O’ZBEKISTON RESPUBLIKASI OLIY VA O’RTA MAXSUS

TA’LIM VAZIRLIGI

ISLOM KARIMOV NOMIDAGI TOSHKENT DAVLAT TEXNIKA UNIVERSITETI

TERMIZ FILIALI

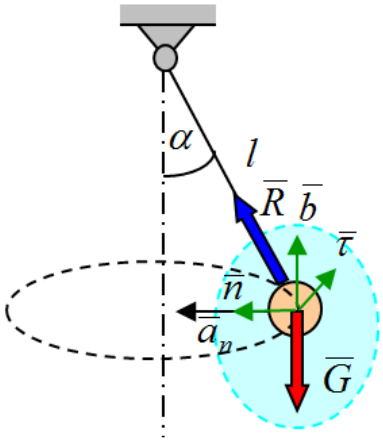
“MATEMATIKA VA TABIIY-ILMIY FANLAR” KAFEDRASI

ALIMNAZAROV OLIM MENGLIBOYEVICH

NAZARIY MEXANIKA FANIDAN

AMALIY MASHG’ULOTLARNI BAJARISH UCHUN

USLUBIY KO’RSATMA



$$\overline{T} = -\overline{R};\ \ T = R = \frac{G}{\cos\alpha}.$$

TERMIZ - 2018

Tuzuvchi: Alimnazarov O.M.

«Nazariy mexanika» fanidan amaliy mashg'ulotlarini bajarish bo'yicha uslubiy ko'rsatma / ToshDTU Termiz filiali, Termiz, 2018 – yil, 56b.

Uslubiy ko'rsatma 5320300-Texnologik mashinalar va jihozlar, 5310600-Yer usti transport tizimlari va ularning ekspluatatsiyasi (transport turlari bo'yicha) ta'lim yo'nalishlari bakalavr talabalariga mo'ljallangan bo'lib, unda amaliy mashg'ulotlarini hisoblash metodi, texnogik mashinalar turli qismlarini hisoblash va ularni qo'llash ko'nikmasiga ega bo'lish nazarda tutilgan. Uslubiy ko'rsatmada mexanikaga tegishli nazariy tushunchalar ham berilgan.

"Matematika va tabiiy-ilmiy fanlar" kafedrasi

Islom Karimov nomidagi Toshkent davlat texnika universiteti Termiz filiali o'quv-uslubiy kengashi qaroriga asosan foydalanishga tavfsiya etildi.

Taqrizchilar: **Jo'rayev B. –**"Matematik va tabiiy-ilmiy fanlar" kafedrasi dotsent, f.m.f.n.

Atoyev N.–"Umumkasbiy fanlar" kafedrasi dotsenti, t.f.n.

KIRISH

Ushbu uslubiy ko’rsatmada “Nazariy mexanika” fani bo’yicha oliy ta’lim muassasalari bakalavr bosqichi, yani 5310600-Yer usti transport tizimlari va ularning ekspluatatsiyasi (transport turlari bo’yicha), 5320300-Texnologik mashinalar va jihozlar (tarmoqlar bo’yicha) ta’lim yo’nalishlari talabalari uchun mo’ljallangan.

Uslubiy ko’rsatmada “Nazariy mexanika” fani bo’yicha amaliy mashg’ulotning mavzulari, ularning qisqacha mazmunlari va masalalarni bajarish tartiblari bo’yicha tavsiyalar va masalalar yechish bo’yicha namunalar berilgan. Shuningdek, mexanikaga oid formulalar qo’llaniladigan asosiy hisoblar qo’yilgan talablar xususida ma’lumotlar berilgan. Tavsiya etiladigan adabiyotlar va ma’lumot materiallari keltirilgan.

Talabalarning bilim olishlari uchun o`qituvchi tomonidan tavsiya qilingan adabiyotlardan tashqari, ularga qo`shimcha adabiyotlar, zamonaviy ma`ruza matnlari, fanlar bo`yicha qishqa masalalar to’plamlarini o`rganib chiqishlarini taklif qilish kerak.

