g'in eng kamida ikkita kinematik juftga qo'shilsa</p> <p>D) ikkitadan ortiq kinematik juftga qo'shilsa</p>                                                        |
| <b>339. Yopik kinematik zanjir deb nimaga aytiladi?</b>         | <p>A) Kinematik zanjirlar tarkibiga kiruvchi har bir bo'g'in eng kamida ikkita kinematik juftga qo'shilsa</p> <p>B) Bir necha bo'g'inning kinematik juftlar vositasi bilan birikishidan hosil bo'lgan qo'zg'aluvchi sistema kinematik zanjir deb ataladi.</p> <p>S) kinematik zanjir tarkibiga kiruvchi bo'g'inlarning biri fakat ikkitadan kinematik juftga kirs</p> <p>D) ikkitadan ortiq kinematik juftga qo'shilsa</p>                                                        |
| <b>340.Mexanizmning klassini nima belgilaydi?</b>               | <p>A) harakatlanuvchan bo'g'inlar soni</p> <p>B) kinematik juftlar soni</p> <p>S) harakatlanuvchan bo'g'inlar va kinematik juftlar soni</p> <p>D) ochiq zanjirlar</p>                                                                                                                                                                                                                                                                                                             |
| <b>341.Bug'inning erkinlik darajasi nima bilan belgilanadi?</b> | <p>A) Bir-biriga bog'lanmagan harakatlar soni bilan</p> <p>B) Mexanizm bo'g'inlarini fazoda qo'zg'ala olish xususiyati bilan</p> <p>S) Mexanizmdagi etakchi bo'g'inlar soni bilan</p> <p>D) Kinematik juftlar soni bilan</p>                                                                                                                                                                                                                                                      |
| <b>342. Kinematik juftning elementlari nima?</b>                | <p>A) sirt, nuqta</p> <p>B) sirt, nuqta, chiziq</p> <p>S) nuqta, chiziq</p> <p>D) sirt, chiziq</p>                                                                                                                                                                                                                                                                                                                                                                                |
| <b>343. Kinematik juftlardagi bog'lanish shart-</b>             | <p>A) Bo'g'inlarning tartibli harakatiga qo'yilgan chek</p> <p>B) Bo'g'inlarning ilgarilanma harakatiga qo'yilgan chek</p> <p>S) Bo'g'inlarning tebranma harakatiga qo'yilgan chek</p>                                                                                                                                                                                                                                                                                            |

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| <b>lari deb nimaga aytiladi?</b>                                            | D) Bo'g'inlarning nisbiy (tartibsiz) harakatiga qo'yilgan chek                                                                                                                                                                                                                                                                                                                          |
| <b>344. Yzgaruvchan koordinatalar soni bo'g'inining nimasini aniqlaydi?</b> | A) erkinlik darajasini<br>B) harakatchanlik darajasini<br>S) bo'g'inining klassini<br>D) bo'g'inining tartibini                                                                                                                                                                                                                                                                         |
| <b>345. Quyi kinematik juft nima?</b>                                       | A) Sirt vositasida hosil bo'lgan birikma.<br>B) Nuqta vositasida hosil bo'lgan birikma<br>S) Chiziq vositasida hosil bo'lgan birikma<br>D) Asur guruhi                                                                                                                                                                                                                                  |
| <b>346. Oliy kinematik juft nima?</b>                                       | A) Sirt vositasida hosil bo'lgan birikma.<br>B) Nuqta vositasida hosil bo'lgan birikma<br>S) Chiziq vositasida hosil bo'lgan birikma<br>D) Asur guruhi                                                                                                                                                                                                                                  |
| <b>347. Mexanizmning harakatlanuvchanligi nimani belgilaydi?</b>            | A) Bir-biriga bog'lanmagan harakatlar soni<br>B) Mexanizm bo'g'inlarini fazoda qo'zg'ala olish xususiyati<br>S) Mexanizmdagi etakchi bo'g'in sonini bildiradi<br>D) Kinematik juftlar sonini bildiradi                                                                                                                                                                                  |
| <b>348. Mexanizmning harakatlanuvchanlik darajasi nimani belgilaydi?</b>    | A) Bir-biriga bog'lanmagan harakatlar soni<br>B) Mexanizm bo'g'inlarini fazoda qo'zg'ala olish xususiyati<br>S) Mexanizmdagi etakchi bo'g'in sonini bildiradi<br>D) Kinematik juftlar sonini bildiradi                                                                                                                                                                                  |
| <b>349. mexanizm deb nimaga aytiladi?</b>                                   | A) Mexanizm tarkibidagi bo'g'inlar bir xil harakatlana-digan mexanizm<br>B) Mexanizm tarkibidagi bo'g'inlar bir xil harakatlan-magan mexanizm<br>S) Mexanizm tarkibidagi bo'g'inlarxar xil harakatlana-digan mexanizm<br>D) Mexanizm tarkibidagi barcha bo'g'inlar bir tekislikda yoki parallel tekisliklarda harakatlanadigan mexanizm                                                 |
| <b>350. Tishli mexanizm deb nimaga aytiladi?</b>                            | A) aylanma harakatni ilgarilanma-qaytma yoki ilgarilanma - qaytma harakatni aylanma harakatga o'zgartirib beruvchi mexanizmlarga aytiladi<br>B) aylanma harakatni tebranma harakatga o'zgartirib beruvchi mexanizmlarga aytiladi<br>S) tebranma xarakatni aylanma xarakatga o'zgartirib beruvchi mexanizmlarga aytiladi<br>D) bir bo'g'indan ikkinchi bo'g'inga aylanma harakat uzatish |
| <b>351. Doiraviy tsilindrik tishli g'ildirak deb nimaga aytiladi?</b>       | A) G'ildirak tishlari doiraviy tsilindr sirtiga joylashgan bo'lsa<br>B) g'ildiraklardan birining tishlari tsilindrning ichki yuzasiga joylashgan bo'lsa<br>S) tishli ikkala bo'g'indagi tishlar tsilindrning sirtqi yuzasiga                                                                                                                                                            |

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|                                                                                                   | o'rnatilgan bo'lsa<br>D) Tsilindrik ilashishda tishli g'ildiraklardan biri reyka bo'lsa                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>352. Kinematik juft erkinlik darajasi bilan bog'lanishlar sonining yig'indisi nimaga teng?</b> | A) mumkin bo'lgan harakatlar soniga<br>B) mumkin bo'lmagan harakatlar soniga<br>S) murakkab harakatga<br>D) Oddiy harakatga                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>353.Sferik juftlik nima?</b>                                                                   | A) qo'zg'aluvchanligi bitta bo'lgan juftlik, bo'g'inlari o'z o'qi atrofida nisbiy aylanma harakat qiladi, geometrik yopiq quyi kinematik juft<br>B) qo'zg'aluvchanligi bitta bo'lgan, bo'g'inlari faqat to'g'ri chiziqli nisbiy ilgarilanma harakat qiladigan geometrik yopiq tarzdagi quyi kinematik juft<br>S) qo'zg'aluvchanligi ikkita bo'lgan, bo'g'inlari mustaqil ravishda aylanma va to'g'ri chiziqli ilgarilanma nisbiy harakatlar qiladigan, geometrik yopiq tarzdagi quyi kinematik juft<br>D) qo'zg'aluvchanligi uchta bo'lgan, bo'g'inlari $x, y, z$ o'qlari atrofida mustaqil ravishda uch marta nisbiy aylana oladigan, geometrik yopiq tarzdagi quyi kinematik juft |
| <b>354.Tsilindr-simon juftlik nima?</b>                                                           | A) qo'zg'aluvchanligi bitta bo'lgan juftlik, bo'g'inlari o'z o'qi atrofida nisbiy aylanma harakat qiladi, geometrik yopiq quyi kinematik juft<br>B) qo'zg'aluvchanligi bitta bo'lgan, bo'g'inlari faqat to'g'ri chiziqli nisbiy ilgarilanma harakat qiladigan geometrik yopiq tarzdagi quyi kinematik juft<br>S) qo'zg'aluvchanligi ikkita bo'lgan, bo'g'inlari mustaqil ravishda aylanma va to'g'ri chiziqli ilgarilanma nisbiy harakatlar qiladigan, geometrik yopiq tarzdagi quyi kinematik juft<br>D) qo'zg'aluvchanligi uchta bo'lgan, bo'g'inlari $x, y, z$ o'qlari atrofida mustaqil ravishda uch marta nisbiy aylana oladigan, geometrik yopiq tarzdagi quyi kinematik juft |
| <b>355. Aylanma juftlik nima?</b>                                                                 | A) qo'zg'aluvchanligi bitta bo'lgan juftlik, bo'g'inlari o'z o'qi atrofida nisbiy aylanma harakat qiladi, geometrik yopiq quyi kinematik juft<br>B) qo'zg'aluvchanligi bitta bo'lgan, bo'g'inlari faqat to'g'ri chiziqli nisbiy ilgarilanma harakat qiladigan geometrik yopiq tarzdagi quyi kinematik juft<br>S) qo'zg'aluvchanligi ikkita bo'lgan, bo'g'inlari mustaqil ravishda aylanma va to'g'ri chiziqli ilgarilanma nisbiy harakatlar qiladigan, geometrik yopiq tarzdagi quyi kinematik juft                                                                                                                                                                                 |

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|                                                                                       | D) qo'zg'aluvchanligi uchta bo'lgan, bo'g'inlari $X, Y, Z$ o'qlari atrofida mustaqil ravishda uch marta nisbiy aylana oladigan, geometrik yopiq tarzdagi quyi kinematik juft                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>356. Ilgarilanma juftlik nima?</b>                                                 | <p>A) qo'zg'aluvchanligi bitta bo'lgan juftlik, bo'g'inlari o'z o'qi atrofida nisbiy aylanma harakat qiladi, geometrik yopiq quyi kinematik juft</p> <p>B) qo'zg'aluvchanligi bitta bo'lgan, bo'g'inlari faqat to'g'ri chiziqli nisbiy ilgarilanma harakat qiladigan geometrik yopiq tarzdagi quyi kinematik juft</p> <p>S) qo'zg'aluvchanligi ikkita bo'lgan, bo'g'inlari mustaqil ravishda aylanma va to'g'ri chiziqli ilgarilanma nisbiy harakatlar qiladigan, geometrik yopiq tarzdagi quyi kinematik juft</p> <p>D) qo'zg'aluvchanligi uchta bo'lgan, bo'g'inlari <math>X, Y, Z</math> o'qlari atrofida mustaqil ravishda uch marta nisbiy aylana oladigan, geometrik yopiq tarzdagi quyi kinematik juft</p> |
| <b>357. Qo'zg'almas bo'g'un va krivo-ship birikmasi-da qanday harakat bajariladi?</b> | <p>A) aylanma</p> <p>B) tebranma</p> <p>S) ilgarilanma - qaytma</p> <p>D) tekis parallel</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>358. Qo'zg'almas bo'g'un va koromislo birikma-sida qanday harakat bajariladi?</b>  | <p>A) aylanma</p> <p>B) tebranma</p> <p>S) ilgarilanma - qaytma</p> <p>D) tekis parallel</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>359. Polzun yo'naltiruvchi birikmasida qanday harakat bajariladi?</b>              | <p>A) aylanma</p> <p>B) tebranma</p> <p>S) ilgarilanma - qaytma</p> <p>D) tekis parallel</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>360. Bog'lanishning ta'siri qanday shart bilan baholanadi?</b>                     | <p>A) bog'lanishlar sharti deb ataluvchi cheklanishlar soni bilan</p> <p>B) bog'lanishlar shartiga kirmagan cheklanishlar soni bilan</p> <p>S) bog'lanishlar shartiga kirgan cheklanishlar bilan</p> <p>D) bog'lanishlar shartidan tashqi soni bilan</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>361. Har bir bog'lanish sharti nimadan mahrum etadi?</b>                           | <p>A) ikkita harakatdan</p> <p>B) bitta harakatdan</p> <p>S) uchta harakatdan</p> <p>D) oltita harakatdan</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>362. Tekis mexanizmlarning tuzilish formulasi?</b>                                 | <p>A) <math>S = 6 - H</math></p> <p>B) <math>S + H = 6</math></p> <p>S) <math>W = 3n - 2P_5 - P_4</math></p> <p>D) <math>W = 2n - 2P_5 - P_4</math></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>363. Dobrovol-skiy formulasi-ni</b>                                                | <p>A) <math>S = 6 - H</math></p> <p>B) <math>S + H = 6</math></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

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| <b>kursating?</b>                                                                                           | S) $W = 3n - 2P_5 - P_4$ D) $W = 2n - 2P_5 - P_4$                                                                                                            |
| <b>364. Chebishev formulasini kursating?</b>                                                                | A) $S = 6 - H$ B) $S + H = 6$<br>S) $W = 3n - 2P_5 - P_4$ D) $W = 2n - 2P_5 - P_4$                                                                           |
| <b>365. Chebishev formulasi</b><br>$W = 3n - 2P_5 - P_4$ -<br><b>dagi <math>P_5</math> nimani bildiradi</b> | A) 5- klass kinematik juftlar sonini<br>B) 4- klass kinematik juftlar sonini<br>S) 3- klass kinematik juftlar sonini<br>D) 2- klass kinematik juftlar sonini |
| <b>366. Chebishev formulasi</b><br>$W = 3n - 2P_5 - P_4$ -<br><b>dagi <math>n</math> nimani bildiradi</b>   | A) Bo'g'inning yukori sinf darajasini<br>B) Qo'zg'aluvchi bo'g'inlar sonini<br>S) Buginning kuyi sinf darajasini<br>D) Kuzgalmas bo'g'inlar sonini           |
| <b>367. Normal tezlanish qaysi formula bilan topiladi?</b>                                                  | A) $a^n = \omega^2 \cdot \ell_{OA}$ B) $a^n = \varepsilon \cdot \ell_{OA}$<br>S) $a^n = \sqrt{a + a^\tau}$ D) $a = \frac{dV}{dt}$                            |
| <b>368. Tangentsial tezlanish qaysi formula bilan topiladi?</b>                                             | A) $a_\tau = \omega^2 \cdot \ell_{OA}$ B) $a_\tau = \varepsilon \cdot \ell_{OA}$<br>S) $a_\tau = \sqrt{a + a^n}$ D) $a = \frac{dV}{dt}$                      |
| <b>369. Uzunlik masshtabi ko'effitsientini ko'rsating</b>                                                   | A) $\mu = \frac{\ell}{ \ell }$ B) $\mu = \frac{S_{\max}}{ y }$<br>S) $\mu = \frac{\mu_s}{H \cdot \mu_t}$ D) $\mu = \frac{\mu_v}{\pi \cdot \mu_t}$            |
| <b>370. Siljish diagrammasi masshtabini ko'rsating?</b>                                                     | A) $\mu = \frac{\ell}{ \ell }$ B) $\mu = \frac{S_{\max}}{ y }$<br>S) $\mu = \frac{\mu_s}{H \cdot \mu_t}$ D) $\mu = \frac{\mu_v}{\pi \cdot \mu_t}$            |
| <b>371. Tezlik grafigining masshtabini ko'rsating?</b>                                                      | A) $\mu = \frac{\ell}{ \ell }$ B) $\mu = \frac{S_{\max}}{ y }$<br>S) $\mu = \frac{\mu_s}{H \cdot \mu_t}$ D) $\mu = \frac{\mu_v}{\pi \cdot \mu_t}$            |
| <b>372. Tezlanish grafigining masshtabini ko'rsating</b>                                                    | A) $\mu = \frac{\ell}{ \ell }$ B) $\mu = \frac{S_{\max}}{ y }$                                                                                               |

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|                                                         | $\text{S) } \mu = \frac{\mu_s}{H \cdot \mu_t} \qquad \text{D) } \mu = \frac{\mu_v}{\pi \cdot \mu_t}$                                                                                                                                                                                                                                                                                                                                                                     |
| <b>373. Tezlik planining masshtabini ko'rsating?</b>    | $\text{A) } \mu = \frac{\ell}{ \ell } \quad \text{B) } \mu = \frac{S_{\max}}{ y } \quad \text{S) } \mu = \frac{\mu_s}{H \cdot \mu_t} \quad \text{D) } \mu = \frac{V_A}{\pi \cdot a}$                                                                                                                                                                                                                                                                                     |
| <b>374. Tezlanish planining masshtabini ko'rsating?</b> | $\text{A) } \mu = \frac{\ell}{ \ell } \quad \text{B) } \mu = \frac{S_{\max}}{ y } \quad \text{S) } \mu = \frac{\mu_s}{H \cdot \mu_t} \quad \text{D) } \mu = \frac{a_A}{\pi_1 \cdot a_1}$                                                                                                                                                                                                                                                                                 |
| <b>375. Mashina nima?</b>                               | <p>A) Energiya hosil qilish uchun harakatlanadigan, quvvat, materiallar va ahborotni to'plash va o'zgartirishda harakat bilan ta'minlovchi insonni jismoniy va akliy mexnatini engillashtiradigan qurilma.</p> <p>B) Detallarni majmuasi.</p> <p>S) Mexanizmlar majmuasi.</p> <p>D) Energiya iste'mol qiluvchi qurilma.</p>                                                                                                                                              |
| <b>376. Detal deb nimaga aytiladi</b>                   | <p>A) Yigib xosil kilinadigan buyumga</p> <p>B) Yig'ma birligisiz bir jinsli materialdan tayyorlangan buyum</p> <p>S) O'zaro biriktirilgan detallardan tashkil topgan tugallangan yig'ma birlik</p> <p>D) bolt va gayka</p>                                                                                                                                                                                                                                              |
| <b>377. Mashina detallari fanining vazifasi nima?</b>   | <p>A) xizmat vazifasi bir xil bo'lgan mexanizm va mashina detallarining ishlashi va ularni hisoblash asoslarini o'rganish.</p> <p>B) xizmat vazifasi bir xil bo'lgan mexanizm va mashina detallarining tuzilishi, ishlashi va ularni hisoblash va loyihalash asoslarini o'rganish.</p> <p>S) xizmat vazifasi bir xil bo'lgan mexanizm va mashina detallarining tuzilishi va loyihalash asoslarini o'rganish.</p> <p>D) Mashina detallarining birikmalarini o'rganadi</p> |
| <b>378. Uzel deb nimaga aytiladi</b>                    | <p>A) Boshkarish apparati, energiya manbai va uzatish mexanizmidan tashkil topgan mashina yoki mexanizmni harakatga keltiradigan qurilmaga</p> <p>B) Yig'ma birligisiz bir jinsli materialdan tayyorlangan buyum</p> <p>S) O'zaro biriktirilgan detallardan tashkil topgan tugallangan yig'ma birlik</p> <p>D) bolt va gaykani birikmasi</p>                                                                                                                             |
| <b>379. Yuritma deb nimaga aytiladi</b>                 | <p>A) Boshkarish apparati, energiya manbai va uzatish mexanizmidan tashkil topgan mashina yoki mexanizmni harakatga keltiradigan qurilmaga</p> <p>B) Yig'ma birligisiz bir jinsli materialdan tayyorlangan buyum</p> <p>S) O'zaro biriktirilgan detallardan tashkil topgan tugallangan yig'ma birlik</p> <p>D) bolt va gaykani birikmasi</p>                                                                                                                             |





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|                                                                        | qurilma.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>387. Mexanik uzatmalarning turlari</b>                              | A) Friksion, tishli, chervyakli, remenli, zanjirli<br>B) Friksion, chervyakli, remenli, zanjirli<br>S) Friksion, tishli, zanjirli<br>D) Zanjirli                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>388. Mashina detallari bo'li-mida qanday uzatmalar o'rganiladi?</b> | A) mexanik<br>S) havoli<br>B) suyuqlikli<br>D) havoli-mexanik                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>389. Yuritmaning blok sxemasi qaysi?</b>                            | A) dvigatel-uzatish mexanizmi-ishchi mexanizm<br>B) dvigatel- ishchi mexanizm- uzatish mexanizmi<br>S) ishchi mexanizm -dvigatel-uzatish mexanizmi<br>D) uzatish mexanizmi-dvigatel- ishchi mexanizm                                                                                                                                                                                                                                                                                                                                                                               |
| <b>390. Tsilindrik tishli uzatma nimalardan tashkil topadi?</b>        | A) ikkita tishli g'ildirakdan<br>S) ikki uchburchakdan<br>B) ikki konusdan<br>D) ikki kvadratdan                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>391. Chervyakli uzatma nimalardan tashkil topadi?</b>               | A) chervyak va chervyak<br>S) ikki uchburchakdan<br>B) ikki konusdan<br>D) ikki tsilindrdan                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>392. Konussimon uzatma nimalardan tashkil topadi?</b>               | A) chervyak va chervyak g'ildiragi<br>B) ikki konusdan<br>S) ikkita konussimon tishli g'ildirakdan<br>D) ikki tsilindrdan                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>393. Tishli uzatma deb nimaga aytiladi?</b>                         | A) dvigateldan mashinaning ish organlariga–aylan-tiruvchi momentlarni, tezliklarni, harakat xarakterini o'zgartirib uzatishga imkon beruvchi qurilma<br>B) aylanma harakatni uzatish, aylanma harakatni ilgari- lanma harakatga yoki, aksincha, ilgarilanma harakatni aylanma harakatga o'zgartirish uchun xizmat qiladi.<br>S) dvigateldan mashinaning ish organlariga–aylantiruvchi momentlarning xarakterini o'zgartirib uzatishga imkon beruvchi qurilma.<br>D) dvigateldan mashinaning ish organlariga–aylantiruvchi momentlarni, tezliklarni, o'zgartirib uzatuvchi qurilma. |
| <b>394. Tishli uzatmalarning turlari</b>                               | A) tsilindrik, konussimon, shevron<br>S) friksion<br>B) chervyakli<br>D) shponkali                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>395. O'qlari parallel uzatmani toping?</b>                          | A) tsilindrik<br>S) chervyakli<br>B) konussimon<br>D) konussimon-tsilindrik                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>396. O'qlari kesishadigan</b>                                       | A) tsilindrik<br>B) konussimon                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

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| <b>uzatmani toping?</b>                                                                      | S) chervyakli                                                                                                                                                                                                                              | D) konussimon-tsilindrik                                 |
| <b>397. O'qlari ayqashaligan uzatmani toping?</b>                                            | A) tsilindrik<br>S) chervyakli                                                                                                                                                                                                             | B) konussimon<br>D) konussimon-tsilindrik                |
| <b>398. Tsilindrik tishli uzatmalarda asosiy geometrik parametr kaysi?</b>                   | A) $m$ -ilashma moduli<br>S) $d_{cm}$ - stupittsa diametri                                                                                                                                                                                 | B) $t$ - tish kadami<br>D) $l_{cm}$ - stupittsa uzunligi |
| <b>399. Tishning kaysi asosiy parametri standartlash-tirilgan?</b>                           | A) $m$ -ilashma moduli<br>S) $d_{cm}$ - stupittsa diametri                                                                                                                                                                                 | B) $t$ - tish kadami<br>D) $l_{cm}$ - stupittsa uzunligi |
| <b>400. Tsilindrik tishli gildirak tishining uchidan o'tuvchi aylana kanday belgiladi?</b>   | A) $d_a$<br>S) $d_1$                                                                                                                                                                                                                       | B) $d_f$<br>D) $d_m$                                     |
| <b>401. Tsilindrik tishli gildirak tishining tubidan o'tuvchi diametri kaysi?</b>            | A) $d_f$<br>S) $d_1$                                                                                                                                                                                                                       | B) $d_a$<br>D) $d_m$                                     |
| <b>402. Tishning qiya burchagi kanchaga cheklangan?</b>                                      | A) $8^\circ \div 15^\circ$<br>S) $3^\circ \div 10^\circ$                                                                                                                                                                                   | B) $5^\circ \div 25^\circ$<br>D) $0^\circ \div 8^\circ$  |
| <b>403. Chervyakli uzatmada chervyak-ning kirimlar soni qancha miqdorda olinadi?</b>         | A) 1...4<br>S) 10...12                                                                                                                                                                                                                     | B) 17<br>D) 12...15                                      |
| <b>404. Chervyakli uzatmada <math>z_1</math> ning qaysi miqdorida F.I.K. yuqori bo'ladi?</b> | A) $z_1 = 1$<br>S) $z_1 = 2$                                                                                                                                                                                                               | B) $z_1 = 4$<br>D) $z_1 = 3$                             |
| <b>405. Buluvchi aylana deb nimaga aytiladi?</b>                                             | A) tsilindrni teng Z kismga bo'lish jarayonida tayyorlangan g'ildirak aylanasi<br>B) tsilindrni teng Z kismga kupaytirish jarayonida tayyorlangan g'ildirak aylanasi<br>S) Tsilindrni aylanasi<br>D) sirtiga tishlar tayyorlangan gildirak |                                                          |
| <b>406. Tishni moduli nima?</b>                                                              | A) Qadamidan - $\pi$ marotaba kichik bo'lgan chiziqli kattalik.<br>B) Buluvchi aylanani - $\pi$ qiymatga bo'linmasi bilan topiladi.                                                                                                        |                                                          |



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| <b>413.Reduktorning bikrlilik talabi nima?</b>           | <p>A) metall kesuvchi stanoklar, dvigatellar, reduktorlar korpusiga qo'yiladigan asosiy talab bo'lib, tashqi ta'sirdan (tebranish ) deformatsiyalanmaslikdir</p> <p>B) katta yuklanishni qabul qilib fundamentga uzatadigan korpus detallarining ishlash layoqatini belgilovchi xarakteristikani aniqlaydi</p> <p>S) ayrim, masalan uchuvchi apparatlar, bug' turbinalari va kondensatorlar korpuslarining ishlash sharoitini belgilaydi.</p> <p>D) korpus oddiy va kam xarajatli shaklda tayyorlanishi.</p> |
| <b>414.Reduktorning texnologik xususiyati nima?</b>      | <p>A) korpus oddiy va kam xarajatli shaklda tayyorlanishi.</p> <p>B) reduktorlar korpusiga qo'yiladigan asosiy talab bo'lib, tashqi ta'sirdan deformatsiyalanmaslikdir</p> <p>S) katta yuklanishni qabul qilib fundamentga uzatadigan korpus detallarining ishlash layoqatini belgilovchi xarakteristikani aniqlaydi</p> <p>D) metall kesuvchi stanoklar, dvigatellar, reduktorlar korpusiga qo'yiladigan asosiy talab bo'lib, tashqi ta'sirdan (tebranish ) deformatsiyalanmaslikdir</p>                    |
| <b>415.Sekinlatuvchi reduktorning uzatishlari soni</b>   | <p>A) <math>i &gt; 1</math> B) <math>i = 1</math></p> <p>S) <math>-i &lt; 1</math> D) <math>-i = 0</math></p>                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>416.Tezlatuvchi reduktorning uzatishlari soni</b>     | <p>A) <math>i &lt; 1</math> B) <math>i = 1</math></p> <p>S) <math>i &gt; 1</math> D) <math>i = 0</math></p>                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>417. Konstruktiv komponovka nima?</b>                 | <p>A) jarayonida uzal va detallarni kichikroq parametrlarida, ularni yig'ish va ekspluatatsiyasida qulaylik yaratigan vaziyati ishlab chiqiladi</p> <p>B) jarayonida uzal parametrlarida, ularni yig'ish va ekspluatatsiyasida qulaylik yaratigan vaziyati ishlab chiqiladi</p> <p>S) jarayonida detallarni kichikroq parametrlarida, ularni yig'ish va ekspluatatsiyasini ishlab chiqiladi</p> <p>D) jarayonida yig'ish va ekspluatatsiyasida qulaylik yaratigan vaziyati ishlab chiqiladi</p>              |
| <b>418. Dumalash podshipniklari deb nimaga aytiladi?</b> | <p>A) sirpanish ishqalanishi dumalash ishqalanishi bilan almashtiriladigan val, o'qlarning tayanchlari–dumalash podshipniklari</p> <p>B) sirpanish ishqalanishi dumalash ishqalanishi bilan almashtirilmaydigan val, o'qlarning tayanchlari–dumalash podshipniklari</p> <p>S) sirpanish ishqalanishi dumalash ishqalanishi bilan almashtiriladigan val, o'qlar–dumalash podshipniklari</p> <p>D) sharikli va rolikli podshipniklar</p>                                                                       |