Bu vazifalarni talaba qanday bajarganligiga qarab baholab borilishi kerak. Baholash tizimining asosiy vazifalari quyidagilardan iborat:

a) talabalarda Davlat ta`lim standartlariga muvofiq tegishli bilim, ko`nikma va malakalar shakllanganligi darajasini nazorat qilish va tahlil qilib borish;

b) talabalarda mustaqil ishlash ko`nikmalarini rivojlantirish, axborot resurslari manbalaridan samarali foydalanishni tashkil etish;

v) fanlarning talabalar tomonidan tizimli tarzda va belgilangan muddatlarda o`zlashtirilishini tashkil etish va tahlil qilish.

Amaliy mashg’ulotlaring vazifasi:

- talabalarda nazariy va amaliy bilimlarni mustahkamlash va tizimlash hamda amaliy tadbiq qilishga yordam berish;

- nazariy bilim ko`nikmalarni shakllantirish va kengaytirish;

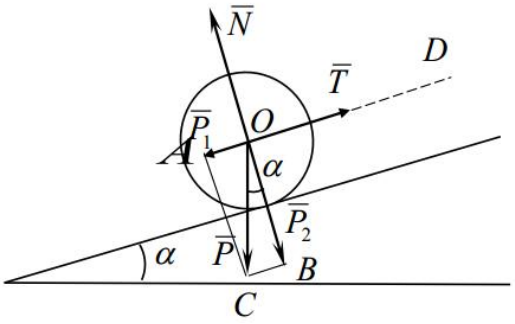
- fanga muvofiq adabiyot va qo`llanmalardan foydalanishni shakllantirish;

- talabalarning mustaqil ish faoliyatida ilmiy izlanishlarga jiddiy qarashlarni shakllantirish.

1-AMALIY MASHG'ULOT

KESISHUVCHI KUCHLAR TIZIMI GEOMETRIK VA ANALITIK MUVOZANATI SHARTI.

1.1-masala. Gorizont bilan α burchak tashkil qilgan silliq qiya tekislikda og'irligi *P* bo'lgan jism qiya tekislikka parallel bo'lgan *OD* ip yordamida muvozanatda tortib turibdi. Ipning taranglik *T* kuchi va jismning qiya tekislikka bo'lgan bosimi aniqlansin.[2]



Yechish: Berilgan *P* kuchni qiya tekislikka parallel va unga perpendikulyar bo'lgan yo'nalishlar bo'yicha P_1va P_2 tashkil etuvchilarga ajratamiz. Buning uchun diagonali P kuchiga teng bo'lgan, *OA* va *OB* tomonlari tanlab olingan yo'nalishlarga parallel bo'lgan *OABC* parallelogrammni quramiz. To'g'ri burchakli *OBC* uchburchakdan quyidagilarni aniqlaymiz:

$$P_1 = P\cos\propto, \quad P_2 = P\sin\propto$$

OD ip bo'ylab yo'nalgan P_1 tashkil etuvchi ip reaksiya kuchi bilan muvozanatlashadi, ya'ni

$$T = P_1 = P\sin\propto$$

Qiya tekislikka perpendikulyar bo'lgan P_2 tashkil etuvchi, izlanayotgan shu tekislikka bo'lgan bosimni ifodalaydi. Shuni ta'kidlaymizki, jismga qo'yilgan qiya tekislikning *N* reaksiya kuchi miqdor jihatidan jismning qiya tekisligiga bo'lgan bosimga teng, ya'ni:

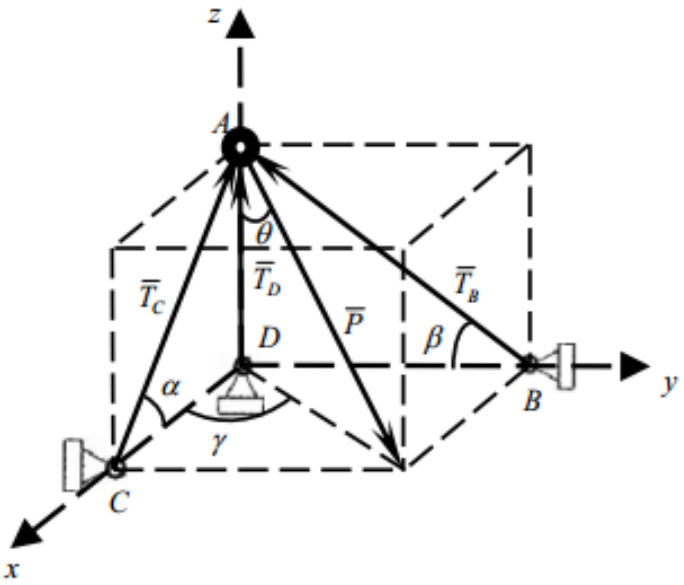
$$N = P_2 = P\cos\propto$$

Shuning uchun, tayanchga bo'lgan bosimni aniqlasak, unga teng bo'lgan tayanch reaksiya kuchini aniqlagan bo'lamiz.