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| <b>419. Dumalash podshipnikining soat birligidagi xizmat muddatini kursating</b>  | A) $L = \left( \frac{C}{P_9} \right)^m$ ;<br>S) $L_n = \frac{10^6 \cdot L}{60 \cdot n}$                                       | B) $L = \left( \frac{C}{P_9} \right)$<br>D) $L_n = \frac{10^6 \cdot n}{60 \cdot L}$                           |
| <b>420. Dumalash podshipnikining million aylanish xizmat muddatini kursating</b>  | A) $L_n = \frac{10^6 \cdot L}{60 \cdot n}$<br>B) $L = \left( \frac{C}{P_9} \right)$                                           | B) $L = \left( \frac{C}{P_9} \right)^m$ ;<br>D) $L_n = \frac{10^6 \cdot n}{60 \cdot L}$                       |
| <b>421. Ajraladigan birikmalar turini kursating</b>                               | A) Rezbali, boltli, shponkali, shlitsali<br>B) Parchin mixli<br>S) Parchin mixli, payvand, elimli<br>D) payvand, elimli       |                                                                                                               |
| <b>422. Ajralmaydigan birikmalar turini kursating</b>                             | A) Parchin mixli, payvand, elimli<br>B) Rezbali, boltli, shponkali, shlitsali<br>S) Parchin mixli<br>D) payvand, elimli       |                                                                                                               |
| <b>423. Parchin mixli birikmani qirqilishga mustahkamlik sharti?</b>              | A) $\tau_{\max} = \frac{F}{n \cdot \frac{\pi \cdot d^2}{4}} \leq [\tau]$<br>S) $\sigma = \frac{F}{t(b_0 - md)} \leq [\sigma]$ | B) $\sigma_c = \frac{F}{n \cdot d \cdot t_1} \leq [\sigma_c]$<br>D) $\tau = \frac{F}{z_1 \cdot t}$            |
| <b>424. Parchin mixli birikmani ezilishga mustahkamlik sharti?</b>                | A) $\sigma_c = \frac{F}{n \cdot d \cdot t_1} \leq [\sigma_c]$<br>S) $\sigma = \frac{F}{t(b_0 - md)} \leq [\sigma]$            | B) $\tau_{\max} = \frac{F}{n \cdot \frac{\pi \cdot d^2}{4}} \leq [\tau]$<br>D) $\tau = \frac{F}{z_1 \cdot t}$ |
| <b>425. Parchin mixli birikmani cho'zilish va siqilishga mustahkamlik sharti?</b> | A) $\sigma = \frac{F}{t(b_0 - md)} \leq [\sigma]$<br>S) $\sigma_c = \frac{F}{n \cdot d \cdot t_1} \leq [\sigma_c]$            | B) $\tau_{\max} = \frac{F}{n \cdot \frac{\pi \cdot d^2}{4}} \leq [\tau]$<br>D) $\tau = \frac{F}{z_1 \cdot t}$ |
| <b>426. Qirqilishga parchin mixlar soni</b>                                       | A) $n \geq \frac{4F}{\pi \cdot d^2 [\tau]}$<br>S) $n \geq \frac{F}{d \delta [\sigma_c]}$                                      | B) 1,2,3,.....<br>D) $n = \frac{F}{z_1 \cdot t}$                                                              |

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| <b>427. Ezilishga parchin mixlar soni</b>         | <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> A) <math>n \geq \frac{F}{d\delta[\sigma_c]}</math><br/> S) <math>n = \frac{F}{z_1 \cdot t}</math> </div> <div style="width: 45%;"> B) <math>n \geq \frac{4F}{\pi \cdot d^2[\tau]}</math><br/> 1,2,3,.....<br/> D) </div> </div>                                                                                                                                                                                             |
| <b>428. Yassi remenli uzatma ta`rifi</b>          | A) foydali kuch remen sirtini ichki tomoni va shktivni tashqi sirti orasidagi ishqalanishida hosil bo'ladi.<br>B) Etaklovchi valni o'zgarmas tezligida etaklanuvchi val burchak tezligini pog'onasiz o'zgartirish uchun xizmat qiladigan mexanik qurilma<br>S) foydali kuch trapetsiyasimon kesimli tasmani yon sirti va shktiv kanalchani yon sirlari orasidagi ishqalanish hisobiga hosil bo'ladi<br>D) foydali kuch remen sirtini tashki tomoni va shktivni ichki sirti orasidagi ishqalanishida hosil bo'ladi. |
| <b>429. Ponasimon remenli uzatma ta`rifi</b>      | A) foydali kuch remen sirtini ichki tomoni va shktivni tashqi sirti orasidagi ishqalanishida hosil bo'ladi.<br>B) Etaklovchi valni o'zgarmas tezligida etaklanuvchi val burchak tezligini pog'onasiz o'zgartirish uchun xizmat qiladigan mexanik qurilma<br>S) foydali kuch trapetsiyasimon kesimli tasmani yon sirti va shktiv kanalchani yon sirlari orasidagi ishqalanish hisobiga hosil bo'ladi<br>D) egiluvchan bog'lanishli birikma                                                                          |
| <b>430. Variatorni ta`rifi</b>                    | A) foydali kuch remen sirtini ichki tomoni va shktivni tashqi sirti orasidagi ishqalanishida hosil bo'ladi.<br>B) Etaklovchi valni o'zgarmas tezligida etaklanuvchi val burchak tezligini pog'onasiz o'zgartirish uchun xizmat qiladigan mexanik qurilma<br>S) foydali kuch trapetsiyasimon kesimli tasmani yon sirti va shktiv kanalchani yon sirlari orasidagi ishqalanish hisobiga hosil bo'ladi<br>B) egiluvchan bog'lanishli birikma                                                                          |
| <b>431. Zanjirli uzatmaning ta`rifini ayting?</b> | A) cheksiz tutash zanjir ko'rinishida yasalgan tortish organining maxsus profilli tishlari bo'lgan g'ildirakdan iborat uzatmaga aytiladi.<br>B) cheksiz tutash zanjir ko'rinishida yasalgan tortish organining tishlari bo'lgan g'ildirakdan iborat uzatmaga aytiladi.<br>S) cheksiz tutash zanjir ko'rinishida yasalgan uzatmaga aytiladi.<br>D) zanjir ko'rinishidagi maxsus profilli tishlari bo'lgan g'ildirak majmuasiga aytiladi.                                                                            |

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| 432. Zanjir kadaminging formulasini ko'rsating?                        | A) $t \geq 2,8 \cdot \sqrt[3]{\frac{M_3 \cdot K_3}{z_1[p]}}$<br>S) $t = \frac{z_1 \cdot t \cdot n_1}{60 \cdot 10^3}$                             | B) $t = \frac{d_1 + d_2}{2} \frac{9+i}{10}$<br>D) $t = \frac{z_1 \cdot t}{60 \cdot 10^3}$                                                         |
| 433. Zanjirli uzatmada o'qlararo masofa formulasini ko'rsating?        | A) $a_w = (6...8)m$<br>S) $a_w = (6-8)m$                                                                                                         | B) $a_w = (6+8)m$<br>D) $a_w = (6 \cdot 8)m$                                                                                                      |
| 434. Yulduzcha bo'luvchi aylanasi diametrining formulasini ko'rsating? | A) $d = \frac{t}{\sin \frac{180^\circ}{Z}}$<br>S) $t \geq 2,8 \cdot \sqrt[3]{\frac{M_3 \cdot K_3}{z_1[p]}}$                                      | B) $t = \frac{d_1 + d_2}{2} \frac{9+i}{10}$<br>D) $t = \frac{z_1 \cdot t \cdot n_1}{60 \cdot 10^3}$                                               |
| 435. Zanjirli uzatma ukalararo masofasining formulasini ko'rsating?    | A) $t = \frac{d_1 + d_2}{2} \frac{9+i}{10}$<br>S) $t \geq 2,8 \cdot \sqrt[3]{\frac{M_3 \cdot K_3}{z_1[p]}}$                                      | B) $d = \frac{t}{\sin \frac{180^\circ}{Z}}$<br>D) $t = \frac{z_1 \cdot t \cdot n_1}{60 \cdot 10^3}$                                               |
| 436. Chervyakdagi egilish kuchlanishining formulasini ko'rsating?      | A) $\sigma_c = \frac{4F_a}{\pi \cdot d_{f1}^2}$<br>S) $\sigma_\delta = \frac{M_1}{0,2d_f^3}$                                                     | B) $\sigma_F = \frac{M_3}{0,1d_t^3}$<br>D) $\sigma_\delta = \frac{F_1}{0,2d_f^3}$                                                                 |
| 437. Chervyakdagi siquvchi kuchlanish formulasini ko'rsating?          | A) $\sigma_c = \frac{4F_a}{\pi \cdot d_{f1}^2}$<br>S) $\sigma_\delta = \frac{M_1}{0,2d_f^3}$                                                     | B) $\sigma_F = \frac{M_3}{0,1d_t^3}$<br>D) $\sigma_\delta = \frac{F_1}{0,2d_f^3}$                                                                 |
| 438. Chervyakdagi burovchi kuchlanish formulasini ko'rsating?          | A) $\tau_c = \frac{4F_a}{\pi \cdot d_{f1}^2}$<br>S) $\tau_\delta = \frac{M_1}{0,2d_f^3}$                                                         | B) $-\tau_F = \frac{M_3}{0,1d_t^3}$<br>D) $-\tau_\delta = \frac{F_1}{0,2d_f^3}$                                                                   |
| 439 Kichik shkivdagi qamrov burchagi                                   | A) $\alpha = 180^\circ - \frac{D_2 - D_1}{a} \cdot \frac{180^\circ}{\pi}$<br>S) $\alpha = 180^\circ - \frac{D_2}{a} \cdot \frac{180^\circ}{\pi}$ | B) $-\alpha = 180^\circ - \frac{D_1}{a} \cdot \frac{180^\circ}{\pi}$<br>D) $-\alpha = 180^\circ - \frac{D_2 - D_1}{a} \cdot \frac{90^\circ}{\pi}$ |



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| <b>440. Yassi tasmali uzatma kichik shkivi diametri-ning formulasi</b>         | A) $D_1 = (0,052 \dots 0,064) \sqrt[3]{\frac{N}{n}}$ B) $D_1 = (0,052 \dots 0,064) \sqrt{\frac{N}{n}}$<br>S) $D_1 = (0,052 \dots 0,064) \sqrt[3]{\frac{n}{N}}$ D) $D_1 = (0,052 \dots 0,064) \sqrt{\frac{n}{N}}$     |
| <b>441. Yassi tasmali uzatma katta shkivining diametri</b>                     | A) $D_2 = i \cdot D_1 [1 - \varepsilon]$ B) $D_2 = D_1 [1 - \varepsilon]$<br>S) $D_2 = i \cdot [1 - \varepsilon]$ D) $D_2 = i \cdot D_1 [\varepsilon - 1]$                                                           |
| <b>442. Yassi tasmani ko'ndalang kesim yuzasi</b>                              | A) $b\delta = \frac{P}{[K]},$ B) $b = \frac{P}{[K]},$<br>S) $\delta = \frac{P}{[K]},$ D) $b\delta = \frac{[K]}{P},$                                                                                                  |
| <b>443. Tasma etaklovchi tarmokining taranglik kuchi</b>                       | A) $2S_0 = S_1 + S_2$ B) $S_1 = S_0 + 0,5P$<br>S) $S_2 = S_0 - 0,5P$ D) $S_0 = S_1 + S_2$                                                                                                                            |
| <b>444. Tasma etaklanuvchi tarmokining taranglik kuchi</b>                     | A) $2S_0 = S_1 + S_2$ B) $S_1 = S_0 + 0,5P$<br>S) $S_2 = S_0 - 0,5P$ D) $S_0 = S_1 + S_2$                                                                                                                            |
| <b>445. Tasmali uzatmadan val va val tayanchlariga tushadigan kuch</b>         | A) $R = 2S_0 \cdot \sin\left(\frac{\alpha_1}{2}\right)$ B) $-R = S_0 \cdot \sin\left(\frac{\alpha_1}{2}\right)$<br>S) $R = K_e \cdot F_t + 2F_f$ D) $-F_r = \frac{2K \cdot M_1}{f \cdot d_1}$                        |
| <b>446. Zanjirli uzatmadan val va val tayanchlariga tushadigan kuch</b>        | A) $R = 2S_0 \cdot \sin\left(\frac{\alpha_1}{2}\right)$ B) $-R = S_0 \cdot \sin\left(\frac{\alpha_1}{2}\right)$<br>S) $R = K_e \cdot F_t + 2F_f$ D) $-F_r = \frac{2K \cdot M_1}{f \cdot d_1}$                        |
| <b>447. Rolikli va vtulkali zanjirlar yulduzcha tishlari uchining diametri</b> | A) $d_a = t \left( \operatorname{ctg} \frac{180^\circ}{Z} + 0,5 \right)$ B) $-d_a = t \operatorname{ctg} \frac{180^\circ}{Z}$<br>S) $d_{am} = d_{a2} + \frac{6m}{z_1 + z}$ D) $d_1 = 2(R_\ell - 0,5b) \sin \delta_1$ |
| <b>448. Tishli zanjirlar yulduzcha tishlari uchining diametri</b>              | A) $d_a = t \left( \operatorname{ctg} \frac{180^\circ}{Z} + 0,5 \right)$ B) $-d_a = t \operatorname{ctg} \frac{180^\circ}{Z}$<br>S) $d_{am} = d_{a2} + \frac{6m}{z_1 + z}$ D) $d_1 = 2(R_\ell - 0,5b) \sin \delta_1$ |
| <b>449. Lentali konveyer bara-</b>                                             | A) $n_{\text{6.M}} = \frac{60 \cdot 1000 \cdot v}{D}$ B) $n_{\text{6.M}} = \frac{60 \cdot 1000 \cdot v}{\pi \cdot D}$                                                                                                |

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| <b>bani valining aylanishlari soni</b>                                    | S) $n_{\text{6.M}} = \frac{60 \cdot 1000 \cdot \nu}{z \cdot p}$                                                                                                                                                                                                                                                                                        | D) $n_{\text{6.M}} = \frac{60 \cdot 1000}{z \cdot p}$                                                                        |
| <b>450. Zanjirli konveyer yulduz-chasi valining aylanishlari soni</b>     | A) $n_{\text{6.M}} = \frac{60 \cdot 1000 \cdot \nu}{D}$<br>S) $n_{\text{6.M}} = \frac{60 \cdot 1000 \cdot \nu}{z \cdot p}$                                                                                                                                                                                                                             | B) $n_{\text{6.M}} = \frac{60 \cdot 1000 \cdot \nu}{\pi \cdot D}$<br>D) $n_{\text{6.M}} = \frac{60 \cdot 1000}{z \cdot p}$   |
| <b>451. Konussimon gildirak tashki diametri</b>                           | A) $d_1 = 2(R_\ell - 0,5b) \sin \delta_1$<br>S) $d_{a2} = d_{\ell 2} + 2m \cos \delta_2$                                                                                                                                                                                                                                                               | B) $d_{a1} = d_{\ell 1} + 2m \cos \delta_1$<br>D) $d_{\ell 1} = m \cdot Z_1$                                                 |
| <b>452. Konussimon shesternya tashki diametri</b>                         | A) $d_1 = 2(R_\ell - 0,5b) \sin \delta_1$<br>S) $d_{a2} = d_{\ell 2} + 2m \cos \delta_2$                                                                                                                                                                                                                                                               | B) $d_{a1} = d_{\ell 1} + 2m \cos \delta_1$<br>D) $d_{\ell 1} = m \cdot Z_1$                                                 |
| <b>453. Konussimon shesternyadagi doiraviy kuch</b>                       | A) $F_{r1} = F \cdot \operatorname{tg} \alpha \cdot \cos \delta_1$<br>S) $F_t = \frac{2M_1}{d_1}$                                                                                                                                                                                                                                                      | B) $F_{a1} = F \cdot \operatorname{tg} \alpha \cdot \sin \delta_1 = F_{r2}$<br>D) $F_r = F_a \cdot \operatorname{tg} \alpha$ |
| <b>454. chervyakdagi doiraviy kuch</b>                                    | A) $F_{r1} = F \cdot \operatorname{tg} \alpha \cdot \cos \delta_1$<br>S) $F_t = \frac{2M_1}{d_1}$                                                                                                                                                                                                                                                      | B) $F_{a1} = F \cdot \operatorname{tg} \alpha \cdot \sin \delta_1 = F_{r2}$<br>D) $F_r = F_a \cdot \operatorname{tg} \alpha$ |
| <b>455. Chervyak g'ildiraki gardishining qamrov burchagi</b>              | A) $\sin \delta = \frac{b_2}{d_{a1} - 0,5m}$<br>S) $\sin \delta = \frac{b_2}{d_{a1} - 0,5}$                                                                                                                                                                                                                                                            | B) $-\sin \delta = \frac{b_2}{d_{a1} - m}$<br>D) $\sin \delta = \frac{b_2}{d_1 - 0,5}$                                       |
| <b>456. To'g'ri tishli tsilindrik uzatma o'qlararo masofasi formulasi</b> | A) $a_w = \frac{z_1 + z_2}{\cos \beta} m$<br>S) $a_w = \frac{z_1 + z_2}{2 \cos \beta} m$                                                                                                                                                                                                                                                               | B) $-a_w = \frac{z_1 + z_2}{2} m$<br>D) $a_w = \frac{z_1 + z_2}{2m} \cos \beta$                                              |
| <b>457. Yassi tasmali uzatmada o'qlararo masofa</b>                       | A) $a_w = \frac{1}{4} \left[ (L - \Delta_1) + \sqrt{(L - \Delta_1)^2 - 8\Delta_2} \right]$<br>B) $a_w = (U + 1)^3 \sqrt{\left( \frac{310}{[\sigma]_H \cdot U} \right)^2 \cdot \frac{M_2 K_H}{\Psi_b}}$<br>$a_w = \left( 1 + \frac{Z_2}{q} \right) \cdot \sqrt[3]{\left( \frac{170}{[\sigma]_z \cdot \frac{Z_2}{q}} \right)^2 \cdot K \cdot M_2}$<br>S) |                                                                                                                              |

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|                                                                              | D) $d_\ell = 2 \cdot \sqrt[3]{\left(\frac{335}{[\sigma]_H}\right)^2 \cdot \frac{M_\delta \cdot K_{H\beta} \cdot i}{(1-0,5\Psi_b)^2 \cdot \Psi_b}}$                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>458. Tsilindrik uzatmada o'qlararo masofa</b>                             | <p>A) <math>a_w = \frac{1}{4} \left[ (L - \Delta_1) + \sqrt{(L - \Delta_1)^2 - 8\Delta_2} \right]</math></p> <p>B) <math>a_w = (U + 1) \sqrt[3]{\left(\frac{310}{[\sigma]_H \cdot U}\right)^2 \cdot \frac{M_2 K_H}{\Psi_b}}</math></p> <p><math>a_w = \left(1 + \frac{Z_2}{q}\right) \cdot \sqrt[3]{\left(\frac{170}{[\sigma]_z \cdot \frac{Z_2}{q}}\right)^2 \cdot K \cdot M_2}</math></p> <p>S)</p> <p>D) <math>d_\ell = 2 \cdot \sqrt[3]{\left(\frac{335}{[\sigma]_H}\right)^2 \cdot \frac{M_\delta \cdot K_{H\beta} \cdot i}{(1-0,5\Psi_b)^2 \cdot \Psi_b}}</math></p> |
| <b>459. Chervyakli uzatmada o'qlararo masofa</b>                             | <p>A) <math>a_w = \frac{1}{4} \left[ (L - \Delta_1) + \sqrt{(L - \Delta_1)^2 - 8\Delta_2} \right]</math></p> <p>B) <math>a_w = (U + 1) \sqrt[3]{\left(\frac{310}{[\sigma]_H \cdot U}\right)^2 \cdot \frac{M_2 K_H}{\Psi_b}}</math></p> <p><math>a_w = \left(1 + \frac{Z_2}{q}\right) \cdot \sqrt[3]{\left(\frac{170}{[\sigma]_z \cdot \frac{Z_2}{q}}\right)^2 \cdot K \cdot M_2}</math></p> <p>S)</p> <p>D) <math>d_\ell = 2 \cdot \sqrt[3]{\left(\frac{335}{[\sigma]_H}\right)^2 \cdot \frac{M_\delta \cdot K_{H\beta} \cdot i}{(1-0,5\Psi_b)^2 \cdot \Psi_b}}</math></p> |
| <b>460. Konussimon uzatma tashqi bo'luvchi aylana diametrining formulasi</b> | <p>A) <math>a_w = \frac{1}{4} \left[ (L - \Delta_1) + \sqrt{(L - \Delta_1)^2 - 8\Delta_2} \right]</math></p> <p>B) <math>a_w = (U + 1) \sqrt[3]{\left(\frac{310}{[\sigma]_H \cdot U}\right)^2 \cdot \frac{M_2 K_H}{\Psi_b}}</math></p> <p><math>a_w = \left(1 + \frac{Z_2}{q}\right) \cdot \sqrt[3]{\left(\frac{170}{[\sigma]_z \cdot \frac{Z_2}{q}}\right)^2 \cdot K \cdot M_2}</math></p> <p>S)</p> <p>D) <math>d_\ell = 2 \cdot \sqrt[3]{\left(\frac{335}{[\sigma]_H}\right)^2 \cdot \frac{M_\delta \cdot K_{H\beta} \cdot i}{(1-0,5\Psi_b)^2 \cdot \Psi_b}}</math></p> |
| <b>461. Tasmalar hisobiy</b>                                                 | A) $L = 2a + \frac{\pi}{2}(D_2 + D_1) + \frac{(D_2 - D_1)^2}{4a}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

|                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
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| <b>uzunligining formulasini ko'rsating?</b>                               | <p>B) <math>L = \frac{1}{4} \left[ (a - \Delta_1) + \sqrt{(a - \Delta_1)^2 - 8\Delta_2} \right]</math></p> <p>S) <math>L = (U + 1) \sqrt[3]{\left( \frac{310}{[\sigma]_H \cdot U} \right)^2 \cdot \frac{M_2 K_H}{\Psi_b}}</math></p> <p>D) <math>d_\ell = 2 \cdot \sqrt[3]{\left( \frac{335}{[\sigma]_H} \right)^2 \cdot \frac{M_\delta \cdot K_{H\beta} \cdot i}{(1 - 0,5\Psi_b)^2 \cdot \Psi_b}}</math></p>                                                                                  |
| <b>462. Zanjirli uzatma o'qlararo masofasining formulasi</b>              | <p>A) <math>a_{\min} = \frac{d_{a1} + d_{a2}}{2} + (30 \dots 50) \cdot 10^{-3}</math></p> <p>B) <math>a_w = \frac{1}{4} \left[ (L - \Delta_1) + \sqrt{(L - \Delta_1)^2 - 8\Delta_2} \right]</math></p> <p>S) <math>a_w = (U + 1) \sqrt[3]{\left( \frac{310}{[\sigma]_H \cdot U} \right)^2 \cdot \frac{M_2 K_H}{\Psi_b}}</math></p> <p>D) <math>a_w = \left( 1 + \frac{Z_2}{q} \right) \cdot \sqrt[3]{\left( \frac{170}{[\sigma]_Z \cdot \frac{Z_2}{q}} \right)^2 \cdot K \cdot M_2}</math></p> |
| <b>463. Zanjir buginlarining soni</b>                                     | <p>A) <math>L_t = \frac{2a}{t} + \frac{Z_2 + Z_1}{2} + \left( \frac{z_2 - z_1}{2\pi} \right)^2</math></p> <p>B) <math>L = 2a + \frac{\pi}{2} (D_2 + D_1) + \frac{(D_2 - D_1)^2}{4a}</math></p> <p>S) <math>L = \frac{1}{4} \left[ (a - \Delta_1) + \sqrt{(a - \Delta_1)^2 - 8\Delta_2} \right]</math></p> <p>D) <math>L = (U + 1) \sqrt[3]{\left( \frac{310}{[\sigma]_H \cdot U} \right)^2 \cdot \frac{M_2 K_H}{\Psi_b}}</math></p>                                                            |
| <b>464. Qiyshiq tishli tsilindrik uzatma o'qlararo masofasi formulasi</b> | <p>A) <math>a_w = \frac{z_1 + z_2}{\cos \beta} m</math></p> <p>B) <math>- a_w = \frac{z_1 + z_2}{2} m</math></p> <p>S) <math>a_w = \frac{z_1 + z_2}{2 \cos \beta} m</math></p> <p>D) <math>a_w = \frac{z_1 + z_2}{2m} \cos \beta</math></p>                                                                                                                                                                                                                                                    |
| <b>465. Val diametrini dastlabki hisoblash</b>                            | <p>A) <math>d \geq \sqrt[3]{\frac{M_{kel}}{0,2[\sigma]}}</math></p> <p>B) <math>d = \sqrt[3]{\frac{M}{0,2[\tau_K]}}</math></p> <p>S) <math>d = \sqrt[3]{\frac{M}{0,2[\sigma_K]}}</math></p> <p>D) <math>d = \sqrt[3]{\frac{M}{[\sigma_K]}}</math></p>                                                                                                                                                                                                                                          |

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| <b>466. Chervyakli uzatma ilashmasining moduli</b>                                                        | A) $m_t = \frac{\pi}{P_t}$ B) $m = \frac{(1,4...1,7)a_w}{z_2}$                                                          |
|                                                                                                           | S) $q = \frac{(2a_w - mz_2)}{m}$ D) $m_t = P_t m$                                                                       |
| <b>467. Chervyak diametrining koeffitsienti</b>                                                           | A) $q = \frac{P_t}{\pi}$ B) $q = \frac{(1,4...1,7)a_w}{z_2}$                                                            |
|                                                                                                           | S) $q = \frac{(2a_w - mz_2)}{m}$ D) $q = P_t m$                                                                         |
| <b>468. Tsilindrik uzatma shesternya tishlarining soni</b>                                                | A) $Z_1 = \frac{2\alpha_\omega}{(u+1)}$ B) $Z_1 = \frac{2\alpha_\omega}{(u+1)m_n}$                                      |
|                                                                                                           | S) $Z_1 = \frac{2\alpha_\omega}{(u)m_n}$ D) $Z_1 = \frac{2\alpha_\omega}{m_n}$                                          |
| <b>469. Chervyak buluvchi aylana-sining diametri</b>                                                      | A) $d_{a1} = m(q+2)$ B) $d_1 = m \cdot q$                                                                               |
|                                                                                                           | S) $d_2 = mZ_2$ D) $d_{a2} = m(Z_2 + 2)$                                                                                |
| <b>470. Chervyak gildiragi buluv-chi aylanasining diametri</b>                                            | A) $d_{a1} = m(q+2)$ B) $d_1 = m \cdot q$                                                                               |
|                                                                                                           | S) $d_2 = mZ_2$ D) $d_{a2} = m(Z_2 + 2)$                                                                                |
| <b>471. Valni buralishga mustahamlik sharti</b>                                                           | A) $\tau_{\max} = \frac{M_\delta}{W_\rho} \leq [\tau]$ B) $\sigma_{\max} = \sqrt{\sigma_s^2 + 3\tau_s^2} \leq [\sigma]$ |
|                                                                                                           | S) $\varphi_{\max} \leq [\varphi]$ D) $f \leq [f]$                                                                      |
| $m = \frac{2a_w}{z_2 + q}$<br><b>472. qanday uzatma ilashma moduli</b>                                    | A) lentali konveyer B) zanjirli konveyer                                                                                |
|                                                                                                           | S) chervyakli uzatma D) tishli uzatma                                                                                   |
| <b>473. <math>v_A = \omega \cdot r</math> da <math>\omega</math> nimani bildiradi</b>                     | A) Chiziqli tezlikni B) Burchak tezlikni                                                                                |
|                                                                                                           | S) Burchak tezlanishni D) Aylanishlar sonini                                                                            |
| <b>474. <math>a^\tau = \varepsilon \cdot r</math> formulada <math>\varepsilon</math> nimani bildiradi</b> | A) Chiziqli tezlikni B) Burchak tezlikni                                                                                |
|                                                                                                           | S) Burchak tezlanishni D) Aylanishlar sonini                                                                            |
| <b>475. Polzun kanday xarakatlanadi</b>                                                                   | A) Aylanma B) Kuzgalmas                                                                                                 |
|                                                                                                           | S) Ilgarilanma D) Tebranma                                                                                              |
| <b>476. Kinematik juft erkinlik darajasi bilan</b>                                                        | A) mumkin bo'lgan harakatlar soniga                                                                                     |
|                                                                                                           | B) mumkin bo'lmagan harakatlar soniga                                                                                   |
|                                                                                                           | S) murakkab harakatga                                                                                                   |

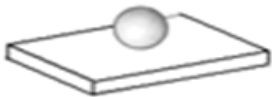
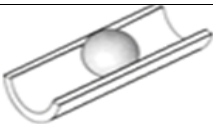
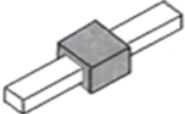
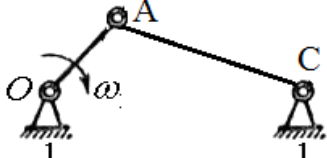
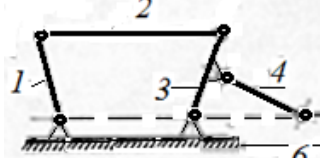
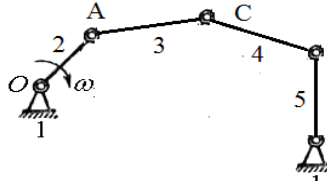
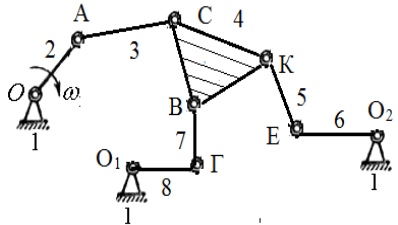
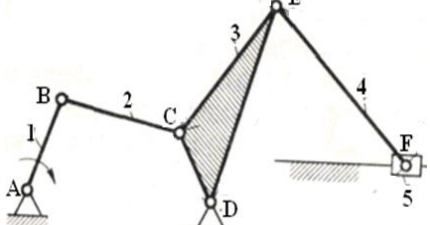
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| <b>bog'lanishlar sonining yig'in-disi nimaga teng?</b>                                                                                                   | D) Oddiy harakatga                                                                                                                                                                                                                                                                                                                                                        |
| <b>477. Tsapfa deb nimaga aytiladi?</b>                                                                                                                  | A) Val va o'qlarni podshipnik bilan tegishadigan qismlari<br>B) Valning oxirida joylashgan tsapfa<br>S) Tayanchga bo'ylama kuchni uzatadigan tsapfa<br>D) Uzunligi boshqa o'lchamlaridan kichik bo'lgan brus                                                                                                                                                              |
| <b>478. Ship deb nimaga aytiladi?</b>                                                                                                                    | A) Val va o'qlarni podshipnik bilan tegishadigan qismlari<br>B) Valning oxirida joylashgan tsapfa<br>S) Tayanchga bo'ylama kuchni uzatadigan tsapfa<br>D) Uzunligi boshqa o'lchamlaridan kichik bo'lgan brus                                                                                                                                                              |
| <b>479. Tovon (pyata) deb nimaga aytiladi?</b>                                                                                                           | A) Val va o'qlarni podshipnik bilan tegishadigan qismlari<br>B) Valning oxirida joylashgan tsapfa<br>S) Tayanchga bo'ylama kuchni uzatadigan tsapfa<br>D) Uzunligi boshqa o'lchamlaridan kichik bo'lgan brus                                                                                                                                                              |
| <b>480. Konveyer barabanining validagi aylan-tiruvchi moment va valni- burchak tezligi – berilgan, elektrodvigatelni talab etilgan quvvatini toping?</b> | A) $N = \frac{M_n \omega_n}{\eta}$<br>S) $N = \frac{P_n V_n}{\eta}$<br>B) $N = \frac{N_n}{\eta}$<br>D) $N = P_n V_n$                                                                                                                                                                                                                                                      |
| <b>481. Etaklanuvchi val uchun kerak bo'lgan quvvat va yuritmaning kinematik sxemasi berilgan</b>                                                        | A) $N = \frac{M_n \omega_n}{\eta}$<br>S) $N = \frac{P_n V_n}{\eta}$<br>B) $N = \frac{N_n}{\eta}$<br>D) $N = P_n V_n$                                                                                                                                                                                                                                                      |
| <b>482. tortish kuchi va harakat tezligi berilgan</b>                                                                                                    | A) $N = \frac{M_n \omega_n}{\eta}$<br>S) $N = \frac{P_n V_n}{\eta}$<br>B) $N = \frac{N_n}{\eta}$<br>D) $N = P_n V_n$                                                                                                                                                                                                                                                      |
| <b>483. Yuritmaning foydali ish koefitsienti nimaga teng?</b>                                                                                            | A) Yuritmaning foydali ish koefitsienti (FIK)- yuritma tarkibidagi barcha xususiy uzatmalar FIK-ning ko'paytmasiga teng<br>B) Yuritmaning foydali ish koefitsienti (FIK)- yuritma tarkibidagi barcha xususiy uzatmalar FIK-ning bo'linmasiga teng<br>S) Yuritmaning foydali ish koefitsienti (FIK)- yuritma tarkibidagi barcha xususiy uzatmalar FIK-ning ayirmasiga teng |

|                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
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|                                                                                                          | D) Yuritmaning foydali ish koeffitsienti (FIK)- yuritma tarkibidagi barcha xususiy uzatmalar FIK-ning yig'indisiga teng                                                                                                                                                                                                                                                                                                                                                                                |
| <b>484. Yuritmaning kinematikasiga nimalar kiradi?</b>                                                   | <p>A) Yuritmaning kinematikasiga – uning uzatishlari nisbati, tarkibidagi alohida uzatmalar uzatishlari soni, vallarning kinematikasi kiradi.</p> <p>B) Yuritmaning kinematikasiga – uning tarkibidagi alohida uzatmalar uzatishlari soni, vallarning kinematikasi kiradi</p> <p>S) Yuritmaning kinematikasiga – uning uzatishlari nisbati, tarkibidagi alohida uzatmalar uzatishlari soni kiradi</p> <p>D) Yuritmaning kinematikasiga – uning uzatishlari nisbati, vallarning kinematikasi kiradi</p> |
| <b>485. Chervyakdagi eguvchi kuchlanish formulasini ko'rsating?</b>                                      | <p>A) <math>\sigma_F = \frac{M_{\vartheta}}{0,1d_t^3}</math>      B) <math>\sigma_C = \frac{4F_a}{\pi \cdot d_{f1}^2}</math></p> <p>S) <math>\tau_{\delta} = \frac{M_1}{0,2d_f^3}</math>      D) <math>\sigma_C = \frac{F_a}{\pi \cdot d_{f1}^2}</math></p>                                                                                                                                                                                                                                            |
| <b>486. Chervyakdagi siquvchi kuchlanish formulasini ko'rsating?</b>                                     | <p>A) <math>\sigma_F = \frac{M_{\vartheta}}{0,1d_t^3}</math>      B) <math>\sigma_C = \frac{4F_a}{\pi \cdot d_{f1}^2}</math></p> <p>S) <math>\tau_{\delta} = \frac{M_1}{0,2d_f^3}</math>      D) <math>\sigma_C = \frac{F_a}{\pi \cdot d_{f1}^2}</math></p>                                                                                                                                                                                                                                            |
| <b>487. Chervyakni buralishidagi kuchlanish formulasini ko'rsating?</b>                                  | <p>A) <math>\sigma_F = \frac{M_{\vartheta}}{0,1d_t^3}</math>      B) <math>\sigma_C = \frac{4F_a}{\pi \cdot d_{f1}^2}</math></p> <p>S) <math>\tau_{\delta} = \frac{M_1}{0,2d_f^3}</math>      D) <math>\sigma_C = \frac{F_a}{\pi \cdot d_{f1}^2}</math></p>                                                                                                                                                                                                                                            |
| <b>488. Bir qatorli podshipniklar uchun yuk ekvivalentligi koeffitsientining formulasini ko'rsating?</b> | <p>A) <math>P_{\vartheta} = (X \cdot V \cdot F_2 + YF_a)K_{\delta} \cdot K_T</math></p> <p>B) <math>P_{\vartheta} = (X \cdot V \cdot F_2 - YF_a)K_{\delta} \cdot K_T</math></p> <p>S) <math>P_{\vartheta} = (X \cdot V \cdot F_2 \cdot YF_a)K_{\delta} \cdot K_T</math></p> <p>D) <math>P_{\vartheta} = (X \cdot V \cdot F_2 \div YF_a)K_{\delta} \cdot K_T</math></p>                                                                                                                                 |
| <b>489. Rezbani ezilishga mustahkamligi</b>                                                              | <p>A) <math>\sigma_{\vartheta\vartheta} = \frac{P}{z \cdot \pi \cdot d_2 \cdot h} \leq [\sigma_{\vartheta\vartheta}]</math>      B) <math>\sigma_{\vartheta} = \frac{F}{A}</math></p> <p>S) <math>\tau = \frac{F}{\pi \cdot d_1 \cdot k \cdot H} \leq [\tau]</math>      D) <math>\tau = \frac{F}{\pi \cdot d \cdot k \cdot H} \leq [\tau]</math></p>                                                                                                                                                  |
| <b>490. Rezbani kesilishga mustahkamligi</b>                                                             | <p>A) <math>\sigma_{\vartheta\vartheta} = \frac{P}{z \cdot \pi \cdot d_2 \cdot h} \leq [\sigma_{\vartheta\vartheta}]</math>      B) <math>\sigma_{\vartheta} = \frac{F}{A}</math></p>                                                                                                                                                                                                                                                                                                                  |

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|                                                                                                                                                 | $S) \tau = \frac{F}{\pi \cdot d_1 \cdot k \cdot H} \leq [\tau] \quad D) \tau = \frac{F}{\pi \cdot d \cdot k \cdot H} \leq [\tau]$                  |
| <b>491.</b> $G = \frac{E}{2(1+\mu)}$<br><b>formulada <math>G</math></b><br><b>qanday kattalik ?</b>                                             | A) Ikkinchi tartibli elastiklik moduli yoki siljish moduli<br>B) elastiklik moduli<br>S) Puasson koeffitsienti<br>D) Vektor kattalik               |
| <b>492.</b> $G = \frac{E}{2(1+\mu)}$<br><b>formulada <math>E</math></b><br><b>qanday kattalik</b>                                               | A) Ikkinchi tartibli elastiklik moduli yoki siljish moduli<br>B) elastiklik moduli<br>S) Puasson koeffitsienti<br>D) Vektor kattalik               |
| <b>493. Tishli</b><br><b>g'ildiralarda <math>m</math></b><br><b>nimani bildiradi?</b>                                                           | A) ilashma moduli<br>S) g'ildirak og'irligini<br>B) g'ildirak massasi<br>D) g'ildirak diametrini                                                   |
| <b>494. Tishli</b><br><b>g'ildirakda</b><br><b><math>P = \pi \cdot m</math> formula</b><br><b>nimani bildiradi?</b>                             | A) tish qadamini<br>S) tish qalinligini<br>B) tish radiusini<br>D) tish qalinligini                                                                |
| <b>495. Tishli</b><br><b>g'ildiraklarda</b><br><b><math>d = mz</math></b><br><b>formulasida <math>z</math> -</b><br><b>nimani bildiradi?</b>    | A) tishlar sonini<br>S) g'ildiraklar sonini<br>B) podshipniklar sonini<br>D) vallar sonini                                                         |
| <b>496. Qanday</b><br><b>uzatmalarda</b><br><b>ilashmani</b><br><b>issiqlikka</b><br><b>hisoblanadi?</b>                                        | A) chervyakli<br>S) tsilindrli<br>B) konussimon<br>D) zanjirli                                                                                     |
| <b>497. Konussimon</b><br><b>uzatmada</b><br><b>bo'luvchi konus</b><br><b>burchaklar</b><br><b>yig'indisi nechaga</b><br><b>teng?</b>           | A) $0^\circ < \Sigma \leq 90^\circ$<br>S) $10^\circ < \Sigma < 100^\circ$<br>B) $0^\circ < \Sigma < 30^\circ$<br>D) $0^\circ < \Sigma < 180^\circ$ |
| <b>498. Yuqori tez-</b><br><b>likda ishlaydi-gan</b><br><b>uzatmalar uchun</b><br><b>qanday</b><br><b>podshipniklar</b><br><b>qo'llaniladi?</b> | A) sirpanish podshipniklari<br>B) dumalash podshipniklari<br>S) radial-tirak podshipniklari<br>D) radial podshipniklari                            |
| <b>499. Ilashmali</b><br><b>uzatmalarda moy</b><br><b>vannalariga qan-</b>                                                                      | A) texnik moy<br>S) solidol<br>B) quyuq moy<br>D) paxta moyi                                                                                       |



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| <b>day moy quyiladi</b>                                                                          |                                                                                                                    |
| <b>500. Dumalash podshipniklarga qanday moy surtiladi?</b>                                       | A) solidol<br>S) industrial moy<br>B) texnik moy<br>D) kungaboqar moyi                                             |
| <b>501. Qanday tasmali uzatmada tasmaning ko'ndalang kesimi to'g'ri to'rt burchakli bo'ladi?</b> | A) yassi tasmada<br>S) aylanasiimon tasmada<br>B) ponasiimon tasmada<br>D) uchburchakli tasmada                    |
| <b>502. Qanday tasmali uzatmada tasmaning ko'ndalang kesimi trapeziya burchakli bo'ladi?</b>     | A) yassi tasmada<br>S) aylanasiimon tasmada<br>B) ponasiimon tasmada<br>D) uchburchakli tasmada                    |
| <b>503. Qanday tasmali uzatmada tasmaning ko'ndalang kesimi doiraviy bo'ladi?</b>                | A) yassi tasmada<br>S) aylanasiimon tasmada<br>B) ponasiimon tasmada<br>D) uchburchakli tasmada                    |
| <b>504. Zanjirli uzatmada qaysi detal ishlatiladi?</b>                                           | A) yulduzcha<br>S) g'ildirak<br>B) tasma<br>D) shkiv                                                               |
| <b>505. Zanjirli uzatmaning ish kriteriyasi qaysi?</b>                                           | A) zanjir sharnirlarining emirilishi<br>B) zanjir massasi<br>S) zanjir sharnirlaridagi bosim<br>D) sharnirlar soni |
| <b>506. Tsilindrik tishli uzatmaning ish kriteriyasi qaysi?</b>                                  | A) tishining emirilishi<br>B) g'ildirak tishining bosimi<br>S) g'ildirak massasi<br>D) tish balandligi             |
| <b>507. Tishli reduktorning chiqish validagi aylanishlar soni</b>                                | A) kamayadi<br>S) ko'payadi<br>B) o'zgarmaydi<br>D) nolga tenglashadi                                              |
| <b>508. Mashina detallarida kanday uzatmalar o'rganiladi</b>                                     | A) pnevmatik<br>B) Suyuklikli<br>S) Mexanik<br>D) Xavoli-mexanik                                                   |

|                                                      |                                                                                                                                                                                                                                                                       |                                                |
|------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|
| 509. Kinematik juftning klassi qancha?               |                                                                                                                                                                                      | A) 1      B) 2    S) 3    D) 4                 |
| 510. Kinematik juftning klassi qancha?               |                                                                                                                                                                                      | A) 1      B) 2    S) 3    D) 4                 |
| 511. Kinematik juftning klassi qancha?               |                                                                                                                                                                                      | A) 2      B) 3    S) 4    D) 5                 |
| 512. Mexanizmni harakatchanlik darajasi nimaga teng? |                                                                                                                                                                                      | A) $W = 0$ B) $W = 1$<br>S) $W = 2$ D) $W = 3$ |
| 513. Mexanizmni harakatchanlik darajasi nimaga teng? |                                                                                                                                                                                      | A) $W = 0$ B) $W = 1$<br>S) $W = 2$ D) $W = 3$ |
| 514. Mexanizmni harakatchanlik darajasi nimaga teng? |                                                                                                                                                                                     | A) $W = 0$ B) $W = 1$<br>S) $W = 2$ D) $W = 3$ |
| 515. Mexanizmni harakatchanlik darajasi nimaga teng? |                                                                                                                                                                                    | A) $W = 0$ B) $W = 1$<br>S) $W = 2$ D) $W = 3$ |
| 516. Mexanizmni harakatchanlik darajasi nimaga teng? |                                                                                                                                                                                    | A) $W = 0$ B) $W = 1$<br>S) $W = 2$ D) $W = 3$ |
| 517. Obod nima vazifani bajaradi?                    | A) kuchni tishdan qabul qiladi, u etarli darajada mustahkam va kuchni tishning uzunligi bo'yicha tekis taqsimlashga yordam berishi kerak<br>B) val bilan g'ildirakni biriktirish uchun xizmat qiladi<br>S) obod va stupitsani birlashtiradi<br>D) Hamma javob to'g'ri |                                                |
| 518. Stupitsa nima vazifani bajaradi?                | A) val bilan g'ildirakni biriktirish uchun xizmat qiladi<br>B) obod va stupitsani birlashtiradi<br>S) kuchni tishdan qabul qiladi, u etarli darajada mustahkam va kuchni tishning uzunligi bo'yicha tekis taqsimlashga yordam berishi kerak                           |                                                |

|                                          |                                                                                                                                                                                                                                                                       |
|------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                          | D) Hamma javob to'g'ri                                                                                                                                                                                                                                                |
| <b>519. Disk nima vazifani bajaradi?</b> | A) obod va stupitsani birlashtiradi<br>B) kuchni tishdan qabul qiladi, u etarli darajada mustahkam va kuchni tishning uzunligi bo'yicha tekis taqsimlashga yordam berishi kerak<br>S) val bilan g'ildirakni biriktirish uchun xizmat qiladi<br>D) Hamma javob to'g'ri |

**520. Mexanizmning kinematik xususiyatlari qaysi qatorda to'liq ko'rsatilgan?**

- A) mexanizm nuqtalarining traektoriyalari, nuqtalari va bo'g'inlarining harakatlari, tezlik va tezlanishlari  
B) mexanizm nuqtalarining traektoriyalari, tezlik va tezlanishlari  
S) mexanizm nuqtalarining va bo'g'inlarining harakatlari  
D) mexanizm bo'g'inlarining harakatlari, tezlik va tezlanishlari

**521. Mexanizmning kinematik tahlili nechta tsiklga o'tkaziladi?**

- A) 1            B) 2            S) 3            D) cheksiz

**522. Mexanizmning vaziyatlar plani deb nimaga aytiladi?**

- A) Etakchi bo'g'inning vaziyati va unga bog'liq holda boshqa bo'g'inning vaziyatlari tasvirlangan mexanizmning kinematik sxemasi  
B) Etakchi bo'g'inning vaziyati va unga bog'liq bo'lmagan boshqa bo'g'inning vaziyatlari tasvirlangan mexanizmning kinematik sxemasi  
S) Etaklanuvchi bo'g'inning vaziyati va unga bog'liq holda boshqa bo'g'inning vaziyatlari tasvirlangan mexanizmning kinematik sxemasi  
D) Etaklanuvchi bo'g'inning vaziyati va unga bog'liq bo'lmagan boshqa bo'g'inning vaziyatlari tasvirlangan mexanizmning kinematik sxemasi

**523. Mexanizmning kinematik sxemasi deb nimaga aytiladi?**

- A) talab qilingan harakat qonuniyatni ta'minlaydigan ketma - ketlikda va ma'lum masshtabda joylashtirilgan bo'g'inlar birikmasinining sxemasiga  
B) Etakchi bo'g'inning vaziyati va unga bog'liq holda boshqa bo'g'inning vaziyatlari tasvirlangan mexanizmning kinematik sxemasi  
S) talab qilingan harakat qonuniyatni ta'minlamaydigan ketma - ketlikda va ma'lum masshtabda joylashtirilgan bo'g'inlar birikmasinining sxemasiga  
D) talab qilingan harakat qonuniyatni ta'minlaydigan ketma - ketlikda va ma'lum masshtabda joylashtirilmagan bo'g'inlar birikmasinining sxemasiga

## GLOSSARIY

| Atamaning o'zbek tilida nomlanishi | Atamaning ingliz tilida nomlanishi | Atamaning rus tilida nomlanishi | Atamaning ma'nosi                                                                                                                                                                                                                                                      |
|------------------------------------|------------------------------------|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Texnika                            | technics                           | Texnika                         | Ishlab chiqarishda tadbiq etiladigan va uni boshqarishda qatnashadigan mehnat qurollari jihozlari mashinalar                                                                                                                                                           |
| Mexanika                           | Mechanics                          | Mexanika                        | Moddiy jismlarni ta'sirlashuvi va mexanik harakati to'g'risidagi fan.                                                                                                                                                                                                  |
| Mexanik harakat                    | mechanical motion                  | Mexanicheskoe dvijenie          | Vaqt oralig'ida moddiy jismning fazodagi holatini (o'rni) o'zgarishi. Tinch holat mexanik harakatning xususiy holi hisoblanadi. Tinch holat va mexanik harakat nisbiydir.                                                                                              |
| Texnik mexanika                    | technical mechanics                | Texnicheskaya mexanika          | Mashina, mexanizm va muxandislik inshootlari tushunchalari, ularni ta'sirlashuvi va kinematikasini analiz va sintezi, mustahkamlikka hisoblash asoslari hamda harakatni amalga oshirishda qatnashadigan uzatma va birikmalarni o'rganish to'g'risidagi fanlar majmuasi |
| Mashina                            | machine                            | Mashina                         | Quvvat, material va axborotni ishlab chiqarishda harakat bilan ta'minlaydigan odamni aqliy va jismoniy mehnatini engillashtiradigan qurilma.                                                                                                                           |
| Ishchi mashina                     | machine tool                       | Rabochaya mashina               | Materiallarni bir turdan ikkinchisiga aylantiradi va o'zgartiradi                                                                                                                                                                                                      |
| Texnologik mashina                 | technic machine                    | Texnologicheskaya mashina       | Buyumlarni shaklini, o'lchamlarini va xususiyatlarini o'zgartiradi                                                                                                                                                                                                     |

|                         |                             |                       |                                                                                                                                                                                                              |
|-------------------------|-----------------------------|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Transport mashinalari   | transport machinery         | Транспортные машины   | Buyumlarni, yuk va odamlarni tashish uchun ishlatiladi                                                                                                                                                       |
| Energetik mashinalar    | energy-converting machinery | Энергетические машины | Energiyani bir turdan ikkinchisiga aylantiradi                                                                                                                                                               |
| Mashina yurituvchilar   |                             | Машина yurituvchilar  | Har qanday energiyani mexanik energiyaga aylantiradi                                                                                                                                                         |
| Mashina generatorlar    | machine generators          | Машина generatorlar   | Mexanik energiyani boshqa turdagi energiyalarga aylantiradi                                                                                                                                                  |
| Axborot mashinalari     | informational machine       | Информационные машины | Axborotlarni olish – uzatish yoki o'zgartirishda ishlatiladi.                                                                                                                                                |
| EHM                     | electronic) somputer        | EVM                   | Sonlar tariqasidagi axborotlarni o'zgartiradi.                                                                                                                                                               |
| Kibernetik mashinalar   | cybernetic machine          | Кибнетические машины  | Insonga yoki tabiatga xos mexanik, fiziologik va biologik jarayonlarni bajaradi yoki imitatsiya qiladi                                                                                                       |
| Muxandislik inshootlari | engineering structure       | Инженерные сооружения | Mashina va mexanizmning ishchi organi harakatlanadi. Bu faktor mashina yoki mexanizmni muxandislik inshootidan farqini belgilaydi. Binolar, ko'priklar, tonnellar, rezervuar va h.k– muxandislik inshootlari |
| Yuritma                 | drive                       | Привод                | Energiya ishlab chiqaruvchi mashina, uzatish mexanizmi va boshqarish apparatidan tashkil topgan.                                                                                                             |
| Detal                   | particulars                 | Детал                 | Yig'ma birligisiz bir jinsli materialdan tayyorlangan buyum.                                                                                                                                                 |
| Val                     | shaft                       | Вал                   | Aylanma harakat va quvvatni uzatadigan, buralishi va egilish deformatsiyalariga uchraydigan pog'onali brus                                                                                                   |

|                    |                |                  |                                                                                                                                                                                                                                                                              |
|--------------------|----------------|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| O'q                | axis           | Os               | Aylanuvchi g'ildiraklar bilan harakatni uzatishda qatnashadigan, egilish deformatsiya-siga uchraydigan brus                                                                                                                                                                  |
| Brus               | beam           | Brus             | Uzunligi qolgan o'lchamlaridan katta bo'lgan jism                                                                                                                                                                                                                            |
| Sterjen            | bar            | Sterjen          | Ingichka brus                                                                                                                                                                                                                                                                |
| Balka              | beam           | Balka            | Egilishga qarshilik ko'rsatadigan brus                                                                                                                                                                                                                                       |
| Rama               | frame          | Rama             | Siniq chiziqli brus                                                                                                                                                                                                                                                          |
| Plastinka          | tablet         | Plastinka        | Qalinligi qolgan o'lchamlaridan kichik bo'lgan jism                                                                                                                                                                                                                          |
| Qobiq              | casing, cover  | Obolochka        | Egri shaklli plastinka                                                                                                                                                                                                                                                       |
| Ishga layoqatlilik | workability    | Rabotosposobnost | Texnik shartlar va hujjatlar va tanlangan o'lchamlar asosida talab qilingan xizmat vazifasini bajarish qobiliyati                                                                                                                                                            |
| Mustahkamlik       | stiffness      | Prochnost        | Material (detal) tashqi kuch ta'siriga emiril-masdan qarshilik ko'rsata olish qobiliyati. Mustahkamlikga hisoblashdagi talab kam material sarflab detallarni berilgan yukga bardosh berishlik qobiliyatini oshiradigan o'lchamlari va shaklini aniqlash imkoniyatini beradi. |
| Bikrlik            | steadiness     | Jestkost         | Konstruktsiya elementlarini deformatsiyasi juda kichik bo'lib, oldindan berilgan qiymatidan oshmasligi                                                                                                                                                                       |
| Ustivorlik         | heat-resistant | Ustoychivost     | Konstruktsiyaning detali o'zining to'g'ri chiziqli muvozanatlashgan holatini yoki shaklini yo'qotmaslik qobiliyati.                                                                                                                                                          |
| Issiqbardoshlik    |                | Teplostoykost    | Yuqori temperatura ta'sirida detallarning o'z mustahkamligi va xususiyatlarini saqlash qobiliyati.                                                                                                                                                                           |

|                           |                                  |                                        |                                                                                                                                                                                                                     |
|---------------------------|----------------------------------|----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tejamlilik                | economy                          | Ekonomichnost                          | Detallarni narxi va ekspluatatsion xarajatlari kam bo'lishi                                                                                                                                                         |
| Oddiylik                  | simplicity                       | Prostota                               | Konstruktsiya detalini shakli va o'lchamlari shunday tanlanishi kerakki, ularni tayyorlash vaqti va mehnati kam sarflanishi                                                                                         |
| Davlat standar-tiga moyil | addiction of government standard | Sklonnost k gosudarstvennym standartam | Alohida detallarni shakli va o'lchami umumiy normativga mos tushishi kerak.                                                                                                                                         |
| Loyihalash                | projection                       | Proektirovanie                         | Buyumni umumiy konstruktsiyasini ishlab chiqish.                                                                                                                                                                    |
| Konstruktsiyalash         | construction                     | Konstruirovanie                        | Printsipial sxemadan real konstruktsiyaga o'tish uchun barcha savollarga ketma-ket javob berish                                                                                                                     |
| Loyiha                    | project                          | Proekt                                 | Loyihalash va konstruktsiyalash natijasida hosil bo'ladigan hujjat.                                                                                                                                                 |
| Eskizli loyihalash        | preliminary design               | Eskiznoe projektirovanie               | Bo'lajak mashinaga tushadigan kuchlarni hisobga olgan holda konstruktor mashina yoki inshoot qismlarining o'lchamlarini hisoblaydi va tanlaydi                                                                      |
| Texnik loyihalash         | technical projection             | Texnicheskoe projektirovanie           | Hisoblashlar asosida mashina umumiy ko'rinishining chizmasi tuziladi.                                                                                                                                               |
| Ishchi loyiha             | working project                  | Rabochiy projekt                       | Tekshirilgan va oxirgi hisoblashlar asosida mashinaning alohida detallari va mexanizmlari umumiy ko'rinishining chizmasi tayyorlanadi; ishchi loyiha mashinani yig'ish uchun kerak bo'lgan barcha ma'lumotlarga ega |
| Konstruktor               | Design engineer                  | Konstruktor                            | Loyiha ishlarini boshqaruvchi va inshoot konstruktsiyasini yaratuvchi                                                                                                                                               |
| Muxandis                  | Engineer                         | Injener                                | Ingenium so'zidan olingan bo'lib yaratuvchi, ixtirochi degan birlamchi ma'noni beradi Hozirgi                                                                                                                       |