1.2-masala. Shaklda ko'rsatilgan qurilmaning (konstruksiyaning) bir qator vaznsiz sterjenlarda hosil bo'ladigan zo'riqishlarning miqdor va yo'nalishlari analitik aniqlansin.[2]

Yechish:

1. *AC* va *AD* sterjenlarning *P* kuchi qo'yilgan *A* nuqtaning muvozanatini tekshiramiz.



2. *AB*, *AC* sterjenlarni kesib, *A* nuqtani ajratib, erkin deb bog'lanishlardan xoli deb qaraymiz. *P* kuchi va sterjenlarda hosil bo'ladigan zo'riqishlarni T_S, T_B va T_D belgilab sterjen o'qlari bo'ylab yo'naltiramiz.

3. Kesishuvchi kuchlarni muvozanat shartlarini tuzamiz, buning uchun kuchlarning koordinata o'qlardagi proyeksiyalarining yig'indisini tuzamiz. γ va θ burchaklarni kiritamiz.

$$\sum F_{kx} = -T_C \cos \propto + P \sin\theta \cos\gamma = 0;$$

$$\sum F_{ky} = -T_B \cos\beta + P \sin\theta \sin\gamma = 0;$$

$$\sum F_{kz} = T_C \sin \propto + T_B \sin\beta + T_D - P\cos\theta = 0.$$

Masalani yechish uchun avvalo $\sin\gamma$, $\cos\gamma$ va $\sin\theta$, $\cos\theta$ larning qiymatlarini hisoblab chiqamiz.

Bu yerdan:

$$tan\,\gamma = \frac{BD}{CD} = \frac{tan \propto}{tan\,\beta} = \frac{tan\,60}{tan\,30}, \qquad tan\,\gamma = 3$$

Trigonometrik formulalarni tatbiq qilib, quyidagilarni aniqlaymiz.

$$sin\,\gamma = \frac{tan\,\gamma}{\sqrt{1+tg^2\gamma}} = \frac{3}{\sqrt{10}}$$

b) Shakldan ko'rinadiki

$$tan\,\delta = \frac{\sqrt{CD^2+BD^2}}{AD}; \;\; tan\,\delta = AD\sqrt{\frac{1}{tg^2\beta}+\frac{1}{tg^2 \propto}} = \sqrt{\frac{10}{3}}$$

Trigonometrik formulalarga asosan

$$\sin\theta = \sqrt{\frac{10}{13}}$$

$$\cos\theta = \sqrt{\frac{3}{13}}$$

Hisoblangan qiymatlarni muvozanat tenglamalariga qo'ysak, quyidagilarni hosil qilamiz.

$$-T_C \cos 60 + P\sqrt{\frac{10}{13}} \cdot \frac{1}{\sqrt{10}} = 0$$

$$-T_B \cos 30 + P\sqrt{\frac{10}{13}}\sqrt{\frac{3}{13}} = 0$$

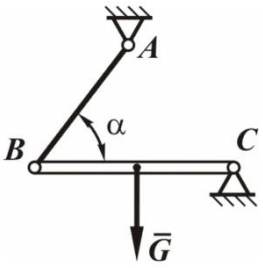
$$T_C \sin 60 + T_B \cos 30 + T_D - P = 0$$

Bulardan quyidagilarni olamiz

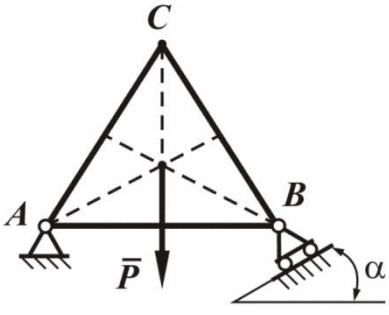
$$T_C = \frac{2P}{\sqrt{10}};\quad T_B = \frac{6P}{\sqrt{39}};\quad T_D = -\frac{3P}{\sqrt{39}}$$

Mustaqil bajarish uchun vazifalar:

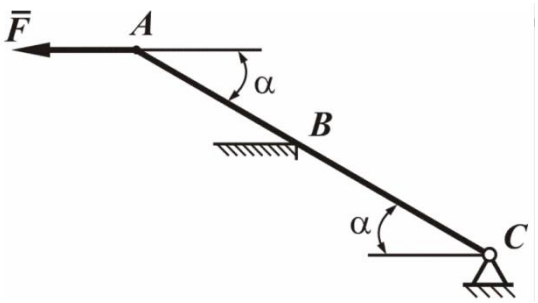
1. Bir jinsli *BC* balka $G = 600\sqrt{3}\ N,\ \alpha = 60^{\circ}$. *C* sharnirning reaktsiya kuchini toping.[6]
   Javob: 600 N.



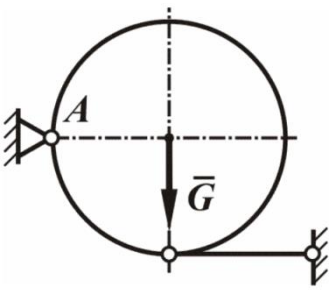
2. Bir jinsli plastinaning teng ta'sir etuvchisi $P = 4\sqrt{3}\ N, \alpha = 30^{\circ}$. B tayanch reaksiya kuchini toping.[6]
   Javob: 4 N.



3. *AB=BC* ga, *F=6 N*. *AC* balka tayanch bilan $\alpha = 30^{\circ}$ ni tashkil etadi. *C* tayanch reaksiya kuchini toping.[6]
Javob: 6 N.



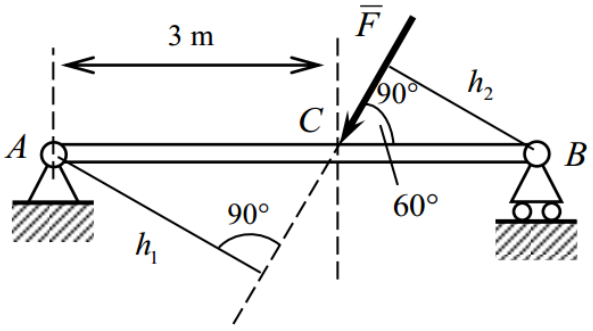
4. Disk og'irligi $G = 30\sqrt{3}\,N$. *A* sharnir reaksiya kuchini toping.[4]
Javob: 60 N.



2-AMALIY MASHG'ULOT

TEKISLIKDAGI KUCHLAR TIZIMI.

2.1-masala. Berilgan *F (F=20 N)* kuchdan *A* va *B* nuqtalarga nisbatan kuch momenti hisoblansin. *AB = 5 m.*[3]



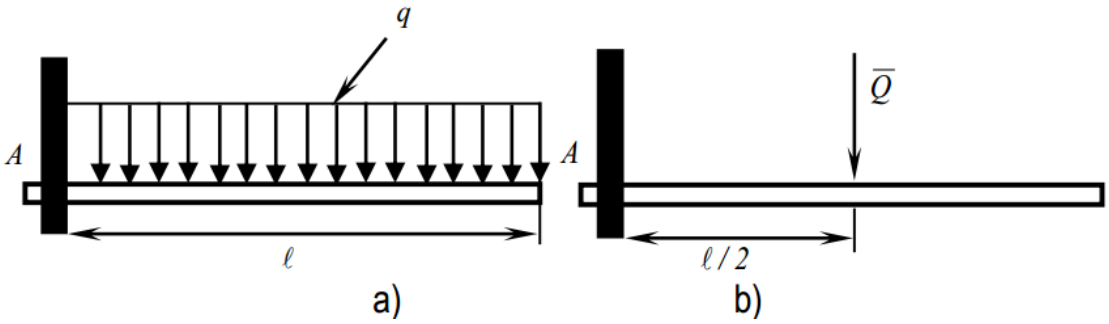
$$m_A(F) = -Fh = -F \cdot AC \sin 60$$

$$m_A(F) = -20 \cdot 3 \cdot \frac{\sqrt{3}}{2} = -30\sqrt{3} \approx -51{,}9\ Nm$$

$$m_B(F) = Fh = F \cdot BC \sin 60$$

$$m_B(F) = 20 \cdot 2 \cdot \frac{\sqrt{3}}{2} = 20\sqrt{3} \approx 34{,}6\ Nm$$

2.2-masala. Intensivligi *q=N/m* bo'lib, tekis yoyilgan yukning A nuqtaga nisbatan momenti hisoblansin