|                                   |                        |                             |                                                                                                                                                                                                                                                               |
|-----------------------------------|------------------------|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                   |                        |                             | vaqtda loyiha ishlarini bajaruvchi, texnikani yaratuvchi konstruktorlik byurolarida faoliyat ko'rsatuvchi xodimlar                                                                                                                                            |
| Mexanik                           | Mehanik                | Mexanik                     | Mashina va mexanizmlarni ta'mirlaydigan, ularni nosoz joylarini ta'mirlaydigan, moylaydigan, ekspluatatsiya qiladigan insonlar                                                                                                                                |
| Nazariy mexanika                  |                        | Teoreticheskaya mexanika    | Jismni harakat qonunlari va xossalari hamda jismning muvozanat shartlarini o'rganadi                                                                                                                                                                          |
| Materiallar qarshiligi            | Strengths of materials | Soprotivlenie materialov    | Inshoot elementlarini tashqi kuch ta'sirida o'zining mustahkamligi, bikrligi va ustuvorligini ta'minlash usullarini o'rganuvchi ta'limotlar majmui                                                                                                            |
| Mexanizm va mashinalar nazariyasi |                        | Teoriya mexanizmov i mashin | mexanizmlarning tuzilishi, kinematikasi va dinamikasini analiz va sintez qilishni o'rganadi                                                                                                                                                                   |
| Mashina detallari                 |                        | Detali mashin               | Mashina detallarining birikmalari, uzatmalarni hisoblash va loyixalash to'g'risidagi fan                                                                                                                                                                      |
| Analiz                            | analysis               | Analiz                      | Berilgan mexanizmlarning tuzilishi, kinematikasi va dinamikasini tekshirish                                                                                                                                                                                   |
| Sintez                            | synthesis              | Sintez                      | Berilgan kinematik va dinamik parametrlar bo'yicha yangi mexanizmlarni loyihalash                                                                                                                                                                             |
| Mexanizm                          | mechanism              | Mexanizm                    | Bir yoki bir nechta jism harakatini boshqa jismlarning aniq qonuniyatga amal qiluvchi harakatiga aylantirib beruvchi, o'zaro bog'lanishdagi jismlardan tashkil topgan qurilma. Mexanizm—barcha mashina, mexanik asbob va sanoat robotlarining kinematik asosi |



|                       |                          |                                |                                                                                                                                                  |
|-----------------------|--------------------------|--------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| Tekis mexanizm        | planar mechanism         | Ploskiy mexanizm               | Barcha nuqtalari o'zaro parallel tekisliklarda harakatlanadigan mexanizm                                                                         |
| Bo'g'in               | link                     | Zveno                          | Bir yoki bir nechta detallarning qo'zg'almas birikmasi                                                                                           |
| Kinematik juft        | kinematic pair           | Kinematicheskaya para          | Bir-biriga nisbatan harakat qiladigan ikkita bug'ining birikmasi                                                                                 |
| Quyi kinematik juft   | low kinematic pair       | Nizshaya kinematicheskaya para | Sirt bo'yicha tegishib turgan ikkita bo'g'inning birikmasi.                                                                                      |
| Oliy kinematik juft   | high kinematic pair      | Vysshaya kinematicheskaya para | Nuqta yoki chiziq bo'yicha tegishib turgan ikkita bo'g'inning birikmasi.                                                                         |
| Erkinlik daraja       | degree of freedom        | Stepen svobody                 | Mexanizmni mumkin bo'lgan harakatlari soni. Bir-biriga bog'lanmagan harakatlar soni                                                              |
| Kinematik zanjir      | kinematic chain          | Kinematicheskaya tsep          | Kinematik juftlar majmuasi.                                                                                                                      |
| Krivoship             | crank                    | Krivoship                      | Qo'zg'almas o'q atrofida aylanma harakat etadigan bo'g'in.                                                                                       |
| Koromislo             | rocker                   | Koromyislo                     | Qo'zg'almas o'q atrofida tebranma harakat etadigan bug'in.                                                                                       |
| Shatun                | coupler link             | Shatun                         | Biror parallel tekislikda murakkab harakat bajaradigan bug'in                                                                                    |
| Polzun                | slider                   | Polzun                         | Ilgarilanma–qaytma harakat etadigan bug'in.                                                                                                      |
| Richagli mexanizm     | rack-and-level mechanics | Richajnyy mexanizm             | Bir turdagi aylanma harakatni boshqa turdagi aylanma harakatga aylantirib beradi.                                                                |
| Kulisali mexanizm     | link mechanics           | Kulisnyy mexanizm              | Bir turdagi aylanma harakatni boshqa turdagi aylanma harakatga yoki uzluksiz aylanma harakatni ilgarilanma – qaytma harakatga o'zgartirib beradi |
| Harakatchanlik daraja | motion freedom           | Stepen podvijnosti             | Mexanizmdagi etakchi bo'g'inlar soni.                                                                                                            |

|                      |  |                          |               |                                  |                |                                                                                                                                                                                                                                          |                                                                                                            |
|----------------------|--|--------------------------|---------------|----------------------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| Assur guruhi         |  | group of ASSURS          |               | Gruppa Assura                    |                | Harakatchanlik darajasi nolga teng boʻlgan strukturaviy guruh.                                                                                                                                                                           |                                                                                                            |
| kulachokli mexanizm  |  | cam gear(ing)            |               | Kulachkovыy mexanizm             |                | Tarkibida oliy quyi kinematik juftlar vositasi bilan etaklanuvchi boʻgʻinning istalgan harakat qonunini amalga oshiradigan mexanizm.                                                                                                     |                                                                                                            |
| Etakchi boʻgʻin      |  | Input link; driving link |               | Veduyee zveno                    |                | Harakatchanlik darajasi mexanizmning xarakatchanlik darajasiga teng boʻlgan boʻgʻin                                                                                                                                                      |                                                                                                            |
| Etaklanuvchi boʻgʻin |  | Output link; driven link |               | Vedomoe zveno                    |                | Harakatni etaklovchi boʻgʻindan olib, uni oʻzgartirib ishchi mashinaga uzatuvchi                                                                                                                                                         |                                                                                                            |
| Kinematika           |  | kinematics               |               | Kinematika                       |                | Moddiy jism massasi va unga taʼsir qiladigan kuchlarni eʼtiborga olmasdan, uning harakati oʻrganiladi                                                                                                                                    |                                                                                                            |
| Nuqtaning harakati   |  | motion of particle       |               | Dvijenіe tochkі                  |                | Nuqtaning biror sanoq sistemasiga nisbatan istalgan vaqtdagi holatini aniqlash usuli maʼlum boʻlsa, uning harakati aniqlangan yoki berilgan deyiladi. Nuqtaning harakatini aniqlovchi ifoda uning harakat tenglamasi yoki harakat qonuni |                                                                                                            |
| Nuqta traektoriyasi  |  | trajectory of particle   |               | Traektoriya tochkі               |                | Harakat vaqtida nuqtani fazoda qoldirgan izi. Traektoriya uzluksiz chiziqdır                                                                                                                                                             |                                                                                                            |
| Vaqt                 |  | time                     |               | Vremya                           |                | Skalyar kattalik, barcha sanoq sistemasi uchun bir xil. Yoʻl, tezlik va tezlanish vaqtning funktsiyasi.                                                                                                                                  |                                                                                                            |
| Radius -vektor       |  | representati<br>on of    | radius vector | Sposoby<br>zadaniya<br>dvijenіya | Radius -vektor |                                                                                                                                                                                                                                          | Harakatlanayotgan nuqtaning har bir ondagi holatini uning radius vektori belgilaydi.                       |
| Koordinatalar        |  |                          | coordinate,   |                                  | Koordinatныy   |                                                                                                                                                                                                                                          | Fazoda harakatlanayotgan nuqtaning har bir vaqtdagi holatini uning uchta Dekart koordinatalari belgilaydi. |

|                     |                         |         |                        |              |                                                                                                                                                           |
|---------------------|-------------------------|---------|------------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tabiiy              |                         | natural |                        | Estestvennyy | Harakatlanayotgan nuqtaning har bir ondagi holati berilgan traektoriyadagi qo'zg'almas sanoq boshi O nuqtadan hisoblangan koordinata bilan aniqlanadi.    |
| Tezlik              | speed                   |         | skorost                |              | Nuqta harakatining o'zgarishini tavsiflovchi kinematik o'lchov.                                                                                           |
| Tezlanish           | acceleration            |         | Uskorenie              |              | Nuqta tezlik vektorinining o'zgarishini tavsiflovchi kinematik o'lchov.                                                                                   |
| Ilgarilanma harakat | translation movement    |         | Postupatelnoe dvijenie |              | Jism harakatlanganda undagi har qanday ixtiyoriy kesma hamma vaqt o'z-o'ziga parallel qoladi.                                                             |
| Aylanma harakat     | rotary motion           |         | Vrassatelnoe dvijenie  |              | Qo'zg'almas o'q atrofida harakatlanayotgan jismning ikkita nuqtasi hamisha qo'zg'almas bo'ladi. Valni o'z o'qi atrofidagi harakati aylanma harakat kiladi |
| Urinma tezlanish    | tangential acceleration |         | Kasatelnoe uskorenie   |              | Tezlik modulining o'zgarishini ifodalaydi va tezlikdan vaqt bo'yicha olingan birinchi tartibli hosilaga teng.                                             |
| Normal tezlanish    | normal acceleration     |         | Normalnoe uskorenie    |              | Tezlik yo'nalishining o'zgarishini ifodalaydi va berilgan nuqta tezlik kvadratini uning egrilik radiusiga nisbati bilan aniqlanadi.                       |
| Absolyut tezlik     | absolute velocity       |         | Absolyutnaya skorost   |              | Jismni - o'zining tinch holatiga nisbatan harakati.                                                                                                       |
| Nisbiy tezlik       | relative acceleration   |         | Otnositelnyy skorost   |              | Qo'zg'almas yoki harakatdagi nuqtaga nisbatan jismni harakati.                                                                                            |
| Burchakli tezlik    | rotary speed            |         | Uglovaya skorost       |              | Jismning aylanma harakat tezligini tavsiflovchi kinematik o'lchov bo'lib, burchakli siljishdan vaqt bo'yicha olingan birinchi tartibli hosilaga teng.     |
| Burchakli tezlanish | angular acceleration    |         | Uglovoe uskorenie      |              | Aylanayotgan jism burchak tezligi o'zgarishining kinematik o'lchovi bo'lib, burchak tezlikdan vaqt                                                        |

|                        |                                   |                            |                                                                                                                                                                                                                                                            |
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|                        |                                   |                            | bo'yicha olingan birinchi tartibli yoki burchagi siljishdan vaqt bo'yicha olingan ikkinchi tartibli hosilaga teng.                                                                                                                                         |
| Tekis parallel harakat | plane-parallel motion             | Ploskoparallelnoe dvijenie | Jismni barcha nuqtalari, o'ziga parallel bo'lgan tekislikda harakatlanadi.                                                                                                                                                                                 |
| Tezliklar oniy markazi | the instantaneous center of speed | Mgnovennyy tsentr skorosti | Har qanday qattiq jismning tekis parallel harakati asosiy tekislikga perpendikulyar joylashgan o'q atrofidagi aylanma harakatida hosil bo'ladi. Aylanish o'qi oniy o'q deyiladi. Oniy aylanish o'qini tekis shaklda hosil qilgan iz tezlikni oniy markazi. |
| Doiraviy tezlik        | Circumferential velocity          | Okrujnaya skorost          | Aylanma harakatdagi jism nuqtasining aylanish yo'nalishiga mos vektor kattalik bo'lib, aylanma harakatning kinematik xarakteristikasi                                                                                                                      |
| Statika                | statics                           | Statika                    | Moddiy jismlarning o'zaro ta'sirlashuvi va muvozanatini tekshiradigan nazariy mexanikaning bo'limi                                                                                                                                                         |
| Muvozanat holat        | balance state                     | Sostoyanie ravnovesiya     | Jism tinch holatda yoki boshq jismga nisbatan to'g'ri va tekis harakatda bo'ladi.                                                                                                                                                                          |
| Absolyut qattiq jism   | absolute rigid body               | Absolyutnoe tverdoe telo   | Tashqi ta'sir ostida xohlagan ikkita nuqtalari orasidagi masofasi o'zgarmagan jism absolyut qattiqdir.                                                                                                                                                     |
| Moddiy nuqta           | material particle                 | Materialnaya tochka        | Harakati va yoki muvozanati tekshirilganda o'lchamlari va shaklining ahamiyati bo'lmagan, massasi bir nuqtda joylashgan deb tasavvur qilinadigan jism                                                                                                      |

|                                    |                            |                              |                                                                                                                                                                           |
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| Sistema                            | system                     | Sistema                      | Harakatlari hamda vaziyatlari o'zaro bog'liq bo'lgan moddiy nuqtalar to'plami                                                                                             |
| Kuch                               | force                      | Sila                         | Jismlar mexanik ta'sirlashuvining o'lchovidir. Kuch uchta element bilan xarakterlanadi: son qiymati, yo'nalishi, qo'yilish nuqtasi. Kuch vektor kattalik.                 |
| Kuch vektorining moduli            | module of vector force     | Modul vektora sil            | Kuchning son qiymati.                                                                                                                                                     |
| Kuchning yo'nalishi                | line of action             | Napravlenie sily             | Tinch holatda bo'lgan moddiy nuqta shu kuch yo'nalishida harakatlanadi.                                                                                                   |
| Kuchni ta'sir chiziqlari           | line of action of a force  | Liniya deystviya sily        | Kuch vektori yo'nalgan to'g'ri chiziq.                                                                                                                                    |
| Kuchlar sistemasi                  | system force               | Sistema sil                  | Jismga qo'yilgan $(F_1, F_2, \dots, F_n)$ kuchlar to'plami kuchlar sistemasi deyiladi                                                                                     |
| Ekvivalent kuchlar sistemasi       | equivalent of system force | Ekvivalentnaya sistema sil   | Jismga qo'yilgan kuchlar sistemasi ko'rsatadigan ta'sirni boshqa kuchlar sistemasi bera olsa, bu ikki kuch sistemasi ekvivalent kuchlar sistemasi bo'ladi                 |
| Teng ta'sir etuvchi kuch           | resultant (force)          | Ravnodeystviyuyushaya sila   | Kuchlar sistemasining ta'sirini yolg'iz bir kuch beradi.                                                                                                                  |
| Muvozanatlashgan kuchlar sistemasi | balanced of system force   | Uravnoveshennaya sistema sil | Tinch turgan jism unga qo'yilgan kuchlar sistemasi ta'sirida ham tinch holatda qoladi. Muvozanatlashgan kuchlar sistemasi nolga ekvivalent                                |
| To'planma kuch                     | concentrated force         | Sosredotochennaya sila       | Ikkita jismni o'zaro ta'sirlashuvi nuqta vositasida amalga oshiriladi, ya'ni yukni qo'yilish yuzasining o'lchami konstruktsiya elementlarining o'lchamlaridan juda kichik |

|                                  |         |                         |           |                                                                                                                                                                                                                     |                                                                                                                                                               |
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| Taqsimlangan kuch                |         | distribution force      |           | Raspredeleennaya sila                                                                                                                                                                                               | Ikkita jismni o'zaro ta'sirlashuvi yuza yoki uzunlik bo'yicha amalga oshiriladi.                                                                              |
| -aksioma                         | 1-axiom | Aksiomalar sil          | 1-aksioma | Ikki kuch ta'siri ostidagi erkin qattik jism muvozanatda turishi uchun bu kuchlar moduli jixatdan bir-biriga teng va bitta to'g'ri chiziq bo'ylab qarama-qarshi tomonga yo'nalishi zarur                            |                                                                                                                                                               |
| 2-aksioma                        | 2-axiom |                         | 2-aksioma | Agar qattiq jismga muvozanatlashgan kuchlar sistemasi qo'yilsa yoki olinsa uning muvozanati buzilmaydi.                                                                                                             |                                                                                                                                                               |
| 3-aksioma                        | 3-axiom |                         | 3-aksioma | Jismning biror nuqtasiga qo'yilgan turli yo'nalishdagi ikki kuchning teng ta'sir etuvchisi, shu kuchlarning geometrik yig'indisiga teng bo'lib shu kuchlarga qurilgan parallelogramning diagonal bo'ylab yo'naladi. |                                                                                                                                                               |
| 4-aksioma                        | 4-axiom |                         | 4-aksioma | Jismlarning bir-biriga ta'siri o'zaro teng va bir to'g'ri chiziq bo'ylab qarama – qarshi tomonga yo'naladi.                                                                                                         |                                                                                                                                                               |
| 5-aksioma                        | 5-axiom |                         | 5-aksioma | Berilgan kuchlar ta'sirida deformatsiyalanadigan jism muvozanat holatida absolyut qattiq jismga aylansa, uning muvozanati o'zgarmaydi.                                                                              |                                                                                                                                                               |
| Tashqi kuch                      |         | external force          |           | Vneshnaya sila                                                                                                                                                                                                      | Tinch – harakatsiz holatda bo'lgan jismga ikkinchi jismni ta'siri                                                                                             |
| Ichki kuch                       |         | inherently force        |           | Vnutrennyaya sila                                                                                                                                                                                                   | Tashqi kuch ta'sirida jism materiali zarrachalarining o'zaro tortishish kuchlarini aktivlashishi                                                              |
| Bog'lanish                       |         | bond                    |           | Svyaz                                                                                                                                                                                                               | Jismning harakat yoki holatini cheklovchi sabab                                                                                                               |
| Tayanch                          |         | Support                 |           | Opora                                                                                                                                                                                                               | Jismning harakatiga qo'yilgan cheklov bog'lanish tayanch deyiladi. Val va o'qlarning ayrim nuqtalari podshipniklarga tayanadi.                                |
| Tayanch reaksiyasi               |         | Reaction at the support |           | Opornaya reaktsiya                                                                                                                                                                                                  | Podshipnikni valga ko'rsatadigan ta'siri tayanch kuchi hisoblanadi.                                                                                           |
| Qo'zg'aluvchan sharnirli tayanch |         | shifting bearing        |           | Podviynaya opora                                                                                                                                                                                                    | Bir chiziqli bog'lanish yoki qo'zg'aluvchan sharnirli tayanch, bog'lanish tekislikida tayanch nuqtasining harakatini cheklaydi. Tayanch kesim ikkita erkinlik |

|                                           |                                      |                                 |                                                                                                                                                                                                                                           |
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|                                           |                                      |                                 | darajaga ega, bitta reaksiya bo'ladi                                                                                                                                                                                                      |
| Qo'zg'almas sharnirli tayanch             | fixed bearing                        | Nepodvijnaya opora              | Bog'lanish yo'nalishlarida gorizonta va vertikal tekisliklarda tayanch kesimining harakatini cheklaydi. Tayanch kesimining aylanishi cheklanmagan. Tayanch kesim bitta erkinlik darajaga ega va unda ikkita reaksiya kuchi hosil bo'ladi. |
| Qistirib mahkamlangan tayanch             | built-in support                     | Zaщemlennaya opora              | Uch bog'lanishli tayanch, hamma erkinlik darajani cheklaydi. Tayanch kesim jism bilan birgalikda biror tekislikda harakatlana-olmaydi. Tayanchda uchta reaksiya kuchi hosil bo'ladi                                                       |
| Reaksiya kuchi                            | force of reactions                   | Sila reaktsii                   | Jismga ta'sir qiladigan bog'lanish kuchi. Jismni harakatlanishiga qarshilik ko'rsatadigan kuch.                                                                                                                                           |
| Aktiv kuch                                | active force                         | Aktivnaya sila                  | Jismni harakatlantiradigan kuch.                                                                                                                                                                                                          |
| Bir nuqtada kesishuvchi kuchlar sistemasi | concurrent system of forces          | Sistema sxodyaщixsya sil        | Ta'sir chiziqlari bir nuqtada kesishadigan kuchlar sistemasi bir nuqtada kesishuvchi kuchlar sistemasi                                                                                                                                    |
| Kuchlar ko'pburchagi                      | polygonal force                      | Mnogougolnik sil                | Ta'sir chiziqlari bir nuqtada kesishadigan kuchlar sistemasining teng ta'sir qiluvchi sini topish usuli                                                                                                                                   |
| Kuchning o'qdagi proektsiyasi             | the projection of forces on the axis | Proektsiya sil na os            | Kuch vektorining boshi va ohiridan o'qqa tushirilgan ikkita perpendikulyar orasidagi kesma uzunligi.                                                                                                                                      |
| Kuchni nuqtaga nisbatan momenti           | moment force about particle          | Moment sil po otnoshenii tochki | Kuchni aylantiruvchi - tavsifi. Kuchning nuqtaga nisbatan momenti – kuch modulini uning elkasiga kupaytmasiga teng.                                                                                                                       |
| Moment markazi                            | center of moment                     | Tsentr momenta                  | Kuch momenti qaysi nuqtaga nisbatan olinsa, shu nuqta moment markazi                                                                                                                                                                      |
| Kuch elkasi                               | arm of force                         | Plecho silы                     | Moment markazidan kuchning ta'sir chizig'igacha bo'lgan eng qisqa oraliq                                                                                                                                                                  |

|                                                         |                                                   |                                                       |                                                                                                                                                                                              |
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| Kuch momentini kim topgan                               | who determined of moment of force.                | Kto opredelil moment silы                             | Kuchning momenti tushunchasini Leonardo do Vinchi (1452-1519) kiritdi                                                                                                                        |
| Kuchni nuqtaga nisbatan momen - tining xossasi          | Properties methods in relation point              | Svoystva momenta sil po otnoshenii tochki             | Kuchning miqdori va yo'nalishini o'zgartirmay ta'sir chizig'i bo'ylab istalgan nuqtaga ko'chirilsa, kuch momenti o'zgarmaydi.                                                                |
| Kuchni nuqtaga nisbatan momen - tining xossasi          | Properties methods in relation point              | Svoystva momenta sil po otnoshenii tochki             | Agar kuchning ta'sir chizig'i moment markazidan o'tsa, uning shu markazga nisbatan momenti nolga teng bo'ladi, chunki bu holda kuchning elkasi nolga teng                                    |
| Kuchni o'qqa nisbatan momenti                           | moment of force of axial ratio                    | Moment silы po otnoshenii osi                         | $\bar{F}$ kuchni o'qqa perpendikulyar tekislikdagi proektsiyasidan o'q bilan tekislikning kesishgan nuqtasiga nisbatan olingan momenti                                                       |
| Qachon kuchni o'qqa nisbatan momenti nolga teng bo'ladi | When the moment of force against the axis is zero | Kogda moment silы po otnoshenii osi ravnyaetsya nulyu | kuchning ta'sir chizig'i o'qni kesib o'tsa yoki o'qqa parallel bo'lsa, chunki birinchi holda kuch elkasi, ikkinchi holda kuchning o'qqa perpendi-kulyar tekislikdagi proektsiyasi nolga teng |
| Juft kuch                                               | Pair of force                                     | Парные silы                                           | Moduli jihatdan o'zaro teng va bir yo'nalishda aylanayotgan ikkita parallel kuchlar.                                                                                                         |
| Juft momenti                                            | Moment pair of force                              | Moment парных sil                                     | Juftni tashkil etuvchi kuchlardan birining modulini uning elkasiga ko'paytmasi.                                                                                                              |
| Fazoda ixtiyoriy joylashgan kuchlar sistemasi           | System of force voluntarily arrangement in spaces | Sistemasil proizvolno raspolojennыx v prostranstve    | Ta'sir chiziqlari fazoda ixtiyoriy ravishda joylashgan kuchlardan tashkil topgan sistema                                                                                                     |
| Kuchlar sistemasi ning bosh vektori                     | resultant of system of forces                     | Главный вектор системы sil                            | Kuchlar sistemasining bosh vektori mazkur kuchlarning geometrik yigindisiga teng bo'ladi.                                                                                                    |
| Kuchlar sistemasining biror                             | resultant of moment system of forces in           | Главный момент системы sil po                         | Fazodagi kuchlar sistemasining biror markazga nisbatan bosh momenti tashkil etuvchi kuchlarning shu markazga                                                                                 |



|                                                                          |                                                                                     |                                                                            |                                                                                                                                                                                                                                                                                                                                             |
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| markazga nisbatan bosh momenti                                           | relative in define centre                                                           | otnoshenii opredelennogo tsentra                                           | nisbatan momentlarining geometrik yig'indisiga teng                                                                                                                                                                                                                                                                                         |
| Muvozanat shart                                                          | conditions of equilibrium                                                           | Usloviya ravnovesiya                                                       | Jismga ta'sir etuvchi fazoda ixtiyoriy joylashgan kuchlar sistemasining Dekart koordinata o'qlarining har biridagi proektsiyalarining algebraik yig'indisini nolga teng bo'lishi va kuchlarning har bir o'qga yoki ixtiyoriy tanlangan nuqtaga nisbatan momentlarining algebraik yig'indisini nolga teng bo'lishini aniqlovchi tenglamalar. |
| Bir nuqtaga kuyilgan kuchlar sistemasining analitik muvozanat shartlari. | The analytical conditions of equilibrium system of forces applied to a single point | Analiticheskaya usloviya ravnovesiya системы сил приложенных к одной точке | Bir nuqtaga qo'yilgan kuchlar ta'siridagi qattiq jism muvozanatda bo'lishi uchun, kuchlarning $X, U, Z$ o'qlaridagi proektsiyalarining yig'indisi nolga teng bo'lishi zarur va etarlidir:<br>$\sum F_{kx} = 0; \quad \sum F_{ky} = 0; \quad \sum F_{kz} = 0;$                                                                               |
| Tekislikdagi parallel kuchlar - ning muvozanat shartlari.                | The equilibrium conditions of parallel forces in the plane                          | Usloviya ravnovesiya параллельных сил на плоскости                         | Bir tekislikda yotgan va bir-biriga parallel bo'lgan kuchlar muvozanatda bo'lishi uchun barcha kuchlarning $U$ o'qidagi proektsiyalarining yig'indisi va kuchlarning tekislikdagi ixtiyoriy $O$ nuqtaga nisbatan olingan momentlarining yig'indisi alohida-alohida nolga teng bo'lishi zarrur va etarli                                     |
| Ishqalanish                                                              | friction                                                                            | Trenie                                                                     | Bir jismni ikkinchi jism sirtida harakatlanishida hosil bo'ladi.                                                                                                                                                                                                                                                                            |
| Ishqalanish kuchi                                                        | Force of friction                                                                   | Sila treniya                                                               | Ikki jismni bir-biriga nisbatan ishqalanib harakatlanishiga qarshilik ko'rsatuvchi kuch                                                                                                                                                                                                                                                     |
| Sirpanib ishqalanish                                                     | sliding friction                                                                    | Treniya skoljeniya                                                         | Bir – biriga tegib turgan jismlarning tezliklari tegishish nuqtalarida turlicha bo'ladigan harakat holatidagi ishqalanish                                                                                                                                                                                                                   |

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| Dumalash<br>ishqalanish              | rolling friction               | Treniya kacheniya                | Bir – biriga urinib turadigan jismlarning urinish nuqtalaridagi tezliklari kattaligi va yo'nalishi jihatidan bir xil bo'ladigan ishqalanish |
| Jismning og'irlik<br>markazi         | body center of<br>gravity      | Tsentr tyajesti tela             | Jismga tegishli barcha elementar zarrachalar parallel og'irlik kuchlarining markazi                                                         |
| Geometrik tavsif                     | geometrical<br>definition      | Geometricheskoe<br>opredelenie   | Geometrik – bog'lanishni nazariyasi                                                                                                         |
| Statik moment                        | static moment                  | Statcheskiy<br>moment            | Kesim yuza bilan o'q orasidagi masofa ko'paytmasining integrali                                                                             |
| Kesim yuzaning<br>og'irlik markazi   | center of figure               | Tsentr tyajesti<br>secheniya     | Kesim yuzadan hisoblab topilgan shunday nuqtaki, bu nuqta atrofida aylangan kesim yuza nuqtalarining chizgan traektoriyasi aylana bo'ladi.  |
| Inertsia momenti                     | moment of inertia              | Moment inertsii                  | Kesim yuza bilan o'q orasidagi masofa kvadratining ko'paytmasining integrali. Kesim yuzani biror o'qqa nisbatan inertsia momenti            |
| Markazdan qochma<br>inertsia momenti | product of inertia             | Tsentrobejnyy<br>moment inertsii | Kesim yuza bilan ikkita o'q orasidagi masofa ko'paytmasining integrali                                                                      |
| Qutb inertsia<br>momenti             | polar moment of<br>inertia     | Polyarnyy moment<br>inertsii     | Kesim yuza bilan qutb nuqtasi orasidagi masofa kvadratining ko'paytmasi                                                                     |
| Qarshilik momenti                    | resisting moment               | Moment<br>soprotivleniya         | Kesim o'lchamlarining bog'lanishi, mustahkamlikni ifodalaydigan geometrik tavsif                                                            |
| Bosh inertsia o'qi                   | The main axis of<br>inertia    | Glavnyy os inertsii              | Bosh inertsia o'qlariga nisbatan kesimni markazdan qochma inertsia momenti nolga teng                                                       |
| Bosh inertsia<br>momenti             | principal moment of<br>inertia | Glavnyy moment<br>inertsii       | Bosh inertsia o'qlariga nisbatan kesimni inertsia momenti                                                                                   |
| Inertsia radiusi                     |                                | Radius inertsii                  | Kesimning biror o'qqa nisbatan inertsia momentini kesim yuzasiga nisbati bilan topiladi                                                     |

|                        |                       |                             |                                                                                                                                                |
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| Material               | radius of inertia     | Material                    | Mexanik va plastiklik xossasiga, ishlov berilish xususiyatiga ega bo'lgan konstruktsiya va inshoot qismlarini tayyorlash mumkin bo'lgan buyum. |
| Qarshilik              | material              | Soprotivlenie               | Har qanday tashqi ta'sirga ichki aks ta'sirini ko'rsata olishlik                                                                               |
| Deformatsiya           | resistance deflection | Deformatsiya                | Tashqi kuch ta'siridan jismda o'lcham yoki shakl o'zgarishi                                                                                    |
| Oddiy deformatsiya     | simple deformation    | Prostaya deformatsiya       | Tashqi kuch yo'nalishida jismning o'lcham yoki shaklini o'zgarishi                                                                             |
| Murakkab deformatsiya  | hard deformation      | Slojnaya deformatsiya       | Bir vaqtda ikkita va undan ko'proq oddiy deformatsiyalarni hosil bo'lishi                                                                      |
| Elastik deformatsiya   | elastic deformation   | Elasticheskaya deformatsiya | Tashqi kuch ta'siri yo'qotilgandan keyin jismning boshlang'ich o'lcham va shaklini tiklanishi                                                  |
| Plastik deformatsiya   | plastic deformation   | Plasticheskaya deformatsiya | Qoldiq deformatsiya, tashqi kuch ta'siri yo'qotilgandan keyin jismning boshlang'ich o'lcham va shaklini tiklanmasligi                          |
| Absolyut deformatsiya  | absolute strain       | Absolyutnaya deformatsiya   | Bir birlik uzunlikka to'g'ri keluvchi uzayish                                                                                                  |
| Nisbiy deformatsiya    | relative deformation  | Otnositelnaya deformatsiya  | Bir birlik uzunlikka to'g'ri keluvchi absolyut uzayish                                                                                         |
| Chiziqli deformatsiya  | linear strain         | Lineynaya deformatsiya      | Tashqi kuch ta'sirida jismda o'lcham yoki shakl o'zgarishi bir chiziq bo'ylab sodir bo'ladi                                                    |
| Burchakli deformatsiya | angular deformation   | Uglovaya deformatsiya       | Tashqi kuch ta'siridan jismda o'lcham yoki shakl o'zgarishi burchak ostida sodir bo'ladi jismni kesimi aylanadi                                |
| Kuchlanish             | tension               | Napryajenie                 | Ichki kuchni kesim yuzada tarqalish qonuniyatini ifodalaydi, ya'ni bir-birlik yuzaga to'g'ri keluvchi kuch.                                    |

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| Hisobiy kuchlanish              | Design stress        | Raschetnoe napryajenie      | Tashqi kuch ta`sirida hisoblangan kuchlanish                                                                                                                 |
| Normal kuchlanish               | normal tension       | Normalnoe napryajenie       | Kesim yuzaga tik yoki unga parallel yo`naladigan kuchlanish                                                                                                  |
| Urinma kuchlanish               | tangential stress    | Kasatelnoe napryajenie      | Kesim yuzaga urinma yo`naladigan kuchlanish                                                                                                                  |
| To`liq kuchlanish               | combined stress      | Polnoe napryajenie          | Normal va urinma kuchlanishlarni geometrik yig`indisi.                                                                                                       |
| Ruxsat etilgan kuchlanish       | working stress       | Dopuskaemoe napryajenie     | Konstruktsiya qismlarining elastik deformatsiya, mustaxkamligi va xavfsiz ishlashini ta`minlash uchun brus materialiga xos bo`lgan cheklangan kuchlanish     |
| Kontaktli kuchlanish            | contact stress       | Kontaktnoe napryajenie      | Tishli g`ildiraklarni ilashish nuqtasida (chiziqda) hosil bo`lgan kuchlanish                                                                                 |
| Kontaktli kuchlanish            | Contact stress       | Kontaktnoe napryajenie      | Ikkita aylanib harakatlanadigan jismlarning tegishib turadigan sirtida hosil bo`ladigan kuchlanish                                                           |
| Kuchlanishlar kontsentratsiyasi | stress concentration | Kontsentratsiya napryajeniy | Teshik, kanavka yoki defekt atrofidagi kuchlanishlar to`plami                                                                                                |
| Kuchlanishlar kontsentratsiyasi | Stress concentration | Kontsentratsiya napryajeniy | Kuchlanishlarni biror sohada (maydonda) to`planishi. Masalan teshik, kanavka yonida                                                                          |
| Qattqlik                        | hardness             | Tverdost                    | Sirtiga singdirilgan detalga qarshilik ko`rsata olish qobiliyati                                                                                             |
| Konstruktsiya                   | construction         | Konstruktsiya               | Detal, mexanizm, mashina, qurilma, inshoot                                                                                                                   |
| Kesish usuli                    | sectioning method    | Metod secheniy              | Tashqi kuch ta`sirida bo`lgan jismning ixtiyoriy kesim yuzasidagi ichki kuch faktorlarini ko`rish va hisoblash usuli                                         |
| Bo`ylama kuch                   | longitudinal force   | Prodolnaya sila             | Brusning kesilgan ko`ndalang kesimidan bir tomonda olib qolingani tashqi kuchlarni ushbu kesimning normal yoki bo`ylama o`qiga proektsiyalarining algebratik |

|                   |                  |                           |                                                                                                                                                   |
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|                   |                  |                           | yig'indisi                                                                                                                                        |
| Burovchi moment   | twisting moment  | Krutyayıcı moment         | Sterjenning kesilgan kesim yuzasidan bir tomonda joylashgan tashqi momentlarning algebraik yig'indisi                                             |
| Ko'ndalang kuch   | transverse force | Poperechnaya sila         | Balkaning ajratib olingan qismidagi barcha kuchlarni balkani kesilgan yuzasidagi kuch chiziqiga proektsiyalarining algebraik yig'indisi           |
| Eguvchi moment    | bending moment   | Izgibayıcı moment         | Balkani ajratib olingan qismidagi barcha kuchlarning, balka kesilgan yuzasining kesim markaziga nisbatan kuch momentlarining algebraik yig'indisi |
| Epyura            | diagram          | Epyura                    | Ichki kuch faktorlarini brusning o'qi bo'ylab o'zgarishini ifodalovchi ma'lum qonuniyat asosida qurilgan grafikasi                                |
| Kuch tekisligi    | plane of force   | Ploskost silы             | Egilishda barcha tashqi va reaksiya kuchlari ta'sir qiladigan yagona tekislik                                                                     |
| Kuch chiziqi      | force line       | Liniya silы               | Kuch tekisligini brusning ko'ndalang kesim yuzasi bilan kesishish chiziqi                                                                         |
| Neytral qatlam    | neutral plane    | Neytralныy sloy           | Balkani egilishida cho'zilmaydigan va siqilmaydigan, o'zining boshlang'ich uzunligini o'zgartirmaydigan material qatlami .                        |
| Neytral o'q       | neutral axis     | Neytralnaya os            | Balkaning ko'ndalang kesim yuzasi bilan neytral qatlamni kesishish chiziqi                                                                        |
| Taqsimlangan kuch | Distributed load | Raspredeleonnaya nagruzka | Uzunlik yoki yuza bo'yicha tarqalgan kuch. Teng yoki notekis taqsimlangan bo'ladi                                                                 |
| Kuch epyurasi     | Load diagram     | Epyura nagruzki           | Kuchni uzunlik yoki balandlik bo'ylab tarqalish qonuniyatini ifodalovchi grafika                                                                  |
| Cho'zilish        | elongating       | Rasstyajenie              | Tashqi kuch ta'sirida brus uzunligini ortishi va ko'ndalang o'lchamini qisqarishi                                                                 |

|                                 |                            |                                  |                                                                                                                                                                           |
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| Siqilish                        | pressing                   | Sjatie                           | Tashqi kuch ta'sirida brus uzunligini qisqarishi va ko'ndalang o'lchamini ortishi                                                                                         |
| Markaziy cho'zilish va siqilish | axial tension and pressing | Tsentrалnoe rastyajenie i sjatie | Tashqi kuch ta'siridan brusning kesim yuzasidagi material zarrachalari bir xil masofaga ko'chadi, ya'ni brusning kesim yuzasi o'q bo'ylab chiziqli qisqaradi yoki ortadi. |
| Guk qonuni                      | Hooke's law                | Zakon Guka                       | Kuch bilan deformatsiya bog'lanishining grafikasi to'g'ri chiziq qonuniyatga bo'ysunishi-ni tavsiflovchi nazariya                                                         |
| Yung moduli                     | Young's modulus            | Modul Yunga                      | Materialni mexanik xossasini xarakterlovchi fizik kattalik. Materialning turiga bog'liq                                                                                   |
| Bo'ylama deformatsiya           | longitudinal strain        | Prodolnaya deformatsiya          | Tashqi kuch ta'siridan brus uzunligini o'q bo'ylab chiziqli uzayishini nisbiy (absolyut) miqdori                                                                          |
| Ko'ndalang deformatsiya         | lateral deformation        | Poperechnaya deformatsiya        | Tashqi kuch ta'siridan brus ko'ndalang kesim yuzasining o'zgarishini absolyut (nisbiy) miqdori.                                                                           |
| Bikrlik                         | Rigidity; stiffness        | Jestkost                         | Tashqi kuch ta'siridan inshoot elementini o'z boshlang'ich shakl va o'lchamlarini o'zgartirmaslik qobiliyati                                                              |
| Elastiklik moduli               | modulus of elasticity      | Modul elastichnosti              | Fizik konstanta, materialni turiga bog'liq                                                                                                                                |
| Puasson koeffitsienti           | Poisson ratio              | Koeffitsient Puassona            | Brus ko'ndalang kesim yuzasining qisqarishini tavsiflaydi.                                                                                                                |
| Diagramma                       | Diagram                    | Diagramma                        | Kuch bilan deformatsiya bog'lanishini koordinata o'qlarida grafikaviy usulda ifodalanishi                                                                                 |
| Mexanik xossa                   | mechanical properties      | Mexanicheskaya svoystva          | Material mustahkamligini xarakterlovchi kuchlanishlar to'plami                                                                                                            |
| Elastiklik chegara              | border of elasticity       | Predel elastichnosti             | Brus materialining elastiklik xossasida – deformatsiya so'nuvchan bo'ladi.                                                                                                |
| Proportsionallik chegara        | border of propotion        | Granitsa proportsialnosti        | Kuch bilan deformatsiya bog'lanishining grafikasi to'g'ri chiziq, ya'ni Guk qonuniyatiga bo'ysunadi.                                                                      |

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| Oquvchanlik chegara      | liquid limit                | Granitsa tekuchesti        | Taxminan o'zgaras kuchlanish ta'sirida brusni uzayishi tez o'sadi.                                                                                          |
| Mustahkamlik chegara     | The boundary strength       | Granitsa prochnosti        | Eng katta kuchga to'g'ri keluvchi kuchlanish                                                                                                                |
| Mahalliy uzayish         | local elongation            | Mestnoe udlinenie          | Brus uzayishini ma'lum bir oraliqda to'planishi yoki sodir bo'lishi                                                                                         |
| Mustahkamlik shart       | strength condition          | Usloviya prochnosti        | Xavfli kesimdagi emirilishni cheklaydigan matematik ifoda                                                                                                   |
| Ruxsat etilgan yuk       | safe load                   | Dopuskaemaya nagruzka      | Konstruktsiya ko'tara olishi mumkin bo'lgan yukning miqdori                                                                                                 |
| Kesimni tanlash          | Selection of cross-sections | Vybor secheniy             | Tashqi kuch ta'siriga emirilmasdan qarshilik ko'rsata oladigan, uning mustahkamligini ta'minlaydigan kesimning o'lchami.                                    |
| Mustahkamlikka hisoblash | Strength design             | Raschet na prochnost       | Inshoot elementining xavfli kesimidagi maksimal kuchlanish ushbu element materiali uchun ruxsat etilgan kuchlanishdan ortib ketmasligini ta'minlovchi shart |
| Mustahkamlik zahirasi    | Factor of safety            | Zapas prochnosti           | Materialni xavfli kuchlanishini ruxsat etilgan kuchlanishga qadar kamaytiruvchi kattalik, materialning turiga bog'liq                                       |
| Plastiklik xossa         | Plastic properties          | Plastiklicheskaya svoystva | Materialni deformatsiyalanish xususiyatini belgilovchi xossa                                                                                                |
| Plastiklik               | Plasticity                  | Plastichnost               | Brusni cho'zilish (siqilish)ga, egilishga va h.k.larga moyilligi, katta qoldiq deformatsiya hosil qilish xususiyati                                         |
| Mo'rtlik                 | Brittleness                 | Xrupkost                   | Materialning plastiklikiga teskari xossasi                                                                                                                  |
| Puxtalanish              | Hardening                   | Uprochnenie                | Birlamchi uzayish evaziga proportsionallik chegarani o'sishi                                                                                                |

|                            |                                       |                                   |                                                                                                                              |
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| Relaksatsiya hodisasi      | Relaxation                            | Relaksatsiya                      | Vaqt o'tishi bilan kuchlanish miqdorini kamayishi                                                                            |
| Kuchlanganlik holat        | stressed state                        | Napryajennoe sostoyanie           | Kubikni tomonlarida va qiya kesim yuzalarida kuchlanishlarni xilma-xilligi va o'zgarishini tahlili                           |
| Chiziqli kuchlanganlik     | linear stresses                       | Lineynaya napryajennost           | Chiziq bo'ylab kubikni ko'ndalang va qiya kesim yuzalarida kuchlanishlarni tahlili                                           |
| Tekis kuchlanganlik        | plane tensity                         | Ploskaya napryajennost            | Kubikni o'zaro perpendikulyar uchta qirralaridan ikkitasining bir vaqtda cho'zilish va siqilishini tahlili                   |
| Bosh yuza                  | principal cross-section               | Glavnaya ploщad                   | Urinma kuchlanishlar ta'siri nolga teng bo'lgan yuzalar                                                                      |
| Bosh kuchlanishlar         | principal stresses                    | Главные napryajeniya              | Bosh yuzalarga qo'yilgan kuchlanishlar                                                                                       |
| Bosh kuchlanish yo'nalishi | principal stress direction            | Napravlenie glavnogo napryajeniya | Cho'zuvchi va siquvchi kuchlanishlar yo'nalishini aniqlash                                                                   |
| Hajmiy deformatsiya        | volumetric deformation                | Ob'emnaya deformatsiya            | Kubikni o'zaro perpendikulyar uchta qirralarining bir vaqtda cho'zilish va siqilishini tahlili                               |
| Hajm o'zgarishi            | strain energy due to change of volume | Izmeneniya ob'ema                 | Kubikni deformatsiyalanishida barcha qirralarini bir xil miqdorga uzayishi yoki qisqarishi, ya'ni kubik kubikligicha qoladi. |
| Shakl o'zgarishi           | mode change                           | Izmenenie form                    | Kubikni deformatsiyalanishida uning qirralari-ning o'lchamlari bir xil o'zgarmaydi, kubik parallelogramm shaklini egallaydi. |
| Gukni hajmiy qonuni        | Hooks volumetric law                  | Ob'emnyy zakon Guka               | Elastik hajmiy deformatsiyani tavsiflovchi qonuniyatni matematik ifodasi                                                     |
| Hajmiy elastiklik modul    | Moduls of extensional elasticity      | Modul ob'emnoy elastichnosti      | Elastik hajmiy deformatsiyadagi fizik konstanta                                                                              |



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| Mustahkamlik nazariya | theory of strength  | Teoriya prochnosti      | Konstruktsiyalarning mustahkamligi to'g'risidagi turli nazariy va tajribaviy mulohaza va g'oyalarni mujassamlashgan holatini matematik ifodasi |
| Mo'rt emirilish       | brittle damage      | Xrupkiy iznos           | Materiallarni elastiklik xossasidan tashqarida darz yorilishi.                                                                                 |
| Plastik emirilish     | plastic damage      | Plasticheskiy iznos     | Materiallarni elastiklik xossasidan tashqaridagi qoldiq deformatsiya                                                                           |
| Xavfli kesim          | dangerous section   | Opasnoe sechenie        | Eng katta kuchlanish ta'siridan kesim yuzada emirilish sodir bo'lishi mumkin                                                                   |
| Xavfli nuqta          | dangerous point     | Opasnaya tochka         | Kuchlanishni eng katta qiymati hosil bo'lgan nuqta.                                                                                            |
| Siljish               | shift               | sdvig                   | Tashqi kuch ta'siridan brus kesim yuzalarini bir-biriga nisbatan ko'chishi                                                                     |
| Absolyut siljish      | absolute shear      | Absolyutnyy sdvig       | Bir-birlik o'lchamga to'g'ri keluvchi siljish                                                                                                  |
| Nisbiy siljish        | relative shear      | Otnositelnyy sdvig      | Bir-birlik o'lchamga to'g'ri keluvchi absolyut siljish                                                                                         |
| Kesilish              | Shear               | Srez; sdvig             | Urinma kuchlanishlar ta'siridagi kubikning deformatsiyasi. Siljishning xavfli holati kesilish bo'ladi. Turli birikmalar siljishga uchraydi     |
| Qirg'ilish            | section             | Srez                    | Xavfli siljish kesimida kesilishga qarshilik ko'rsatish qobiliyati                                                                             |
| Ezilish               | crushing            | Smyatie                 | Siljish tekisligiga perpendikulyar yuzada material zarrachalarini ko'chishi                                                                    |
| Siljish moduli        | modulus of rigidity | Modul sdviga            | Siljishda fizik konstanta, ikkinchi tartibli elastiklik moduli                                                                                 |
| Birikma               | Compound            | Soedinenie              | Ikkita jismni tutashtirish yuzasi va usuli                                                                                                     |
| Payvand birikma       | Weided joint        | Svarnoe soedinenie      | Ikkita element materiallarini suyuq holatda biriktirish usuli                                                                                  |
| Parchin<br>birikma    | River connexion     | Zaklepochnoe soedinenie | Ikkita elementni parchin mix vositasida biriktirish usuli                                                                                      |

|                          |                       |                            |                                                                                                                                                            |
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| Buralish                 | torsion               | Kruchenie                  | Parallel joylashgan ikkita doiraviy kesimlarni bir o'q atrofida va bir-biriga nisbatan aylanishi                                                           |
| Buralish                 | Torsion               | Kruchenie                  | Aylantiruvchi moment ta'siridan val kesimini o'z o'qi atrofida aylanishi.                                                                                  |
| Buralish burchagi        | The angle of torsion  | Ugol krucheniya            | Valning ko'ndalang kesim yuzasini o'q atrofida aylanish burchagini belgilaydi                                                                              |
| Bikrlik shart            | Sonditions stiffness  | Uslovie jestkosti          | Brus deformatsiyasini cheklangan qiymatini belgilovchi matematik ifoda                                                                                     |
| Ko'chish                 | displacement          | Peremeshenie               | Nuqtaning tashqi kuch ta'sirida shu kuch yo'nalishida bir chiziq bo'ylab ko'chishi                                                                         |
| Egilish                  | Bending               | Izgib                      | Bo'ylama o'qiga perpendikulyar tekislikda ta'sir qilayotgan kuch ta'sirida brus shaklini ushbu kuch yo'nalishida o'zgarishi yoki brus o'qining egrilanishi |
| Differentsial bog'lanish | Differential bond     | Differentsialnaya svyaz    | Balka kesimining aylanish burchagi bilan salqilik orasidagi bog'lanish                                                                                     |
| Differentsial tenglama   | Differential equation | Differentsialnoe uravnenie | Balka egilgan o'qini tashqi kuch va bikrlik bilan bog'lanishining matematik ifodasi                                                                        |
| Universal formula        | Universal formula     | Universalnaya formula      | Balka ixtiyoriy kesimining aylanish burchagi va salqiligining formulasi                                                                                    |
| Grafoanalitik usul       | semigraphical method  | Grafoanaliticheskiy metod  | Balka tanlangan kesimining aylanish burchagi va salqiligini aniqlashni analitik va grafikaviy usullarini mujassamlangan ko'rinishi                         |
| Konsol balka             | Cantilever beam       | Konsolnaya balka           | Konsol deb tayanchdan bir tomonda joylashgan balkaning bir qismiga deyiladi                                                                                |
| Murakkab qarshilik       | Complex resistange    | Slojnoe soprotivlenie      | Konstruktsiyani ikkita va undan ortiq oddiy deformatsiyalar ta'sirida bo'lishi                                                                             |

|                                               |                         |                            |                                                                                                                                                                                         |
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| Qiyshiq egilish                               | Oblique bending         | Kosoy izgib                | Tashqi kuchning ta'sir chizig'i bo'ylama o'qiga perpendikulyar joylashib, ko'ndalang kesimining birorta ham bosh inertsia o'qlari tekisligidan o'tmaydigan sterjenning deformatsiyasi   |
| Markazlashmagan siqilish                      | Eccentric compression   | Vnetsentrennoe sjatie      | Bo'ylama o'qiga parallel kuch ta'sirida cho'zilish (siqilish)ga uchraydigan va ko'ndalang kesimining birorta ham bosh inertsia o'qlari tekisligida egilmaydigan brusning deformatsiyasi |
| Buralish bilan egilishni birgalikdagi ta'siri | Twisting and bending    | Kruchenie i izgib          | Valning kesim yuzasida burovchi va eguvchi momentlarni hosil bo'lishi, ya'ni valni buralish bilan egilish deformatsiyalarining birgalikdagi ta'sirida bo'lishi                          |
| Keltirilgan moment                            | The above point         | Privedenny moment          | Turli mustahkamlik nazariyalari asosida hisoblangan burovchi va eguvchi momentlarning yig'indisi                                                                                        |
| Noustuvorlik                                  | instability             | Neustoychivost             | Siquvchi kuch ta'sirida sterjenning to'g'ri chiziqli shaklini saqlab qola olmasligi                                                                                                     |
| Kritik kuch                                   | Critical force          | Kriticheskaya sila         | Sterjen ustuvorligini yo'qolishiga sabab bo'luvchi kuch                                                                                                                                 |
| Egiluvchanlik                                 | eligibility             | Izgibaemost                | Turli uzunlik va o'lchamdagi sterjenlarni to'g'ri chiziqli shaklini elastik o'zgartirish xususiyatini ifodalovchi konstanta                                                             |
| Ustuvorlik sharti                             | The stability condition | Uslovie ustoychivosti      | Ingichka va uzun sterjenlar ustuvor holati ni ta'minlovchi shartni matematik ifodasi                                                                                                    |
| Dinamika                                      | dynamic                 | Dinamika                   | Jismlarning mexanik harakatini ularning massasiga va harakatni vujudga keltiruvchi kuchlarga bog'liq ravishda o'rganadi                                                                 |
| Differentsial tenglama                        |                         | Differentsialnoe uravnenie | Moddiy nuqta harakatining matematik ifodasi (tenglama) koordinata o'qlariga proektsiyalanadi.                                                                                           |

|                                 |                                   |                                  |                                                                                                                                                |
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| Massa                           | Mass                              | Massa                            | Jism inertligining miqdor o'lchovi. Jism xususiy og'irligini erkin tushish tezlanishiga nisbati bilan topiladi.                                |
| Zarb                            | Impact                            | Udar                             | Konstruktsiya qismining yoki bir bo'lagining juda kichik vaqt davrida tezligi o'zgarishining hodisasi-zarb ta'sirida sodir bo'ladi             |
| Dinamik yuklanish               | Dynamic loading                   | Dinamicheskoe nagrujenie         | Qisqa vaqt orligida miqdorini keskin o'zgartiradigan kuch                                                                                      |
| Inertsia kuchi                  | Force of inertia                  | Sila inertsii                    | Jismni massasi bilan tezlanishining ko'paytmasiga teng bo'lgan vektor, harakat yo'nalishiga teskari yo'naladi                                  |
| Kuchlanishlar tsikli            | Stress cycle                      | Tsikl napryazheniy               | Kuchlanishlarning maksimal va minimal qiymatlarini takrorlanish soni.                                                                          |
| Kuchlanishning simmetrik tsikli | Completely reversed stress cycles | Simmetrichnyy tsikl napryazheniy | Kuchlanishlarning maksimal va minimal qiymatlari o'zaro teng. Maksimal va minimal kuchlanishlar yig'indisi nolga teng                          |
| Ko'chish, siljish               | Distance; displacement            | Put; peremeshenie                | Biror sanoq sistemasiga nisbatan nuqtaning ma'lum $t$ vaqt ichida fazoda bir holatdan boshqa holatga ixtiyoriy ravishda o'tishi                |
| Mexanik sistema                 |                                   | Mexanicheskaya sistema           | Y'zaro bog'lanishda bo'lgan moddiy nuqtalarning majmuasi.                                                                                      |
| Inertsia kuch                   |                                   | Sila inertsii                    | Nuqta massasini uning tezlanishiga ko'paytmasi. Inertsia kuchi nuqtaning tezlanishiga teskari yo'nalishda bo'ladi.                             |
| Dalamber printsiplari           |                                   | Printsip Dalamberta              | Moddiy nuqtaga ta'sir qilayotgan aktiv va reaktiv kuchlari inertsia kuchi bilan birgalikda muvozanatlashgan kuchlar sistemasini tashkil etadi. |
| Dinamik kuch                    | Dynamic force                     | Dinamicheskaya sila              | Qisqa vaqt oralig'ida qiymatini o'zgartiruvchi kuch                                                                                            |

|                         |                     |                             |                                                                                                                                                                                            |
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| Dinamik deformatsiya    | Dynamic deformation | Dinamicheskaya deformatsiya | Dinamik kuch ta'siridagi brusni shakl yoki o'lchamlarini o'zgarishi                                                                                                                        |
| Zarb ta'siri            | Influence of shot   | Vliyanie udara              | Ma'lum balandlikdan tushgan yukni jismga ta'siri                                                                                                                                           |
| Zarbga sinash           | Impact test         | Ispytanie na udar           | Zarb ta'sirida material xossalarini o'rganish                                                                                                                                              |
| O'zgaruvchan kuchlanish | AC voltage          | Peremennoe napryazhenie     | Vaqt oralig'ida qiymati va ishorasini o'zgartiradigan kuchlanish                                                                                                                           |
| Materialni toliqishi    | Fatigue material    | Uсталost materiala          | O'zgaruvchan kuchlanish ta'sirida materialni darz yorilishi                                                                                                                                |
| Chidamlilik chegara     | Stamina boeder      | Granitsa vyinoslivosti      | Materiallarning toliqishini cheklaydigan chegara                                                                                                                                           |
| Ish                     |                     | Rabota                      | Kuch modulini bosib o'tilgan masofaga ko'payt-masi. Ishni o'lchov birligi-djoul. Musbat ishorali ish bajargan kuchharakatlantiruvchi; manfiy ishorali ish bajargan kuch – qarshilik kuchi. |
| Quvvat                  |                     | Мощност                     | vaqt birligida bajarilgan ish; kuch modulini - o'zi ta'sir qilayotgan nuqtaning tezligiga ko'paytmasi; aylantiruvchi momentni burchak tezlikga ko'paytmasi                                 |
| Uzatish nisbati         |                     | Peredatochnoe otnoshenie    | Etakchi bo'g'in burchak tezligini etaklanuvchi bo'g'in burchak tezligiga nisbati.                                                                                                          |
| Uzatish soni            |                     | Peredatochnoe chislo        | Katta burchak tezlikni kichik burchak tezlikga nisbati. Bu son birga teng yoki birdan katta                                                                                                |
| Uzatma                  |                     | Peredacha                   | Dvigateldan energiyani (harakatni), aylantiruvchi momentlarni, tezliklarni, ayrim hollarda harakat xarakterini o'zgartirib mashinaning ishchi organlariga uzatishga imkon beruvchi qurilma |
| Tishli uzatma           |                     | Zubchataya peredacha        | Ikkita tishli g'ildirak va tayanchdan tashkil topgan mexanizm. Ilashadigan tishli g'ildiraklardan kichik diametrli shesternya va katta diametrli g'ildirak.                                |