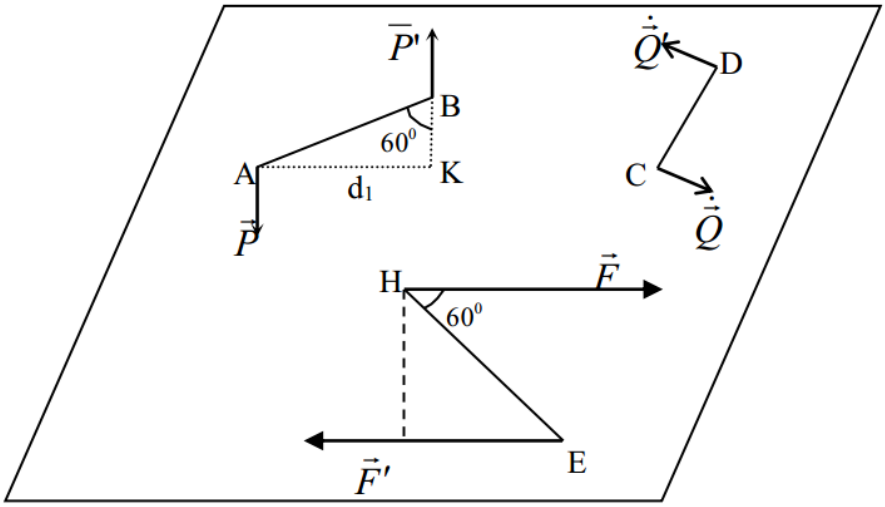
Yoyilgan kuchni to'plangan *Q* kuchi *Q=q*l* bilan almashtiramiz. U holda Varin'on teoremasiga asosan quyidagini olamiz.

$$M_A = -Q \cdot \frac{l}{2} = -\frac{l^2}{2} q \quad Nm$$

2.3-masala. shaklda tasvirlangan *(P P,), (Q Q), (F F)* juftlar sistemasi muvozanatda bo'lishi mumkinligi tekshirib ko'rilsin, agar *P=10N*, $Q = 5\sqrt{3}$ *N F=10N. AB=1m, CD=0,6m, EH=1,6m.*[4]

Yechish:

Berilgan juftlar momentlarini hisoblaymiz.



$$m_1 = P \cdot d_1 = P \cdot AB \cdot \sin 60 = 10 \cdot 1 \cdot \frac{\sqrt{3}}{2} = 5\sqrt{3} \quad Nm$$

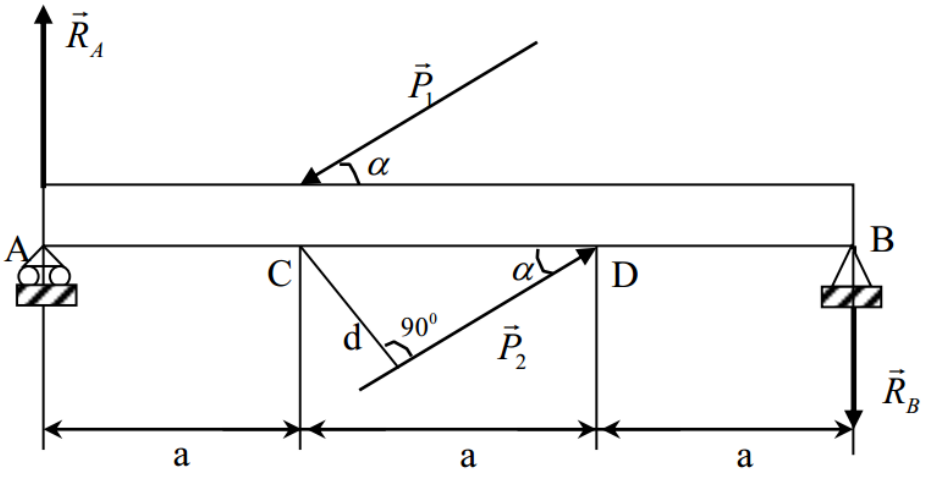
$$m_2 = Q \cdot d_2 = 5\sqrt{3} \cdot 0{,}6 = 3\sqrt{3}\ Nm$$

$$m_3 = -F \cdot EH \cdot \sin 60 = -10 \cdot 1{,}6 \cdot \frac{\sqrt{3}}{2} = -8\sqrt{3}\ \ Nm$$