|                          |  |                                    |                                                                                                                                                                                        |
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| Ilashma moduli           |  | Modul zatsepleniya                 | Tishni moduli bo'luvchi aylana qadamidan $\pi$ marotaba kichik bo'lgan chiziqli kattalik. Modul kattalashsa tish profilining balandligi ortadi.                                        |
| Bo'luvchi aylana         |  | Delitelnyy diametr                 | Tsilindrni teng Z qismga bo'lish jarayonida tayyorlangan g'ildirak aylanasi.                                                                                                           |
| o'qlararo masofa         |  | Mejosevoe rasstoyanie              | Ikkita g'ildirak bo'luvchi aylanalari radiuslarining yig'indisi.                                                                                                                       |
| Tish uchining balandligi |  | Vysota golovki zuba                | G'ildirakning bo'luvchi aylanasi tishni uchigacha bo'lgan masofa.                                                                                                                      |
| Tish tubining balandligi |  | Vysota nojki zuba                  | G'ildirakning bo'luvchi aylanasi tishni tubigacha bo'lgan masofa.                                                                                                                      |
| Doiraviy kuch            |  | Okrujnaya sila                     | Tishli g'ildirakining aylanasi bo'ylab ta'sir etadi. G'ildirakni aylantiradi. Tishni egilish deformatsiyasiga uchratadi.                                                               |
| Radial kuch              |  | Radialnaya sila                    | Tishni ko'ndalang kesimidan g'ildirak aylana markaziga yo'nalgan. Bu kuch ta'sirida tish siqiladi.                                                                                     |
| Buylama kuch             |  | Prodolnaya sila                    | Qiyshiq tishli ilashmada hosil bo'lib, g'ildirak valining o'qi buylab yo'naladi.                                                                                                       |
| Konussimon tishli uzatma |  | Konicheskaya zub-chataya peredacha | Shesternya va g'ildirakning shakllari konus-simon bo'lib, ularning o'qlari kesishadi.                                                                                                  |
| Tashqi konus masofa      |  | Vneshnee konusnoe rasstoyanie      | Yqlarni kesishish nuqtasidan shesternya tashqi bo'luvchi diametrigacha bo'lgan masofa                                                                                                  |
| Chervyakli uzatma        |  | Chervyachnaya peredacha            | Chervyak deb ataladigan aylanuvchi vintdan va chervyak o'ramlari bilan ilashadigan tishli chervyak g'ildiragidan iborat. Chervyak va chervyak g'ildiragi vallarining o'qlari ayqashadi |

|                        |                       |                            |                                                                                                                                                                                                        |
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| Vint – gayka<br>uzatma |                       | Peredacha vint-<br>gayka   | Vintli kinematik juft bo'lib, aylanma harakatni ilgarilanma harakatga aylantirish, katta aniqlik bilan ko'chish hosil qilish                                                                           |
| Tasmali uzatma         |                       | Remennaya<br>peredacha     | Kamida ikkita shkivlarga ma'lum taranglik bilan tortilgan egiluvchan bog'lanishli ishqalanish asosida ishlaydigan tasmadan iborat                                                                      |
| Yassi tasma            | flat belt             | Ploskiy remen              | Ko'ndalang kesim yuzasining shakli to'g'ri to'rtburchakli, har xil materiallardan turli usullarda tayyorlangan, tasma sirtini ichki tomoni va shkivni tashqi sirti orasida ishqalanish bilan ishlaydi. |
| Ponasimon tasma        | wedge-belt            | Klinoremennyy              | Foydali kuch trapetsiyasimon kesimli tasmani yon sirti va shkiv kanalchasini yon sirlari orasidagi ishqalanish hisobiga hosil bo'ladi                                                                  |
| Zanjirli uzatma        | Chain drive           | Tsepnaya peredacha         | Cheksiz tutash zanjir ko'rinishida tayyorlangan tortish elementining maxsus profilli tishlari bo'lgan g'ildirakdan iborat.                                                                             |
| Friktsion uzatma       | Friction transmission | Friktsionnaya<br>peredacha | Ishqalanish kuchi ta'sirida harakatlanuvchi g'ildiraklar majmuasi.                                                                                                                                     |
| Tsapfa                 | Pivot bolt            | Tsapfa                     | Yq va vallarning tayanch yuzalari.                                                                                                                                                                     |
| Obod                   | Rim                   | Obod                       | Kuchni tishdan qabul qiladi, u etarli darajada mustahkam va kuchni tishning uzunligi bo'yicha tekis taqsimlashga yordam berishi kerak                                                                  |
| Stupitsa               | Nave box              | Stupitsa                   | Val bilan g'ildirakni biriktirish uchun xizmat qiladi, u obodga nisbatan simmetrik, nosimmetrik joylashtirilishi mumkin yoki obodni kengligiga teng bo'ladi                                            |
| Disk                   | disc                  | Disk                       | Obod va stupitsani birlashtiradi                                                                                                                                                                       |

|                         |                  |                        |                                                                                                                                                                                                                                                                                                |
|-------------------------|------------------|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Planetar uzatma         | planetarygear    | Planetarnaya peredacha | Tarkibida kamida bitta qo'zg'aluvchan o'qqa o'rnatilgan tishli qildirakli uzatma                                                                                                                                                                                                               |
| Variator                | variator         | Variator               | Etaklovchi valni o'zgarmas tezligida etaklanuvchi val burchak tezligini pog'onasiz o'zgartirish uchun xizmat qiladigan mexanik qurilma                                                                                                                                                         |
| Mufta                   | clutch           | Mufta                  | Aylantiruvchi moment yo'nalishini o'zgar-tirmasdan val va uzatmalarni biriktirish uchun mo'ljallangan qurilma                                                                                                                                                                                  |
| Reduktor                | reduction gear   | Reduktor               | Tishli yoki chervyaksimon uzatmadan tashkil topgan, alohida agregat ko'rinishida tayyorlangan va dvigateldan ishchi mashinaga quvvat uzatishda xizmat qiladigan mexanizm.                                                                                                                      |
| Reduktorni komponovkasi | gear arrangement | Komponovka reduktora   | Shesternya va tishli g'ildirak holatini, podshipniklar o'rnini, tayanch kuchlarini aniqlash, barcha detallarni konstruktiv jihozlash                                                                                                                                                           |
| Birikma                 | tie              | Soedinenie             | Detallarni yig'ish vositasi (usuli).                                                                                                                                                                                                                                                           |
| Rezba                   | carving          | Rezba                  | Doiraviy kesimli sterjenni sirtida keskich yoki boshqa vosita asosida tayyorlangan, standart shakl va o'lchamga ega bo'lgan ariqcha.                                                                                                                                                           |
| Shponka                 | dowel            | Shponka                | G'ildirakdan valga yoki aksinacha, valdan g'ildirakka aylanma harakatni uzatish uchun ishlatiladigan biriktiruvchi detal                                                                                                                                                                       |
| Insert                  | insert           | Insert                 | samarali o'qish va fikrlash uchun belgilashning interfaol tizimi hisoblanib, mustaqil o'qib-o'rganishda yordam beradi. Bunda ma'ruza mavzulari, kitob va boshqa materiallar oldindan o'quvchiga vazifa qilib beriladi. Uni o'qib chiqib, «V; +; -; ?» belgilari orqali o'z fikrini ifodalaydi. |



|                        |                          |                        |                                                                                                                                                                                                                  |
|------------------------|--------------------------|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Klaster                | cluster                  | Klaster                | Inglizcha soʻz bħlib, gʻuncha, bogʻlam maʼnosini bildiradi. Axborotlar klasterlarga ajratish interfaol pedagogik strategiya boʻlib, yangi fikrlarni uygʻotadi, muayyan mavzu boʻyicha fikr yuritishga chorlaydi. |
| Ajraladigan birikma    | Detachable joint         | Razʼemnoe soedinenie   | Ajraluvchan -boltli, rezbali, shlitsali, shponkali, ponasimon birikmalar Detallarni yigʻish va ajratishda birikma shikastlanmaydi                                                                                |
| Ajralmaydigan birikma  | Permanent joint          | Nerazʼemnoe soedinenie | Ajralmas - payvand, parchin mixli, elimli birikmalar. Detallarni yigʻish va ajratishda birikma emiriladi.                                                                                                        |
| Ajraladigan korpus     | Split housing            | Razʼyomnyy korpus      | Reduktorlar va ichki yonuv dvigatellarining korpuslari ajraluvchan. Korpus va qopqoq oʻzaro boltli birikmalar bilan biriktiriladi.                                                                               |
| Ajralmaydigan korpus   | Solid housing            | Nerazʼyomnyy korpus    | Chervyakli reduktorlar, myasorubkalar va hokazolarning korpuslari ajralmas.                                                                                                                                      |
| Assimmetrik tsikl      | Fluctuating stress cycle | Asimmetrichnyy tsikl   | Kuchlanishlarni maksimal va minimal qiymat-lari farqli boʻlgan nosimmetrik oʻzgaruvchan kuchlanish.                                                                                                              |
| Aylana toʻsin          | Collar                   | Burtik                 | Tishli gʻildirakni boʻylama harakatini cheklovchi valda tayyorlangan eng katta diametrli kesimi.                                                                                                                 |
| Aylanishlar chastotasi | Rotational frequency     | Chastota vrasheniya    | Valni bir minutdagi aylanishlari soni                                                                                                                                                                            |
| Doiraviy kuch          | Tangential force         | Okrujnaya sila         | Aylanma harakatdagi ikkita tishli gʻildirakning ilashish nuqtasida hosil boʻladigan vektor kattalik                                                                                                              |
| Aylantiruvchi moment   | Torgue                   | Vrashayushiy moment    | Bir tomonga aylanayotgan modullari teng ikkita kuchdan bittasini ushbu kuchlar elkasiga koʻpaytmasi juft momenti deyiladi. Juft momenti jismning sirtiga qoʻyiladi va u aylantiruvchi moment deyiladi.           |

|                                  |                                       |                                  |                                                                                                                                                           |
|----------------------------------|---------------------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Baraban                          | Thimble; Auger; Drum                  | Baraban                          | Aylanma harakatni uzatmadan konveyerning lentasiga uzatadi. Ma'lum diametrga ega bo'lgan tsilindr shaklida, unga hisobiy taranglikdagi lenta o'rnatiladi. |
| Bir (ikki) rezbali kirim         | Single Double)- start thread          | Oдно (dvux) zaxodnaya rezba      | Rezbaga kirish sonini belgilaydi                                                                                                                          |
| Bir pog'onali uzatma             | Single-stage-transmission             | Odnostupenchataya peredacha      | Uzatmaning tarkibida bitta shesternya va bitta tishli g'ildirak harakatni uzatishda qatnashadi. Ayrim holatlarda bir ilashmali uzatma deb ham aytiladi.   |
| Bir qatorli dumalash podshipniki | Singlerow bearing                     | Odnoryadный podshipnik kacheniya | Podshipnikda dumalash elementlari ( sharik, rolik) bir qator joylashgan                                                                                   |
| Bir pog'onali reduktor           | Single-stage reducer                  | Odnostupenchatый reduktor        | Reduktorning tarkibida bitta shesternya va bitta tishli g'ildirak harakatni uzatishda qatnashadi.                                                         |
| bolt                             | Bolt                                  | Bolt                             | Biriktirish vosidasi. Golovka, rezba kesilgan sterjendan iborat                                                                                           |
| Sho'ng'itib moylash.             | Bath lubrication                      | Смазывание погружением           | Reduktorda moyga shesternya tishining balandligi bo'yicha sho'ng'itiladi                                                                                  |
| Burchak chok                     | Corner weld; fillet weld              | Угловой шов                      | Nakladkali yoki T shaklli payvandlashda hosil bo'ladi                                                                                                     |
| Bo'luvchi aylana                 | Reference                             | делительный окружность           | Bo'luvchi aylana deb, tsilindrni teng $Z$ qismga bo'lish jarayonida tayyorlangan g'ildirak aylanasi aytiladi                                              |
| Bo'luvchi konus burchagi         | Pitch angle                           | Угол делительного конуса         | Bo'luvchi konus burchagi miqdor jihatdan uzatishlar soniga teng                                                                                           |
| Bo'yin                           | Neck journal                          | Шейка                            | valning o'rta qismi ( шейка ) bo'yin deyiladi                                                                                                             |
| Dastlabki hisoblash              | Preliminary calculation               | Предварительный расчет           | Eskizli loyiha uchun taqriban bajarilgan Hisoblash.                                                                                                       |
| Dumalash podshipniki             | Antifriction bearing; rolling-element | Подшипник качения                | Sirpanish ishqalanishi dumalash ishqalanishi bilan almashtirilgan va dumalash elementli val tayanchi                                                      |

|                                                          |                                        |                                                       |                                                                                                                          |
|----------------------------------------------------------|----------------------------------------|-------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
|                                                          | bearing                                |                                                       |                                                                                                                          |
| Dumalash podship-nikining dinamik yuklanishga sezgirligi | Basic load rating; dynamic load rating | Dinamicheskaya gruzopod`yomnost podshipnika kacheniya | Podshipniklarni dinamik kuch ta`siriga sezgirligi                                                                        |
| Dumalash podship-nikining statik yuklanishga sezgirligi  | Static load rating                     | Staticheskaya gruzopod`yomnost podshipnika kacheniya  | Podshipniklarni statik kuchlarni kabul kilish kobiliyati                                                                 |
| Dumalok tasma                                            | Round belt                             | Kruglyy remen                                         | Doiraviy kesim yuzali remen                                                                                              |
| Friksion uzatma                                          | Friction gearing                       | Friksionnaya peredacha                                | Ishqalanish kuchi evaziga harakatni uzatadigan ikkita g`ildirak va tayanchlardan tashkil topgan uzatma                   |
| Haqiqiy o`lcham                                          | Nominal size                           | Deystvitelnyy razmer                                  | Buyumning hisoblash yoki konstruktiv mulohazalar asosida tanlangan o`lchami                                              |
| Ikki pog'onali reduktor                                  | Two-stage reducer                      | Dvuxstupenchatyy reduktor                             | Reduktordagi uchta valda ikkita shesternya va ikkita tishli g`ildirak bo`lib, ikki ilashmali uzatma                      |
| To`planma kuch                                           | Concentrated load                      | Sosredotochennaya nagruzka                            | Ta`siri bir nuqtadan uzatiladi. Masalan poezdning og`irligi relsga g`ildirak bilan relsni tegishish nuqtasidan uzatiladi |
| Sekinlatuvchi uzatma                                     | Reducing transmission                  | Ponijayumaya peredacha                                | Uzatishlar soni birdan katta bo`lgan uzatma<br>Burchak tezlik pog`onasimon kamayadi                                      |
| Kirimlar soni                                            | Number of thread                       | Chislo zaxodov                                        | Chervyak o`ramiga kirish soni                                                                                            |
| Konussimon reduktor                                      | Right-angle reducer                    | Konicheskiy reduktor                                  | O`qlari kesishadigan konussimon tishli uzatmadan tashkil topgan reduktor                                                 |
| Konussimon tishli uzatma                                 | Bevel gearing                          | Konicheskaya zubchataya peredacha                     | O`qlari kesishadigan konussimon tishli uzatma                                                                            |

|                             |                         |                              |                                                                                                                                                                                                                                                                                                                      |
|-----------------------------|-------------------------|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Konussimon tishli g'ildirak | Bevel gear              | Konicheskoe zubchatoe koleso | Harakatni konussimon shesternyadan olib uzatmaning etaklanuvchi valiga harakatni uzatadi                                                                                                                                                                                                                             |
| Korpus                      | Housing                 | Korpus                       | Uzatmaning barcha uzal va detallarini tashqi muhitdan ajratadigan quyma yoki payvand asosida tayyorlangan murakkab shaklli detal                                                                                                                                                                                     |
| Materiallarni tliqishi      | Fatigue of metals       | Ustalost metallov            | Yzgaruvchan yuklar ta'sirida materiallarni strukturasi o'zgaradi, shuning uchun materialda «toliqishi» – «charchash» hosil bo'lib emiriladi-plastiklik mo'rtlik bilan almashadi                                                                                                                                      |
| Mufta                       | Clutch; shaft coupling  | Mufta                        | Aylantiruvchi moment yo'nalishini o'zgartirmasdan val va uzatmalarni biriktirish uchun mo'ljallangan qurilma. Turli xil vaziyatlar-dagi vallarni birlashtiradi, yuritmadagi dinamik ta'sirni yumshatib silliq uzatadi, detallarni montaj-demontaj ishlarini osonlashtiradi, mashinani o't oldirishni engillashtiradi |
| Mustahkam birikma           | Firm joint              | Prochnoe soedinenie          | Qirqilish, ezilish, cho'zilish va siqilishga emirilmasdan qarshilik ko'rsatadigan har qanday birikma mustahkam                                                                                                                                                                                                       |
| Podshipnik                  | Bearing                 | Podshipnik                   | Vallarni tayanchi. Sirpanish va dumalash podship-niklari mavjud. Ilashmada hosil bo'ladigan kuchlarga bog'liq holda dumalash podshipniklari sharikli, rolikli va h.k turlarga bo'linadi                                                                                                                              |
| Pog'onali val               | Stepped (Smooth) shaft  | Stupenchatyy (gladkiy) val   | Valni uzunligi bo'ylab kesimlarining diametrlari o'zgaruvchan bo'ladi.                                                                                                                                                                                                                                               |
| Prujina                     | Spring                  | Prujina                      | Zarb ta'sirini silliqalashtirish uchun qo'llaniladi                                                                                                                                                                                                                                                                  |
| Pulsatsiyalanuvchi tsikl    | Pulsating stress cycles | Pulsiruyuyiy tsikl           | Minimal qiymati nolga teng bo'lgan o'zgaruvchan kuchlanishga aytiladi                                                                                                                                                                                                                                                |

|                                    |                           |                               |                                                                                                                                   |
|------------------------------------|---------------------------|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| Qattqlik                           | Hardness                  | Tvyordost                     | Materialni sirtiga qo'yilgan kuch ta'siriga qarshilik ko'rsata olish qobiliyati                                                   |
| Qiya tish                          | Helical bevel tooth       | Kosoy zub                     | Tish val o'qiga nisbatan qiya burchak ostida joylashgan                                                                           |
| Qopqoq                             | Cover                     | Крышка                        | Reduktor korpusining ichidagi detallarni tashqi muhitdan ajratib turadi.                                                          |
| Qovurg'a                           | Rib                       | Rebro                         | Masalan bikrlilik qirralari, korpusni deformatsiyalanishiga qarshilik etadi                                                       |
| Radial tirak podshipnik            | Radial and thrust bearing | Radialno-upornyy podshipnik   | Radial-tirakli sharikli podshipnik – radial va bo'ylama kuchlarni qabul qiladi.                                                   |
| Radial tirqish                     | Bottom clearance          | Radialnyy zazor               | Shesternya tishining tubi bilan g'ildirak tishining uchi orasida qoldirilgan ilashma modulining to'rtidan bir qismiga teng masofa |
| Radial kuch                        | Radial (Axial) load       | Radialnaya (osevaya) nagruzka | Tishlarni ilashish nuqtasidan valni bo'ylama o'qiga tik yo'nalgan kuch                                                            |
| Rolikli podshipnik                 | Roller bearing            | Rolikovyy podshipnik          | Konussimon rolikli podshipnik– katta yuklanishda va bo'ylama kuchlarni qabul qiladi.                                              |
| Rolikli radial sharikli podshipnik | Annular ball bearing      | Radialnyy shariko podshipnik  | Faqat radial kuchlarni qabul qiladi. Bir qatorli radial sharikli podshipnik - radial va bo'ylama kuchlarni qabul qiladi           |
| Rolikli zanjir                     | Roller chain              | Rolikovaya tsep               | Rolikli zanjir ketma – ket almashib turadigan ichki va tashqi sharnirli bog'langan bo'g'inlardan tashkil topgan                   |
| Tsikl kuchlanishlari amplitudasi   | Strees amplitude          | Amplituda napryajeniya tsikla | O'zgaruvchan kuchlanishlarning maksimal va minimal miqdorlarining yarmiga aytiladi                                                |
| Tsikllar soni                      | Number of cycles          | Chislo tsiklov                | Kuchlanishlarni takrorlanish soni                                                                                                 |
| Tsikllarning bazaviy soni          | Basic number of cycles    | Bazovoe chislo tsiklov        | Shunday tsikllar soni-ki, agar val ushbu tsikllar soniga qadar emirilmasa keyingi tsikllar sonida ham emirilmaydi                 |

|                        |                                      |                              |                                                                                                                                                                           |
|------------------------|--------------------------------------|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Salqilik               | Deflection                           | Progib                       | Tashqi kuch ta'siridan balka biror nuqtasining ushbu kuch yo'nalishida ko'chishi                                                                                          |
| Tasmali uzatma         | Belt drive                           | Remennaya peredacha          | egiluvchan bog'lanishli ishqalanish bilan ishlaydigan uzatmalar qatoriga kiradi va bir nechta shkivlarga ma'lum tarang qilib tortilgan cheksiz egiluvchan tasmadan iborat |
| Tekshiruv hisobi       | Check calculation                    | Proverochnyy raschet         | Inshoot elementining mustahkamligi tekshiriladi                                                                                                                           |
| Teng qarshilik balkasi | Beam of uniform strength             | Balka ravnogo soprotivleniya | Uzunligi bo'ylab barcha kesimlarida ruxsat etilgan kuchlanishga teng kuchlanish hosil bo'lgan balka teng qarshilik ko'rsatuvchi balka                                     |
| Tig'iz o'tkazish       | Interference fit                     | Posadka s natyagom           | Detallar o'zaro tig'iz biriktiriladi, ya'ni valning nominal diametri teshikning nominal diametridan kattaroq bajariladi                                                   |
| Tishli uzatma          | Toothed gearing; gearing; gear train | Zubchataya peredacha         | ikkita tishli g'ildirak va tayanchdan tashkil topgan mexanizm                                                                                                             |
| Tishli g'ildirak       | Toothed gear; gear                   | Zubchatoe koleso             | harakatni shesternyadan olib valga uzatadigan g'ildirak etaklanuvchi                                                                                                      |
| To'g'ri tishli uzatma  | Spur gear                            | Pryamozuboe koleso           | harakatni shesternyadan olib valga uzatadigan g'ildirak tishlarining yo'nalishi valning o'qiga parallel                                                                   |
| Uzatishlar nisbati     | Transmission ratio                   | Peredatochnoe otnoshenie     | Uzatishlar nisbati deb, etaklovchi bo'g'in burchak tezligini etaklanuvchi bo'g'in burchak tezligiga nisbatiga aytiladi.                                                   |
| Uzatishlar soni        | Velocity (speed) ratio               | Peredatochnoe chislo         | Uzatishlar soni - katta diametrli g'ildirak tishlari sonini kichik diametrli g'ildi-rak tishlari soniga nisbatiga teng                                                    |
| Uzatma                 | Power transmission; transmission     | Peredacha                    | Dvigateldan ishchi organga energiyani uzatishga imkon beruvchi qurilma                                                                                                    |

|                      |                    |                           |                                                                                                                                                    |
|----------------------|--------------------|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| Val                  | Shaft              | Val                       | aylantiruvchi moment uzatish uchun xizmat qilib, qo'yilgan yuklar ta'siridan buralish va egilish deformatsiyalariga uchraydigan brus               |
| Val shesternya       | Pinion-shaft       | Val-shesternya            | Val va shesternya bir butun detal quyma shaklida tayyorlangan                                                                                      |
| Birlamchi loyiha     | Preliminary design | Eskiznyy proekt           | bir necha variantda bajarilishi mumkin, bunda to'liq va aniq hisoblash asosidagi tahlili bajariladi va eng qulay variant qabul qilinadi            |
| Yassi tasmali uzatma | Flat-belt drive    | Ploskoremennaya peredacha | foydali kuch tasma sirtini ichki tomoni va shkivni tashqi sirti orasidagi ishqalanishida hosil bo'ladi                                             |
| Emirilish            | Rupture            | Razrushenie               | Emirilish xavfli va chegaraviy holatdir. Emirilish yorilish yoki qoldiq deformatsiya ko'rinishida namoyon bo'ladi                                  |
| Emiruvchi sinovlar   | Destructive tests  | Razrushayushie ispytaniya | Tajriba ishi emirilish bo'lgunga qadar olib boriladi                                                                                               |
| Etaklanuvchi val     | Driven shaft       | Vedomyy val               | Harakatni tishli g'ildirakdan olib ishchi mashinaga uzatuvchi val                                                                                  |
| Etakchi val          | Driving shaft      | Vedushiy val              | Harakatni elektrodvigateldan olib shesternyaga uzatuvchi val                                                                                       |
| Yuritma              | Drive              | Privod                    | Mashina yoki mexanizmni harakatga keltiradigan qurilma. Energiya manbai, uzatish mexanizmi va boshqaruv apparatidan tashkil topgan mexanik qurilma |
| Zanjirli uzatma      | Chain transmission | Tsepnaya peredacha        | Zanjirli uzatmalar cheksiz tutash zanjir ko'rinishida yasalgan tortish organining maxsus profilli tishlari bo'lgan g'ildirakdan iborat             |
| Bo'g'in              | Link               | Zveno                     | Bir yoki bir nechta detallarning qo'zg'almas birikmasi                                                                                             |
| O'q                  | Axle               | Os                        | aylanadigan va aylanmaydigan bo'lib, aylantiruvchi momentni uzatmaydi, faqat egilishga ishlaydigan brus                                            |

|                     |                              |                            |                                                                                                                                                 |
|---------------------|------------------------------|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| O'qlararo masofa    | Centre distance              | Mejosevoe<br>rasstoyanie   | Etaklovchi va etaklanuvchi vallarning o'qlari orasidagi masofa                                                                                  |
| O'tqazma            | Fit                          | Posadka                    | Detallar birikmasining xarakteri o'tqazma deyiladi. Eng katta va kichik chegaraviy o'lchamlar orasidagi soha (maydon) o'tqazma maydoni deyiladi |
| O'zgaruvchan kuch   | Fluctuating load             | Peremennaya<br>nagruzka    | Vaqt oraligida miqdori va miqdorini davriy o'zgartirib turadigan kuch                                                                           |
| G'adir budirlik     | Roughness; surface<br>finish | Sheroxovatost              | Detallarni sirtida mexanik ishlov berish yoki quyma holatida qolgan g'adir budirlik                                                             |
| Shponkali birikma   | Key joint                    | Shponochnoe<br>soedinenie  | G'ildirakdan valga yoki aksincha aylantiruvchi momentni uzatish uchun qo'llaniladi                                                              |
| Chervyakli uzatma   | Worm gearing                 | Chervyachnaya<br>peredacha | O'qlari ayqashadigan vallar orasida aylanma harakatni uzatish uchun qo'llaniladi                                                                |
| Chidamlilik chegara | Endurance limit              | Predel vьmoslivosti        | Material yuklanish davrining $10 \cdot 10^6$ qiymatida emirilishga olib keladigan kuchlanishga chidamlilik chegarasi deyiladi.                  |



## ILOVALAR

### I-1. Uzatmalarning foydali ish koeffitsientlari ( FIK )

| Uzatmaning turi                      | yopiq       | ochiq       |
|--------------------------------------|-------------|-------------|
| Tishli:                              |             |             |
| tsilindrik                           | 0,96...0,97 | 0,93...0,95 |
| konussimon                           | 0,95...0,97 | 0,92...0,94 |
| Chervyakli, turli uzatishlar sonida, |             |             |
| 30 dan yuqori $z_1 = 1$              | 0,70...0,75 |             |
| 14...30 $z_1 = 2$                    | 0,80...0,85 |             |
| 8... 14 $z_1 = 4$                    | 0,85...0,95 |             |
| Zanjirli                             | 0,95...0,97 | 0,90...0,93 |
| Tasmali:                             |             |             |
| yassi tasmali                        |             | 0,96...0,98 |
| ponasimon                            |             | 0,95...0,97 |

### I-2. Turli aylanishlar chastotasi ( $n$ ) da 4A seriyali dvigatellar quvvatining diapazoni.

| $(n)$<br>$\frac{a\ddot{u}l}{min}$ | Dvigatel turi |              |              |              |             |              |            |            |          |
|-----------------------------------|---------------|--------------|--------------|--------------|-------------|--------------|------------|------------|----------|
|                                   | 56 V          | 63 A         | 71 A         | 80 A         | 90 L        | 100 S<br>(L) | 112<br>M   | 132<br>SM  | 160<br>S |
| 3000                              | 0,25          | 0,37<br>0,55 | 0,75<br>1,1  | 1,5<br>2,2   | 3,0         | 4,0<br>5,5   | 7,5        |            |          |
| 1500                              |               | 0,15<br>0,37 | 0,55<br>0,75 | 1,1<br>1,5   | 2,2         | 3,0<br>4,0   | 5,5        | 7,5        |          |
| 1000                              |               | 0,25         | 0,37<br>0,55 | 0,75<br>1,1  | 1,5         | 2,2          | 3,0<br>4,0 | 5,5<br>7,5 |          |
| 750                               |               |              | 0,25         | 0,37<br>0,55 | 0,75<br>1,1 | 1,5          | 2,2<br>3,0 | 4,0<br>5,5 | 7,5      |

### I-3. Tishli uzatmalar uchun $K_{H\beta}$ – koeffitsient [22]

| $K_{H\beta}$ – yukni tish gardishi-ning eni bo'ylab taqsimlanishi koeffitsienti | Tayanchga nisbatan tishli g'ildirakni joylashishi | Tish sirtining qattiqligi |             |
|---------------------------------------------------------------------------------|---------------------------------------------------|---------------------------|-------------|
|                                                                                 |                                                   | $< HB250$                 | $> HB350$   |
|                                                                                 | Simmetrik                                         | 1,0 - 1,15                | 1,05 – 1,25 |
|                                                                                 | Nosimmetrik                                       | 1,10 – 1,25               | 1,15 – 1,35 |
|                                                                                 | Konsol                                            | 1,20 – 1,35               | 1,25 – 1,45 |

#### I-4. Kontaktli chidamlilik chegarasi [22]

| Tishlarni termoximik<br>ishlov berish usullari | Tish sirti-ning<br>o'rtacha<br>qattiqligi | Po'lot                      | $\sigma_H, \frac{H}{\text{MM}^2}$ |
|------------------------------------------------|-------------------------------------------|-----------------------------|-----------------------------------|
| Normallashtirish yoki<br>yaxshilash            | $\leq HB350$                              | Uglerodli<br>va legirlangan | $2HB + 70$                        |
| Hajmiy toblash                                 | $HRC38 - 50$                              |                             | $18HRC + 150$                     |
| Sirtqi toblash                                 | $HRC40 - 50$                              |                             | $17HRC + 200$                     |
| Tsementatsiya                                  | $\succ HRC56$                             | Legirlangan                 | $23HRC$                           |
| Azotlash                                       | $HV550 - 750$                             |                             | 1050                              |

#### I-5. Po'lat materialining mexanik xossalari. [22]

| Po'lat<br>markasi | Detalni<br>diametri<br><i>mm</i> | Mustahkamlik<br>chegarasi,<br>$\sigma_b \frac{H}{\text{MM}^2}$ | Oquvchanlik<br>chegarasi<br>$\sigma_T \frac{H}{\text{MM}^2}$ | Qattiq-<br>lik<br>NV | Termik<br>ishlov |
|-------------------|----------------------------------|----------------------------------------------------------------|--------------------------------------------------------------|----------------------|------------------|
| 45                | 100 - 500                        | 570                                                            | 290                                                          | 190                  | normal           |
| 45                | 90 gacha                         | 780                                                            | 440                                                          | 230                  | yaxshilash       |
|                   | 90 – 100                         | 730                                                            | 390                                                          | 210                  |                  |
|                   | $\succ 130$                      | 690                                                            | 340                                                          | 200                  |                  |
| 30XGS             | $\prec 140$                      | 1020                                                           | 840                                                          | 260                  |                  |
|                   | $\succ 140$                      | 930                                                            | 740                                                          | 250                  |                  |
| 40X               | 120 gacha                        | 930                                                            | 690                                                          | 270                  |                  |
|                   | 120 – 160                        | 880                                                            | 590                                                          | 260                  |                  |
|                   | $\succ 160$                      | 830                                                            | 540                                                          | 245                  |                  |
| 40XN              | 150 gacha                        | 930                                                            | 690                                                          | 280                  |                  |
|                   | 140 – 180                        | 880                                                            | 590                                                          | 265                  |                  |
|                   | $\succ 180$                      | 835                                                            | 540                                                          | 250                  |                  |
| 40L               |                                  | 520                                                            | 290                                                          | 160                  | Normal           |
| 45L               |                                  | 540                                                            | 310                                                          | 180                  |                  |

#### I-6. Qiya tishlik uzatma uchun $K_{H\alpha}$ koeffitsient [22]

| Aniqlik<br>darajasi | Doiraviy tezlik, $v, \frac{M}{c}$ |      |      |      |      |
|---------------------|-----------------------------------|------|------|------|------|
|                     | $\succ 1$                         | 5    | 10   | 15   | 20   |
| 6                   | 1                                 | 1,02 | 1,03 | 1,04 | 1,05 |
| 7                   | 1,02                              | 1,05 | 1,07 | 1,10 | 1    |
| 8                   | 1,06                              | 1,09 | 1,13 | -    | 12   |
| 9                   | 1,1                               | 1,16 | -    | -    | -    |

### I-7. Koeffitsient $K_{H\beta}$ [22]

| $\psi_{bd} = \frac{b}{d_1}$                                                            | Tish sirtining qattiqligi |      |      |              |      |      |
|----------------------------------------------------------------------------------------|---------------------------|------|------|--------------|------|------|
|                                                                                        | $\leq HB350$              |      |      | $\leq HB350$ |      |      |
|                                                                                        | I                         | II   | III  | I            | II   | III  |
| 0,4                                                                                    | 1,15                      | 1,04 | 1,0  | 1,33         | 1,08 | 1,02 |
| 0,6                                                                                    | 1,24                      | 1,06 | 1,02 | 1,50         | 1,14 | 1,04 |
| 0,8                                                                                    | 1,30                      | 1,08 | 1,03 | -            | 1,21 | 1,06 |
| 1,0                                                                                    | -                         | 1,11 | 1,04 | -            | 1,29 | 1,09 |
| 1,2                                                                                    | -                         | 1,15 | 1,05 | -            | 1,36 | 1,12 |
| 1,4                                                                                    | -                         | 1,18 | 1,07 | -            | -    | 1,16 |
| 1,6                                                                                    | -                         | 1,22 | 1,09 | -            | -    | 1,21 |
| 1,8                                                                                    | -                         | 1,25 | 1,11 | -            | -    | -    |
| 2,0                                                                                    | -                         | 1,30 | 1,14 | -            | -    | -    |
| Ilova: I konsol; II nosimmetrik va III simmetrik o'rnatilgan tishli g'ildiraklar uchun |                           |      |      |              |      |      |

### I-8. Koeffitsient $K_{Hv}$ [22]

| Uzatma         | Tishni qattiqligi | Doiraviy tezlik $v, \frac{m}{c}$ |      |      |      |
|----------------|-------------------|----------------------------------|------|------|------|
|                |                   | 5                                | 10   | 15   | 20   |
|                |                   | Aniqlik darajasi                 |      |      |      |
|                |                   | 8                                | 8    | 7    | 7    |
| To'g'ri tishli | $HB350$           | 1,05                             | -    | -    | -    |
|                | $\succ HB350$     | 1,10                             | -    | -    | -    |
| Qiyshiq tishli | $HB350$           | 1,0                              | 1,01 | 1,02 | 1,05 |
|                | $\succ HB350$     | 1,0                              | 1,05 | 1,07 | 1,10 |

### I-9. Konussimon g'ildirakning tashqi bo'luvchi diametri

| G'ildirakning tashqi bo'luvchi diametri [29] | Uzatishlar nisbati, mm              |      |     |     |      |
|----------------------------------------------|-------------------------------------|------|-----|-----|------|
|                                              | 2                                   | 2,24 | 2,5 | 2,8 | 3,15 |
|                                              | Konussimon tishli g'ildirak eni, mm |      |     |     |      |
| 63                                           | 10                                  | -    | -   | -   | -    |
| 80                                           | 13                                  | 12   | 12  | -   | -    |
| 100                                          | 16                                  | 16   | 15  | 15  | 15   |
| 125                                          | 20                                  | 19   | 19  | 19  | 19   |
| 160                                          | 25                                  | 25   | 25  | 24  | 24   |
| 200                                          | 40                                  | 40   | 38  | 38  | 38   |
| 260                                          | 45                                  | 45   | 42  | 42  | 42   |

### I-10 Chervyakli uzatma uzatishlar soni [22]

|         |   |      |      |    |      |    |      |    |    |    |    |
|---------|---|------|------|----|------|----|------|----|----|----|----|
| 1-qator | 8 | 10   | 12,5 | 16 | 20   | 25 | 31,5 | 40 | 50 | 63 | 80 |
| 2-qator | 9 | 11,2 | 14   | 18 | 22,4 | 28 | 35   | 45 | 56 | 71 |    |

### I-11. Chervyak g'ildiragi uchun ruxsat etilgan kontaktli kuchlanish [22]

| Material                     |                              | $[\sigma]_H, \left(\frac{H}{mm^2}\right)$ ni qiymati $V_s, \frac{M}{c}$ tezliklarda |      |     |     |      |     |     |     |     |
|------------------------------|------------------------------|-------------------------------------------------------------------------------------|------|-----|-----|------|-----|-----|-----|-----|
| Chervyak g'ildiragi gardishi | Chervyak                     | 0                                                                                   | 0,25 | 0,5 | 1   | 2    | 3   | 4   | 6   | 8   |
| Br.AJ9-4L                    | Po'lat >HRC 45               | -                                                                                   | -    | 182 | 179 | 173  | 167 | 161 | 150 | 138 |
| Br.AJN 10-4-4L               | Po'lat >HRC 45               | -                                                                                   | -    | 196 | 192 | 187  | 181 | 175 | 164 | 152 |
| SCh 15-32 yoki SCh 18-36     | St 20 yoki 20X tsementatsiya | 184                                                                                 | 155  | 128 | 113 | 84,5 | -   | -   | -   | -   |

### I-12. Chervyakli ilashma moduli va chervyak g'ildiragi diametrining koeffitsienti [22]

| $m$ | $q$ | $m$  | $q$  | $m$   | $q$  |
|-----|-----|------|------|-------|------|
|     |     |      | 8,0  |       | 8,0  |
|     |     |      | 10,0 |       | 10,0 |
|     |     | 3,15 | 12,5 | 8,00  | 12,5 |
|     |     |      | 16,0 |       | 16,0 |
|     |     |      | 20,0 |       | 20,0 |
|     |     |      | 8,0  |       | 8,0  |
|     |     |      | 10,0 |       | 10,0 |
|     |     | 4,00 | 12,5 | 10,00 | 12,5 |
|     |     |      | 16,0 |       | 16,0 |
|     |     |      | 20,0 |       | 20,0 |

| $m$ | $q$  | $m$  | $q$  | $m$   | $q$  |
|-----|------|------|------|-------|------|
|     | 8,0  |      | 8,0  |       | 8,0  |
|     | 10,0 |      | 10,0 |       | 10,0 |
| 2,0 | 12,5 | 5,00 | 12,5 | 12,50 | 12,5 |
|     | 16,0 |      | 16,0 |       | 16,0 |
|     | 20,0 |      | 20,0 |       | 20,0 |
|     | 8,0  |      | 8,0  |       | 8,0  |
|     | 10,0 |      | 10,0 |       | 10,0 |
|     | 12,5 | 6,30 | 12,5 | 16,00 | 12,5 |
|     | 16,0 |      | 16,0 |       | 16,0 |
|     | 20,0 |      | 20,0 |       | 8,0  |
|     |      |      |      | 20,00 | 10,0 |

### I-13. Tsilindrik chervyakli uzatmaning asosiy parametrlari. [22]

|     | $m, \text{mm}$ | $q$  | $z_2 : z_1 = u$  |
|-----|----------------|------|------------------|
| 50  | 2,5            | 8    | 32:4; 32:2; 32:1 |
|     | 2              | 10   | 40:4; 40:2; 40:1 |
| 63  | 3,15           | 8    | 32:4; 32:2; 32:1 |
| 80  | 4              | 8    | 32:4; 32:2; 32:1 |
| 100 | 5              | 8    | 32:4; 32:2; 32:1 |
|     | 4              | 10   | 40:4; 40:2; 40:1 |
| 125 | 5              | 10   | 40:4; 40:2; 40:1 |
|     | 4              | 12,5 | 50:4; 50:2; 50:1 |
| 140 | 5              | 16   | 40:4; 40:2; 40:1 |
|     | 5              | 10   | 46:4; 46:2; 46:1 |
| 160 | 8              | 8    | 32:4; 32:2; 32:1 |
| 200 | 10             | 8    | 32:4; 32:2; 32:1 |
|     | 8              | 10   | 40:4; 40:2; 40:1 |
| 250 | 12,5           | 8    | 32:4; 32:2; 32:1 |
|     | 10             | 10   | 40:4; 40:2; 40:1 |
|     | 8              | 12,5 | 50:4; 50:2; 50:1 |
| 280 | 10             | 16   | 40:4; 40:2; 40:1 |
|     | 10             | 10   | 46:4; 46:2; 46:1 |
| 400 | 20             | 8    | 32:4; 32:2; 32:1 |
|     | 16             | 10   | 40:4; 40:2; 40:1 |
| 500 | 20             | 10   | 40:4; 40:2; 40:1 |
|     | 16             | 12,5 | 50:4; 50:2; 50:1 |

### I-14. Chervyak o'ramining bo'luvchi ko'tarilish burchagi [22]

| $Z_1$ | $q$ ni turli qiymatlarida $\gamma$ |             |             |             |             |             |             |
|-------|------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|
|       | 16                                 | 14          | 12          | 10          | 9           | 8           | 7,5         |
| 1     | 3° 34' 35"                         | 4° 05' 09"  | 3° 34' 35"  | 5° 42' 38"  | 6° 20' 25"  | 7° 07' 30"  | 7° 35' 41"  |
| 2     | 7° 34' 35"                         | 8° 07' 48"  | 7° 34' 35"  | 11° 18' 36" | 12° 31' 44" | 14° 02' 10" | 14° 55' 53" |
| 3     | 10° 34' 35"                        | 12° 05' 40" | 10° 34' 35" | 16° 41' 56" | 18° 26' 06" | 20° 33' 22" | 21° 48' 00" |
| 4     | 14° 34' 35"                        | 15° 56' 43" | 14° 34' 35" | 21° 48' 05" | 23° 57' 45" | 26° 33' 54" | 28° 04' 21" |

### I-15. Chervyakni deformatsiya koeffitsienti $\theta$ [22]

| $Z_1$ | Koeffitsient $q$ -ni qiymatlari |    |    |     |     |     |     |
|-------|---------------------------------|----|----|-----|-----|-----|-----|
|       | 7,5                             | 8  | 9  | 10  | 12  | 14  | 16  |
| 1     | 63                              | 72 | 89 | 108 | 147 | 179 | 194 |
| 2     | 50                              | 57 | 71 | 86  | 117 | 149 | 163 |
| 4     | 42                              | 47 | 58 | 70  | 94  | 120 | 131 |

### I-16. Chervyak g'ildiragi materialining mexanik xarakteristikalari.

| Bronza va cho'yon turlari | Mustahkamlik chegara<br>$\sigma_6$<br>$\frac{H}{mm^2}$ | Chervyakni qattiqligiga bog'liq ruxsat etilgan kuchlanish $\frac{H}{mm^2}$ |                     |                |                  |                     |                |
|---------------------------|--------------------------------------------------------|----------------------------------------------------------------------------|---------------------|----------------|------------------|---------------------|----------------|
|                           |                                                        | < HRC 45                                                                   |                     |                | ≥ HRC 45         |                     |                |
|                           |                                                        | $[\sigma_o]_F^I$                                                           | $[\sigma_{-1}]_F^I$ | $[\sigma]_H^I$ | $[\sigma_o]_F^I$ | $[\sigma_{-1}]_F^I$ | $[\sigma]_H^I$ |
| BrOF10-1                  | 177                                                    | 39                                                                         | 28                  | 128            | 49               | 35                  | 157            |
| BrOF10-1 <sup>x</sup>     | 255                                                    | 57                                                                         | 41                  | 186            | 71               | 51                  | 221            |
| BrONF                     | 284                                                    | 64                                                                         | 45                  | 206            | 80               | 56                  | 246            |
| BrOTsS6-6-3 <sup>x</sup>  | 177                                                    | 45                                                                         | 32                  | 132            | 53               | 38                  | 159            |
| BrOTsS6-6-3               | 147                                                    | 35                                                                         | 25                  | 111            | 45               | 32                  | 133            |
| BrAJ9-4L                  | 392                                                    | 81                                                                         | 63                  |                | 98               | 75                  |                |
| BrAJ9-4L <sup>x</sup>     | 490                                                    | 85                                                                         | 69                  |                | 108              | 83                  |                |
| BrAJN10-4L                | 590                                                    | 101                                                                        | 81                  |                | 130              | 98                  |                |
| SCh12 - 28                | 118                                                    | 33                                                                         | 20                  |                | 41               | 25                  |                |
| SCh15 - 32                | 147                                                    | 37                                                                         | 23                  |                | 47               | 29                  |                |
|                           | 177                                                    | 42                                                                         | 26                  |                | 53               | 33                  |                |
|                           | 206                                                    | 47                                                                         | 29                  |                | 59               | 36                  |                |

### I-17. Tsilindrik chervyakli uzatmaning asosiy parametrlari [23]

| $m, mm$ |         | $\dot{a}_W, mm$ |         | $m, mm$ |         | $\dot{a}_W, mm$ |         |
|---------|---------|-----------------|---------|---------|---------|-----------------|---------|
| 1 qator | 2 qator | 1 qator         | 2 qator | 1 qator | 2 qator | 1 qator         | 2 qator |
| 1,6     | 1,5     | 50              | -       | 6,3     | -       | 200             | 180     |
| 2,0     | 3,0     | 63              | -       | 8,0     | -       | 250             | 225     |
| 2,5     | 3,5     | 80              | -       | 10,0    | -       | 315             | 280     |
| 3,15    | 6,0     | 100             | -       | 12,5    | -       | 400             | 355     |
| 4,0     | 7,0     | 125             | -       | 16,0    | -       | 500             | 450     |
| 5,0     | 12,0    | 160             | 140     | 20,0    | -       | -               | -       |

### I-20. $z_1 = 17$ O'rtacha ruxsat etilgan bosim [r] [22]

| $n_1$<br>ayl/min | Zanjirni qadami, mm |        |       |      |       |      |       |      |
|------------------|---------------------|--------|-------|------|-------|------|-------|------|
|                  | 12,7                | 15,875 | 19,05 | 25,4 | 31,75 | 38,1 | 44,45 | 50,8 |
| 50               | 46                  | 43     | 39    | 36   | 34    | 31   | 29    | 27   |
| 100              | 37                  | 34     | 31    | 29   | 27    | 25   | 23    | 22   |
| 200              | 29                  | 27     | 25    | 23   | 19    | 19   | 18    | 17   |
| 300              | 26                  | 24     | 22    | 20   | 16    | 17   | 16    | 15   |
| 500              | 22                  | 20     | 18    | 17   | 14    | 13   | 13    | 12   |
| 750              | 19                  | 17     | 16    | 15   | 13    |      |       |      |
| 1000             | 17                  | 16     | 14    | 13   |       |      |       |      |
| 1250             | 16                  | 15     | 13    | 12   |       |      |       |      |

# I-21. Bir qatorli PR zanjirlari [22]

| $t$    | $V_{VN}$ | $d$   | $d_1$ | $h$  | $b$ | $Q, kgs$ | $q, kg/m$ | $A, mm^2$ |
|--------|----------|-------|-------|------|-----|----------|-----------|-----------|
| 12,7   | 5,40     | 4,45  | 8,51  | 11,8 | 19  | 1820     | 0,65      | 39,6      |
| 15,875 | 6,48     | 5,08  | 10,16 | 14,8 | 20  | 2270     | 0,8-0     | 54,8      |
| 19,05  | 12,70    | 5,96  | 11,91 | 18,2 | 33  | 3180     | 1,5       | 105,8     |
| 25,4   | 15,88    | 7,95  | 15,88 | 24,2 | 39  | 5670     | 2,6       | 179,7     |
| 31,75  | 19,05    | 9,55  | 19,05 | 30,2 | 46  | 8850     | 3,8       | 262       |
| 38,10  | 25,4     | 11,1  | 22,23 | 36,2 | 58  | 12700    | 5,5       | 394       |
| 44,45  | 25,4     | 12,7  | 25,4  | 42,4 | 62  | 17240    | 7,5       | 473       |
| 50,8   | 31,75    | 14,29 | 28,58 | 48,3 | 72  | 22680    | 9,7       | 646       |

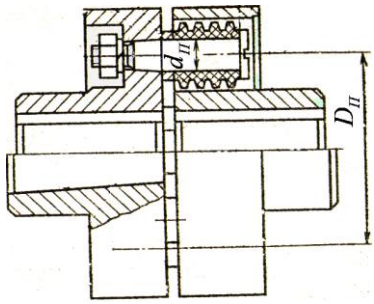
## Ehtiyotlik koefitsientni normativ qiymati [n]

| $n_1$<br>ayl/min | Zanjirni qadami, mm |        |       |       |       |      |       |      |
|------------------|---------------------|--------|-------|-------|-------|------|-------|------|
|                  | 12,7                | 15,875 | 19,05 | 25,4  | 31,75 | 38,1 | 44,45 | 50,8 |
| 50               | 7,1                 | 7,2    | 7,2   | 7,3   | 7,4   | 7,5  | 7,6   | 7,6  |
| 100              | 7,3                 | 7,4    | 7,5   | 7,6   | 7,8   | 8,0  | 8,1   | 8,3  |
| 300              | 7,9                 | 8,2    | 8,4   | 8,9   | 9,4   | 9,8  | 10,3  | 10,8 |
| 500              | 8,5                 | 8,9    | 9,4   | 10,2  | 11,0  | 11,8 | 12,5  |      |
| 750              | 9,3                 | 10,0   | 10,7  | 12,0  | 13,0  | 14,0 |       |      |
| 1000             | 10,0                | 10,8   | 11,7  | 13,38 | 15,0  |      |       |      |
| 1250             | 10,6                | 11,6   | 12,7  | 14,5  |       |      |       |      |

## I-26. Bir qatorli radial va radial – tirakli podshipniklar uchun X va Y - koefitsientlar [22]

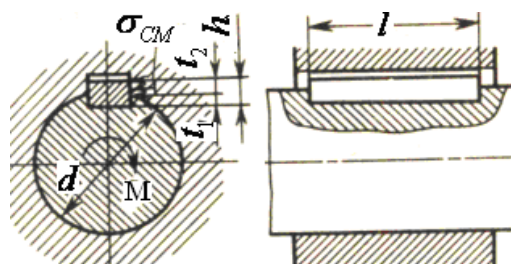
| Kontakt<br>burchagi<br>$\alpha^0$ | $\frac{F_a}{C_0}$ | $\frac{F_a}{V \cdot F_r} \succ e$ |      | e    | Kontakt<br>burchagi<br>$\alpha^0$ | $\frac{F_a}{C_0}$ | $\frac{F_a}{V \cdot F_r} \succ e$ |      | e    |
|-----------------------------------|-------------------|-----------------------------------|------|------|-----------------------------------|-------------------|-----------------------------------|------|------|
|                                   |                   | X                                 | Y    |      |                                   |                   | X                                 | Y    |      |
| 0                                 | 0,014             | 0,56                              | 2,30 | 0,19 | 12                                | 0,014             | 0,45                              | 1,81 | 0,30 |
|                                   | 0,028             |                                   | 1,99 | 0,22 |                                   | 0,029             |                                   | 1,62 | 0,34 |
|                                   | 0,056             |                                   | 1,71 | 0,26 |                                   | 0,057             |                                   | 1,46 | 0,37 |
|                                   | 0,084             |                                   | 1,55 | 1,28 |                                   | 0,086             |                                   | 1,34 | 0,41 |
|                                   | 0,110             |                                   | 1,45 | 0,30 |                                   | 0,110             |                                   | 1,22 | 0,45 |
|                                   | 0,170             |                                   | 1,31 | 0,34 |                                   | 0,170             |                                   | 1,13 | 0,48 |
|                                   | 0,280             |                                   | 1,15 | 0,38 |                                   | 0,290             |                                   | 1,04 | 0,52 |
|                                   | 0,420             |                                   | 1,04 | 0,42 |                                   | 0,430             |                                   | 1,01 | 0,54 |
|                                   | 0,560             |                                   | 1,00 | 0,44 |                                   | 0,570             |                                   | 1,00 | 0,54 |
|                                   |                   |                                   |      |      | 26                                | -                 | 0,41                              | 0,87 | 0,68 |
|                                   |                   |                                   |      |      | 36                                | -                 | 0,37                              | 0,66 | -,95 |

### I-27. Elastik vtulkali-paletsli mufta ( MUVP) [22]

| $M, Nm$ | Val diametri    | $D, mm$ | $L, mm$ | $e$ |  |
|---------|-----------------|---------|---------|-----|-------------------------------------------------------------------------------------|
| 31,5    | 16,18           | 90      | 81      | 40  |                                                                                     |
| 63      | 20,22           | 100     | 104     | 50  |                                                                                     |
| 125     | 25,28           | 120     | 125     | 60  |                                                                                     |
| 125     | 30              | 120     | 100     | 80  |                                                                                     |
| 250     | 32,35,38        | 140     | 165     | 80  |                                                                                     |
| 250     | 40,42,45        | 140     | 225     | 110 |                                                                                     |
| 500     | 40,42,45        | 170     | 225     | 110 |                                                                                     |
| 710     | 45,58,50,55,56  | 190     | 226     | 110 |                                                                                     |
| 1000    | 50,55,56        | 220     | 226     | 110 |                                                                                     |
| 1000    | 60,63,65,70     | 220     | 285     | 140 |                                                                                     |
| 2000    | 63,65,70,71,75  | 250     | 288     | 140 |                                                                                     |
| 2000    | 80,85,90        | 250     | 348     | 170 |                                                                                     |
| 4000    | 80,85,90,95     | 320     | 350     | 170 |                                                                                     |
| 5000    | 100,110,120,125 | 400     | 432     | 210 |                                                                                     |

### I-28. Prizmatik shponkalar. [22]

| Val diametri<br>( $d$ ) | shponkaning<br>kesimi |     | Paz<br>chuqurligi |       |
|-------------------------|-----------------------|-----|-------------------|-------|
|                         | $b$                   | $h$ | $t_1$             | $t_2$ |
| 12-17                   | 5                     | 5   | 3                 | 2,3   |
| 17-22                   | 6                     | 6   | 3,5               | 2,8   |
| 22-30                   | 8                     | 7   | 4                 | 3,3   |
| 30-38                   | 10                    | 8   | 5                 | 3,3   |
| 38-44                   | 12                    | 8   | 5                 | 3,3   |
| 44-50                   | 14                    | 9   | 5,5               | 3,8   |
| 50-58                   | 16                    | 10  | 6                 | 4,3   |
| 58-65                   | 18                    | 11  | 7                 | 4,4   |
| 65-75                   | 20                    | 12  | 7,5               | 4,9   |
| 75-85                   | 22                    | 14  | 9                 | 5,4   |
| 85-95                   | 25                    | 14  | 9                 | 5,4   |
| 95-110                  | 28                    | 16  | 10                | 6,4   |
| 110-130                 | 32                    | 18  | 11                | 7,4   |



uzunlikning (mm) standart  
qiymati,

6;8;10;  
12;14;16;18;20;22;25;28;32;  
36;45;50;63;70;80;90;100;  
110;125;160;180....500