U holda juftlar muvozanatda bo'ladi.

$$M = m_1 + m_2 + m_3 = 5\sqrt{3} + 3\sqrt{3} - 8\sqrt{3} = 0$$

2.4-masala. Juft *(P_1,P_2)* ta'siri ostidagi to'sinning tayanch reaksiyalari aniqlansin, agar *AC=CD=BD=a*.[5]



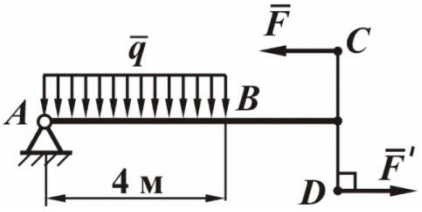
Yechish:

Juft kuchi *(P_1, P_2)*ni qarama-qarshi yo'nalishdagi *(R_A, R_B)* juft kuch bilan muvozanatlashtirish mumkin. To'sinning *A* sharnirli tayanchi qo'zg'aluvchan g'ildiraklar ustiga tayangan, shuning uchun R_A reaksiya vertikal yuqoriga yo'nalgan bo'ladi. U holda R_B reaksiya vertikal pastga yo'nalgan. Quyidagi belgilashni olamiz). $m_1 = m(P_1P_2), m_2 = (R_AR_B)$. U holda ikki juftning muvozanat sharti $m_1+m_2=0$ quyidagi ko'rinishni oladi:

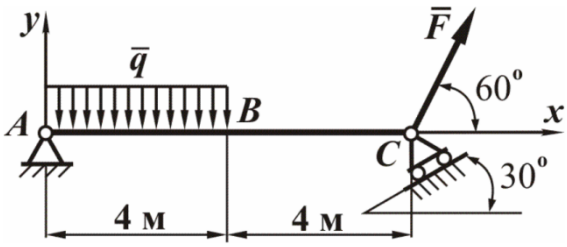
$$P_1 a \sin \propto -R_A \cdot 3a = 0, \qquad R_A = R_B = \frac{P \sin \propto}{3}$$

Mustaqil bajarish uchun vazifalar:

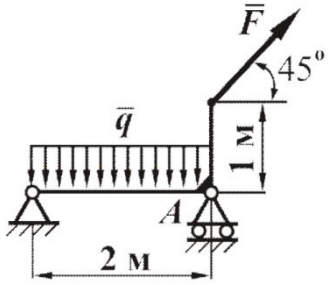
1. *$F=F^l=16$ N, CD=5m, q=10 N/m.* *A* tayanchga nisbatan kuch juftining bosh momentini toping.[6]
   Javob: 0.



2. *F=4N*, $q = 2\sqrt{3}\ N/m$. *C* tayanch reaksiya kuchini toping.[4]
Javob: 0.



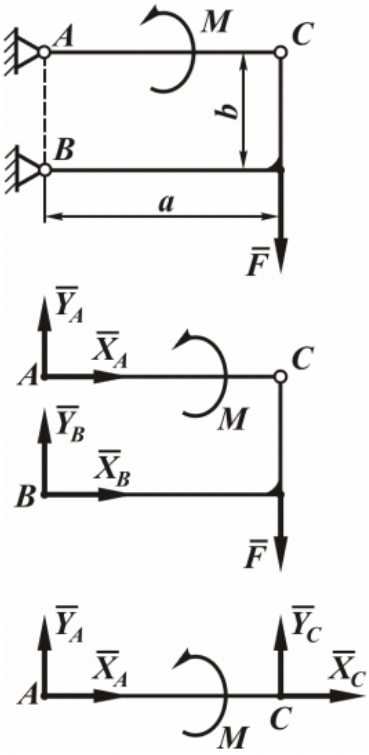
3. *F*=$4\sqrt{3}\ N$, intensivligi *q=3N/m* bo'lgan tqasimlangan kuch. *A* tayanch reaksiya kuchini toping.[2]
Javob: 1 N.