### I-29. AOP2 seriyali elektrodvigatellar [22]

| AOP2<br>turi | $N_{HOM}$ ,<br>kVt | $n$ ,<br>ob/min | $\frac{M_{nyck}}{M_{HOM}}$ | AOP2<br>turi | $N_{HOM}$ ,<br>kVt | $n$ ,<br>ob/min | $\frac{M_{nyck}}{M_{HOM}}$ |
|--------------|--------------------|-----------------|----------------------------|--------------|--------------------|-----------------|----------------------------|
| 41-4         | 4                  | 1440            | 1,8                        | 71-6         | 17                 | 970             | 1,8                        |
| 42-4         | 5,5                |                 |                            | 72-6         | 22                 |                 |                            |
| 51-4         | 7,5                |                 |                            | 81-6         | 30                 |                 |                            |
| 52-4         | 10                 |                 |                            | 82-6         | 40                 |                 |                            |
| 61-4         | 13                 |                 |                            | 91-6         | 55                 | 980             |                            |
| 62-4         | 17                 |                 |                            | 92-6         | 75                 |                 |                            |
| 71-4         | 22                 | 1450            |                            | 1,7          | 41-8               | 2,2             | 710                        |
| 72-4         | 30                 |                 |                            |              | 42-8               | 3               |                            |
| 81-4         | 40                 | 51-8            |                            |              | 4                  |                 |                            |
| 82-4         | 55                 | 52-8            |                            |              | 5,5                |                 |                            |
| 91-4         | 75                 | 1480            |                            |              | 61-8               | 7,5             | 720                        |
| 92-4         | 100                |                 |                            |              | 62-8               | 10              |                            |
| 41-6         | 3                  | 955             |                            |              | 71-8               | 13              | 730                        |
| 42-6         | 4                  |                 |                            |              | 72-8               | 17              |                            |
| 51-6         | 5,5                |                 |                            |              | 81-8               | 22              | 735                        |
| 52-6         | 7,5                |                 |                            |              | 82-8               | 30              |                            |
| 61-6         | 10                 |                 |                            |              | 970                | 91-8            | 40                         |
| 62-6         | 13                 | 92-8            |                            |              |                    | 55              |                            |

### Ayrim plastmassalarning xarakteristiklari [21]

| Material                  | Marka | $\sigma_{ПЧЭ}.$         | $\sigma_{ПЧС}.$ | qo'llanilishi                                                                                                                                     |
|---------------------------|-------|-------------------------|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
|                           |       | $\frac{H}{\text{мм}^2}$ |                 |                                                                                                                                                   |
| tekstolit                 | 2     | 120                     | 150             | shkivlar, tishli g'ildi-rak, podshipnik vklad-shi, vtulkalar, tishli g'ildiraklar, yuqori mustahkamli detallar, kranlar, katta o'lchamli detallar |
| tekstolit                 | PTK   | 160                     | 150             |                                                                                                                                                   |
| yog'och qatlam-li plastik | DSP.G | 100                     | 120             |                                                                                                                                                   |
| Kapron                    | -     | 60-70                   | 70-80           |                                                                                                                                                   |
| stekloplastik             | -     | 150-350                 | -               |                                                                                                                                                   |
|                           |       |                         |                 |                                                                                                                                                   |

### Ayrim mashinasozlik materiallarining xarakteristiklari [21]

| marka     | material                                | $\sigma_{II\gamma}(\sigma_B)$ | $\sigma_{o\kappa}(\sigma_{0,2})$ | $\sigma_{-1}$ | Qaerda<br>qo'llaniladi                                                                                                         |
|-----------|-----------------------------------------|-------------------------------|----------------------------------|---------------|--------------------------------------------------------------------------------------------------------------------------------|
|           |                                         | $\frac{H}{\text{мм}^2}$       |                                  |               |                                                                                                                                |
| St.3      | Uglerodli<br>oddiy<br>sifatli<br>po'lot | 380-470                       | 240                              | 180           | Parchin mix,<br>bolt, gayka<br>val, shponka<br>tishli g'ildirak                                                                |
| St.5      |                                         | 500-620                       | 280                              | 240           |                                                                                                                                |
| St.6      |                                         | 600-720                       | 310                              | 280           |                                                                                                                                |
| St.15     | Uglerodli<br>konstruk-<br>tsion po'lot  | 350                           | 210                              | 160           | Tsementatsiya-<br>lanadigan<br>detallar, bolt,<br>gayka<br>val, tishli<br>g'ildiraklar,<br>kulachokli<br>muftalar,<br>katoklar |
| St.35     |                                         | 520                           | 300                              | 230           |                                                                                                                                |
| St.45-50  |                                         | 600                           | 340                              | 260           |                                                                                                                                |
| St.50G    |                                         | 650                           | 370                              | 290           |                                                                                                                                |
| St.20X    | Legirlan-<br>gan kons-<br>truktsion     | 800                           | 600                              | 350           |                                                                                                                                |
| St.40X    |                                         | 1000                          | 800                              | 420           |                                                                                                                                |
| Sch.12-18 | Kul rang<br>cho'yondan<br>quyma         | 120                           | -                                | 280           | korpuslar,<br>g'ildiraklar<br>richaglar                                                                                        |
| Sch.15-32 |                                         | 150                           | -                                | 320           |                                                                                                                                |
| Sch.21-40 |                                         | 210                           | -                                | 400           |                                                                                                                                |
| BrOTsS-55 | Bronza<br>qalayli                       | 180-220                       | 80-100                           | -             | Podshipnik<br>vkladyishi                                                                                                       |
| BrOF10-1  | Bronza<br>qalayli                       | 200-350                       | 200                              | -             | Podshipnik,<br>chervyak<br>g'ildiragi<br>gardishi                                                                              |
| BrAJ9-4   | Bronza<br>qalaysiz                      | 500-550                       | 350                              | -             |                                                                                                                                |

### I-30. Bir qatorli radial sharikli podshipniklar [22]

| odship-<br>nikni<br>belgisi | $d$ | $D$ | $B$ | $r$ | Dinamik<br>yuklanish<br>$S, kN$ | Statik<br>yuklanish<br>$S_0, kN$ |
|-----------------------------|-----|-----|-----|-----|---------------------------------|----------------------------------|
| Engil seriya                |     |     |     |     |                                 |                                  |
| 200                         | 10  | 30  | 9   | 1   | 4,6                             | 2,61                             |
| 201                         | 12  | 32  | 10  | 1   | 4,7                             | 2,65                             |
| 202                         | 15  | 35  | 11  | 1   | 5,85                            | 3,47                             |
| 203                         | 17  | 40  | 12  | 1   | 3,37                            | 4,38                             |
| 204                         | 20  | 47  | 14  | 1,5 | 9,81                            | 6,18                             |
| 205                         | 25  | 52  | 15  | 1,5 | 10,8                            | 6,95                             |
| 206                         | 30  | 62  | 16  | 1,5 | 15,0                            | 10,0                             |
| 207                         | 35  | 72  | 17  | 2   | 19,7                            | 13,6                             |
| 208                         | 40  | 80  | 18  | 2   | 25,1                            | 17,8                             |

|              |     |     |    |     |      |      |
|--------------|-----|-----|----|-----|------|------|
| 209          | 45  | 85  | 19 | 2   | 25,2 | 17,8 |
| 210          | 50  | 90  | 20 | 2   | 27,0 | 19,7 |
| 211          | 55  | 100 | 21 | 2,5 | 33,3 | 25,0 |
| 212          | 60  | 110 | 22 | 2,5 | 40,3 | 30,9 |
| 213          | 65  | 120 | 23 | 2,5 | 44,0 | 34,0 |
| 214          | 70  | 125 | 24 | 2,5 | 47,9 | 37,4 |
| 215          | 75  | 130 | 25 | 2,5 | 50,9 | 41,1 |
| 216          | 80  | 140 | 26 | 3   | 55,9 | 44,5 |
| 217          | 85  | 150 | 28 | 3   | 64,1 | 53,1 |
| 218          | 90  | 160 | 30 | 3   | 73,8 | 60,5 |
| 219          | 95  | 170 | 32 | 3,5 | 83,7 | 69,5 |
| 220          | 100 | 180 | 34 | 3,5 | 93,9 | 79,0 |
| O'rta seriya |     |     |    |     |      |      |
| 300          | 10  | 35  | 11 | 1,0 | 6,24 | 3,76 |
| 301          | 12  | 37  | 12 | 1,5 | 7,48 | 4,64 |
| 302          | 15  | 42  | 13 | 1,5 | 8,73 | 5,4  |
| 303          | 17  | 47  | 14 | 1,5 | 10,7 | 6,67 |
| 304          | 20  | 52  | 15 | 2,0 | 12,3 | 7,79 |
| 305          | 25  | 62  | 17 | 2,0 | 17,3 | 11,4 |
| 306          | 30  | 72  | 19 | 2,0 | 21,6 | 14,8 |
| 307          | 35  | 80  | 21 | 2,5 | 25,7 | 17,6 |
| 308          | 40  | 90  | 23 | 2,5 | 31,3 | 22,3 |
| 309          | 45  | 100 | 25 | 2,5 | 37,1 | 26,2 |
| 310          | 50  | 110 | 27 | 3,0 | 47,6 | 35,6 |
| 311          | 55  | 120 | 29 | 3,0 | 54,9 | 41,8 |
| 312          | 60  | 120 | 31 | 3,5 | 62,9 | 48,4 |
| 313          | 65  | 140 | 33 | 3,5 | 71,3 | 55,6 |
| 314          | 70  | 150 | 35 | 3,5 | 80,1 | 63,3 |
| 315          | 75  | 160 | 37 | 3,5 | 87,3 | 71,4 |
| 316          | 80  | 170 | 39 | 3,5 | 94,6 | 80,1 |
| 317          | 85  | 180 | 41 | 4,0 | 102  | 89,2 |
| 318          | 90  | 190 | 43 | 4,0 | 110  | 99,0 |
| 319          | 95  | 200 | 45 | 4,0 | 118  | 109  |
| 320          | 100 | 215 | 47 | 4,0 | 133  | 130  |
| Og'ir seriya |     |     |    |     |      |      |
| 403          | 17  | 62  | 17 | 2,0 | 17,5 | 11,9 |
| 405          | 25  | 80  | 21 | 2,5 | 28,6 | 20,4 |
| 406          | 30  | 90  | 23 | 2,5 | 36,5 | 26,7 |
| 407          | 35  | 100 | 25 | 2,5 | 42,8 | 31,3 |
| 408          | 40  | 110 | 27 | 3,0 | 49,3 | 36,3 |
| 409          | 45  | 120 | 29 | 3,0 | 59,2 | 45,5 |
| 410          | 50  | 130 | 31 | 3,5 | 67,2 | 53,0 |
| 411          | 55  | 140 | 33 | 3,5 | 77,2 | 62,5 |

|     |    |     |    |     |      |      |
|-----|----|-----|----|-----|------|------|
| 412 | 60 | 150 | 35 | 3,5 | 83,9 | 70,0 |
| 413 | 65 | 160 | 37 | 3,5 | 90,8 | 78,1 |
| 414 | 70 | 180 | 42 | 4,0 | 111  | 105  |
| 415 | 75 | 190 | 45 | 4,0 | 117  | 115  |
| 416 | 80 | 200 | 48 | 4,0 | 126  | 125  |
| 417 | 85 | 210 | 52 | 5,0 | 133  | 135  |

**I-31. Radial – tayanchli bir qatorli sharikli podshipnik [22]**

| Podshipnikni<br>turi | $d$ | $D$ | $b$ | $r$ | $r_1$ | Dinamik<br>yuklanish<br>qobiliyati<br>$S, kN$ | Statik<br>yuklanish<br>qobiliyati<br>$S_o, kN$ |
|----------------------|-----|-----|-----|-----|-------|-----------------------------------------------|------------------------------------------------|
| 46202                | 15  | 35  | 11  | 1   | 0,3   | 5,95                                          | 3,51                                           |
| 46203                | 17  | 40  | 12  | 1   | 0,3   | 8,83                                          | 5,62                                           |
| 46204                | 20  | 47  | 14  | 1,5 | 0,5   | 11,4                                          | 7,64                                           |
| 46205                | 25  | 52  | 15  | 1,5 | 0,5   | 12,2                                          | 8,34                                           |
| 46206                | 30  | 62  | 16  | 1,5 | 0,5   | 16,9                                          | 12,0                                           |
| 46207                | 35  | 72  | 17  | 2,0 | 1,0   | 22,3                                          | 16,3                                           |
| 46208                | 40  | 80  | 18  | 2,0 | 1,0   | 28,3                                          | 21,3                                           |
| 46209                | 45  | 85  | 19  | 2,0 | 1,0   | 29,8                                          | 23,1                                           |
| 46210                | 50  | 90  | 20  | 2,0 | 1,0   | 31,2                                          | 24,3                                           |
| 46211                | 55  | 100 | 21  | 2,5 | 1,2   | 38,6                                          | 31,5                                           |
| 46212                | 60  | 110 | 22  | 2,5 | 1,2   | 44,5                                          | 36,1                                           |
| 46213                | 65  | 120 | 23  | 2,5 | 1,2   | 53,3                                          | 46,0                                           |
| 46214                | 70  | 125 | 24  | 2,5 | 1,2   | 58,0                                          | 50,4                                           |
| 46215                | 75  | 130 | 25  | 2,5 | 1,2   | 60,3                                          | 53,7                                           |
| 46216                | 80  | 140 | 26  | 3,0 | 1,5   | 67,6                                          | 60,0                                           |
| 46303                | 17  | 47  | 14  | 1,5 | 0,5   | 12,4                                          | 7,99                                           |
| 46304                | 20  | 52  | 15  | 2,0 | 1,0   | 13,7                                          | 8,99                                           |
| 46305                | 25  | 62  | 17  | 2,0 | 1,0   | 20,7                                          | 14,6                                           |
| 46306                | 30  | 72  | 19  | 2,0 | 1,0   | 25,1                                          | 18,3                                           |
| 46307                | 35  | 80  | 21  | 2,5 | 1,2   | 32,8                                          | 24,7                                           |
| 46308                | 40  | 90  | 23  | 2,5 | 1,2   | 38,4                                          | 30,1                                           |
| 46309                | 45  | 100 | 25  | 2,5 | 1,2   | 47,2                                          | 37,0                                           |
| 46310                | 50  | 110 | 27  | 3,0 | 1,5   | 55,2                                          | 43,9                                           |
| 46311                | 55  | 120 | 29  | 3,0 | 1,5   | 67,6                                          | 56,3                                           |
| 46312                | 60  | 130 | 31  | 3,5 | 2,0   | 77,3                                          | 65,3                                           |
| 46313                | 65  | 140 | 33  | 3,5 | 2,0   | 87,3                                          | 74,9                                           |
| 46314                | 70  | 150 | 35  | 3,5 | 2,0   | 98,1                                          | 85,3                                           |

### I-32. Bir katorli konussimon rolikli podshipnik

| Podship-<br>niklarni turi | $d$ | $D$ | $T$   |       | $B$                         | $C_1$ | $r$ | $r_1$ | Dinamik<br>yuklanish, C,<br>$kN$ | $Y$   | $e$   | Statik<br>yuklanishp,<br>$C_0, kN$ | $Y_0$ |
|---------------------------|-----|-----|-------|-------|-----------------------------|-------|-----|-------|----------------------------------|-------|-------|------------------------------------|-------|
|                           |     |     | $max$ | $min$ |                             |       |     |       |                                  |       |       |                                    |       |
| Engil seriya              |     |     |       |       |                             |       |     |       |                                  |       |       |                                    |       |
| 7202                      | 15  | 35  | 12,0  | 11,5  | 11                          | 9     | 1,0 | 0,3   | 8,61                             | 1,329 | 0,451 | 6,02                               | 0,731 |
| 7203                      | 17  | 40  | 13,5  | 13,0  | 12                          | 11    | 1,5 | 0,5   | 13,5                             | 1,909 | 0,314 | 9,12                               | 1,050 |
| 7204                      | 20  | 41  | 15,5  | 15,0  | 14                          | 12    | 1,5 | 0,5   | 18,7                             | 1,666 | 0,360 | 13,0                               | 0,916 |
| 7205                      | 25  | 52  | 16,5  | 16,0  | 15                          | 13    | 1,5 | 0,5   | 23,4                             | 1,666 | 0,360 | 17,6                               | 0,916 |
| 7206                      | 30  | 62  | 17,5  | 17,0  | 16                          | 14    | 1,5 | 0,5   | 29,2                             | 1,645 | 0,365 | 21,9                               | 0,905 |
| 7207                      | 35  | 72  | 18,5  | 18,0  | 17                          | 15    | 2,0 | 0,5   | 34,5                             | 1,624 | 0,369 | 25,8                               | 0,893 |
| 7208                      | 40  | 80  | 20,0  | 19,0  | 20                          | 16    | 2,0 | 0,8   | 41,6                             | 1,565 | 0,383 | 32,1                               | 0,861 |
| 7209                      | 45  | 85  | 20,5  | 20,0  | 19                          | 16    | 2,0 | 1,2   | 41,9                             | 1,450 | 0,414 | 32,8                               | 0,798 |
| 7210                      | 50  | 90  | 22,0  | 21,5  | 21                          | 17    | 2,0 | 0,8   | 51,9                             | 1,604 | 0,374 | 39,8                               | 0,882 |
| 7211                      | 55  | 100 | 23,0  | 22,5  | 21                          | 18    | 2,5 | 0,8   | 56,8                             | 1,459 | 0,411 | 45,2                               | 0,802 |
| 7212                      | 60  | 110 | 24,0  | 23,5  | 23                          | 19    | 2,5 | 0,8   | 70,8                             | 1,710 | 0,351 | 82,4                               | 0,940 |
| 7214                      | 70  | 125 | 26,0  | 26,0  | 26                          | 21    | 2,5 | 0,8   | 94,0                             | 1,124 | 0,369 | 80,5                               | 0,893 |
|                           |     |     |       |       | Engil kengaytirilgan seriya |       |     |       |                                  |       |       |                                    |       |
| 7506                      | 30  | 62  | 21,5  | 21,0  | 20,5                        | 17    | 1,5 | 0,5   | 34,2                             | 1,645 | 0,365 | 27,0                               | 0,905 |
| 7507                      | 35  | 72  | 24,5  | 24,0  | 23,0                        | 20    | 2,0 | 0,8   | 49,2                             | 1,733 | 0,346 | 39,5                               | 0,953 |
| 7508                      | 40  | 80  | 25,0  | 25,0  | 23,5                        | 20    | 2,0 | 0,8   | 52,9                             | 1,575 | 0,381 | 43,9                               | 0,866 |
| 7509                      | 45  | 85  | 25,0  | 25,0  | 23,5                        | 20    | 2,0 | 0,8   | 50,6                             | 1,442 | 0,416 | 41,8                               | 0,793 |
| 7510                      | 50  | 90  | 25,0  | 25,0  | 23,5                        | 20    | 2,0 | 0,8   | 58,6                             | 1,426 | 0,421 | 50,4                               | 0,784 |
| 7511                      | 55  | 100 | 27,0  | 27,0  | 25,0                        | 21    | 2,5 | 0,8   | 70,8                             | 1,666 | 0,360 | 60,4                               | 0,916 |

|                             |    |     |      |      |      |      |     |     |      |       |       |      |       |
|-----------------------------|----|-----|------|------|------|------|-----|-----|------|-------|-------|------|-------|
| 7512                        | 65 | 110 | 30,0 | 30,0 | 28,0 | 24   | 2,5 | 0,8 | 82,4 | 1,528 | 0,392 | 74,1 | 0,840 |
| 7513                        | 65 | 120 | 33,0 | 33,0 | 31,0 | 27   | 2,5 | 0,8 | 107  | 1,624 | 0,369 | 97,0 | 0,893 |
| 7514                        | 70 | 125 | 33,5 | 33,0 | 31,0 | 27   | 2,5 | 0,8 | 108  | 1,547 | 0,388 | 99,0 | 0,851 |
| 7515                        | 75 | 130 | 33,5 | 33,0 | 31,0 | 27   | 2,5 | 0,8 | 113  | 1,476 | 0,407 | 106  | 0,812 |
| 7516                        | 80 | 140 | 33,5 | 33,0 | 33,0 | 28   | 3,0 | 1,0 | 130  | 1,493 | 0,402 | 124  | 0,821 |
| O'rta seriya                |    |     |      |      |      |      |     |     |      |       |       |      |       |
| 7304                        | 20 | 52  | 16,5 | 16,0 | 16   | 13   | 2,0 | 0,8 | 24,5 | 2,026 | 0,296 | 17,4 | 1,114 |
| 7305                        | 25 | 62  | 18,5 | 18,0 | 17   | 15   | 2,0 | 0,8 | 29,0 | 1,666 | 0,360 | 20,5 | 0,916 |
| 7306                        | 30 | 72  | 21,0 | 20,5 | 19   | 17   | 2,0 | 0,8 | 39,2 | 1,780 | 0,337 | 29,3 | 0,979 |
| 7307                        | 35 | 80  | 23,0 | 22,5 | 21   | 18   | 2,5 | 0,8 | 47,2 | 1,881 | 0,319 | 34,6 | 1,035 |
| 7308                        | 40 | 90  | 25,5 | 25,0 | 23   | 20   | 2,5 | 0,8 | 59,8 | 2,158 | 0,278 | 45,1 | 1,187 |
| 7309                        | 45 | 100 | 27,5 | 27,0 | 26   | 22   | 2,5 | 0,8 | 74,6 | 2,090 | 0,287 | 58,2 | 1,150 |
| 7310                        | 50 | 110 | 29,5 | 29,0 | 29   | 23   | 3,0 | 1,0 | 94,7 | 1,937 | 0,310 | 74,4 | 1,065 |
| 7311                        | 55 | 120 | 32,0 | 31,0 | 29   | 25   | 3,0 | 1,0 | 10   | 1,804 | 0,332 | 79,9 | 0,92  |
| 7312                        | 60 | 130 | 34,0 | 33,0 | 31   | 27   | 3,5 | 1,2 | 116  | 1,966 | 0,305 | 94,4 | 1,081 |
| 7313                        | 65 | 140 | 36,5 | 35,0 | 33   | 28   | 3,5 | 1,2 | 131  | 1,966 | 0,305 | 109  | 1,081 |
| 7314                        | 70 | 150 | 38,5 | 37,0 | 37   | 30   | 3,5 | 1,2 | 165  | 1,937 | 0,310 | 134  | 1,065 |
| O'rta kengaytirilgan seriya |    |     |      |      |      |      |     |     |      |       |       |      |       |
| 7604                        | 20 | 52  | 22,5 | 22,0 | 21,0 | 18,5 | 2,0 | 0,8 | 28,9 | 2,011 | 0,298 | 21,6 | 1,106 |
| 7605                        | 25 | 62  | 25,5 | 25,0 | 24,0 | 21,0 | 2,0 | 0,8 | 44,6 | 1,149 | 0,273 | 35,9 | 1,206 |
| 7606                        | 30 | 72  | 29,0 | 28,5 | 29,0 | 23,0 | 2,0 | 0,8 | 60,1 | 1,882 | 0,319 | 50,0 | 1,035 |
| 7607                        | 35 | 80  | 33,0 | 32,5 | 31,0 | 27,0 | 2,5 | 0,8 | 70,2 | 2,026 | 0,296 | 60,3 | 1,114 |
| 7609                        | 45 | 100 | 38,5 | 38,0 | 36,0 | 31,0 | 2,5 | 0,8 | 102  | 2,058 | 0,291 | 88,8 | 1,131 |
| 7610                        | 50 | 110 | 42,5 | 42,0 | 40,0 | 34,0 | 3,0 | 1,0 | 120  | 2,026 | 0,296 | 106  | 1,114 |
| 7611                        | 55 | 120 | 46,0 | 45,0 | 44,5 | 36,5 | 3,0 | 1,0 | 145  | 1,855 | 0,323 | 137  | 1,020 |
| 7612                        | 60 | 130 | 49,0 | 48,0 | 47,5 | 39,0 | 3,5 | 1,2 | 168  | 1,966 | 0,305 | 154  | 1,081 |

|      |    |     |      |      |      |      |     |     |     |       |       |     |       |
|------|----|-----|------|------|------|------|-----|-----|-----|-------|-------|-----|-------|
| 7613 | 65 | 140 | 51,5 | 50,0 | 48,0 | 41,0 | 3,5 | 1,2 | 175 | 1,829 | 0,328 | 165 | 1,006 |
| 7614 | 70 | 150 | 54,5 | 53,0 | 51,0 | 43,0 | 3,5 | 1,2 | 200 | 1,711 | 0,351 | 182 | 0,940 |

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| 2  | R.Karimov,<br>A.Soliev        | Amaliy mexanika. Toshkent, «Fan va texnologiyalar » nashriyoti 2005 yil, 270 bet                                  |
| 3  | A.Jo'raev va<br>boshqalar     | Amaliy mexanika. Toshkent «Fan va texnologiyalar » nashriyoti 2007 yil , 397 bet                                  |
| 4  | A.N. Nabiev va<br>bosh.       | Amaliy mexanika. «Sharq» nashriyoti Toshkent, 2010 yil                                                            |
| 5  | G. A. Kurbanova               | Texnik mexanika. Oliy ta'lim muassasalari uchun darslik. Toshkent TTESI 2010 yil, 195 bet                         |
| 6  | N.S Bibutov                   | Texnik mexanikadan amaliy mashg'ulotlar Toshkent, «Ilm – ziyo» nashriyoti. 2006 yil, 186 bet                      |
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| 9  | A.A.Erdedi va b.              | Amaliy mexanika. Toshkent, «O'qituvchi», 1987 yil                                                                 |
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## MUALLIF: BIBUTOV NARZULLA SALIMOVICH



1950 yil 7 iyul Buxoro viloyat Qorako'l rayonida to'g'ilgan. 1972 yil Toshkent qishloq xo'jaligini mexanizatsiyalash va irrigatsiyalash injenerlari institutini tamomlagan. Bibutov N 1973 yildan Toshkent Politehnika instituti Buxoro kechki filialining «Mexanika» kafedra-sida katta laborant, assistent, katta o'qituvchi, lavozimlarida ishladi. 1983 yil O'rta Osiyo qishloq xo'jaligini mexanizatsiyalash va elektrlashtirish ilmiy tekshirish institutida nomzodlik dissertatsiyasini himoya qilgan. N.Bibutov 1978

yillar Buxoro oziq – ovqat va engil sanoat texnologiyasi instituti «Mexanika» kafedrasida katta o'qituvchi 1985 – 1986 yillar kafedra mudiri vazifasini bajaruvchi, 1986 – 1992 yillar «Oziq – ovqat texnologiyasi » fakultetida dekan muovini, 1998 – 2005 yillar institut ilmiy–tadqiqot bo'limining boshlig'i 1991 yildan dotsent, 2007 yildan professor lavozimida ishlagan.

N.Bibutov 200 ga yaqin ilmiy - uslubiy ish chop etgan: jumladan, «Materiallar qarshiligi» va «Amaliy mexanika» fanlaridan 6 ta darslik, 6 ta o'quv qo'llanma, 12 ta elektron darslik va qo'llanma, 3 ta monografiya , 140 ta ilmiy va 60 dan ortiq o'quv-uslubiy qo'llanmalar.

N.Bibutov « Materiallar qarshiligi » va « Amaliy mexanika » fanlaridan ma'ruzalar o'qiydi, amaliy va tajriba mashg'ulotlarini olib boradi, oliy ta'lim muassasalari uchun «Materiallar qarshiligi asoslari» darsligi ( « Minhoj » nashriyoti, Toshkent 2003yil), « Amaliy mexanika » darsligi («Yangiyo'l poligraf servis» nashriyoti, Toshkent 2008 yil ), kasb–hunar kollejlari uchun «Amaliy mexanika» ( «Uzinkommarkaz» bosmaxonasi, Toshkent 2002 yil ) va «Texnik mexanikadan amaliy mashg'ulotlar » (« Ilm-ziyo » nashriyoti, Toshkent 2006 yil ), «Materiallar qarshiligini o'qitish metodikasi » (xam mauallif N.M.Murodov, «Durdon» bosmaxonasi, Buxoro 2013 yil o'quv qo'llanmalarining muallifi

O'zbekiston Respublikasi Oliy va o'rta maxsus ta'lim vazirligi, « Iste'dod » jamg'armasining 2007 yil 5 – oktyabr №205-25-93 sonli qo'shma qaroriga asosan « Yilning eng yaxshi darsligi va o'quv adabiyoti muallifi » 2007 yil Respublika tanlovida umum-kasbiy fanlar bo'yicha «Texnik mexanikadan amaliy mashg'ulotlar» o'quv qo'llanmasi faxrli uchinchi o'rinni egalladi.

2017-2020 yillarda «Materiallar qarshiligi» darsligi (3-4 nashrlari) (hammualif A.X.Hojiev, Fan va texnologiyalar nashriyoti), «Materiallar qarshiligini o'qitish metodikasi» o'quv qo'llanmasi ( hammualif A.X.Hojiev, Fan va texnologiyalar nashriyoti) hamda «Materiallar qarshiligidan tajriba ishlari» o'quv qo'llanmasi ( TDTU bilan hamkorlikda ), « Amaliy mexanika » (Buxoro Durdon nashriyoti 2020 yil) darsligini nashr etdi