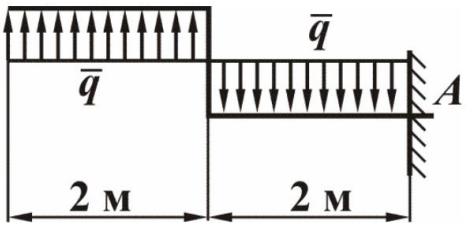
4. *6* ta muvozanat tenglamasi tuzulgan. Ko'rsatilgan qaysi tenglamada xatolik bor.[2]

$$a)\ X_A + X_B + X_C = 0;$$
$$b)\ Y_A + Y_C = 0; \quad v)\ M - Y_A \cdot a = 0;$$
$$g)\ X_A + X_C = 0;$$
$$d)\ Y_B - F - Y_C = 0; \quad e)\ -Y_A \cdot a = 0.$$

Javob: a), g), e)



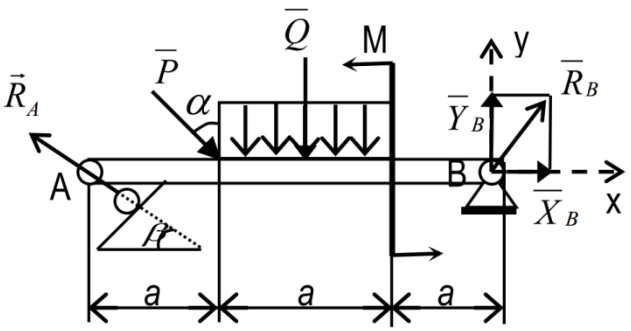
5. Intensivligi *q=100 N/m* bo'lgan taqsimlangan kuchning *A* nuqtaga nisbatan mometini toping.[2]
Javob: 400 Nm.



3-AMALIY MASHG'ULOT

IXTIYORIY JOYLASHGAN KUCHLAR TIZIMI.

3.1-masala. shaklda ko'rsatilgan balkaga ta'sir qiluvchi kuchlar ta'siridan uning *A* va *B* nuqtalaridagi tayanch reaksiyalari analitik usulda aniqlansin. [1]



Yechish:

AB balkani erkin jism deb qarab muvozanatini tekshiramiz. Unga quyidagi kuchlar ta'sir qiladi:

1. Vertikal bilan $\propto$ burchak tashkil qilgan P kuchi.

2. Momenti *M* ga teng bo'lgan juft kuch.

3. *a* uzunlikdagi segment bo'ylab tekis tarqalgan yoyilgan kuch, uning teng ta'sir etuvchi miqdori.

$$Q = q \cdot a \;\; ya'ni \;\; Q = 3\left[\frac{N}{m}\right] \cdot 2[m] = 6\,N$$

4. Bog'lanish reaksiya kuchlari: R_A, X_B va Y_B Endi muvozanat tenglamalarini yozamiz.

$$\sum_{i=1}^{n} F_{kx} = X_B - R_A \cos\beta + P \sin\alpha = 0$$

$$\sum_{i=1}^{n} m_A F_k = Y_B \cdot 3a + M - Q \cdot \frac{3}{2}a - P\cos \propto = 0$$

$$\sum_{i=1}^{n} m_B\, F_K = -R_A \sin\beta \cdot 3a + P\cos \propto \cdot\, 2a + Q \cdot \frac{3}{2}a + M = 0$$

Berilgan son qiymatlarini tenglamalar sistemasiga qo'ysak, quyidagilarni olamiz.

$$X_B - R_A \cdot \cos 60 + 6 \sin 30 = 0$$

$$Y_B \cdot 3 \cdot 2 + 12 - 6 \cdot \frac{3}{2} \cdot 2 - 6\cos 30 \cdot 2 = 0$$

$$-R_A \sin 60 \cdot 3 \cdot 2 + 6 \cos 30 \cdot 2 \cdot 2 + 6 \cdot \frac{3}{2} \cdot 2 + 12 = 0$$

Bulardan

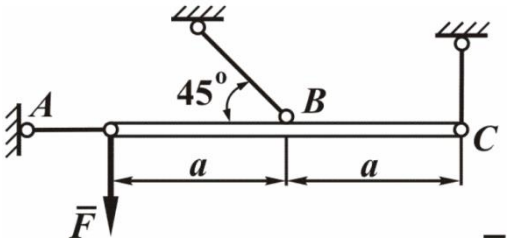
$$X_B - 0{,}5R_A + 3 = 0; \qquad X_B = 1{,}92\ N$$

$$Y_B - 2{,}73 = 0; \qquad Y_B = 2{,}73\ N$$

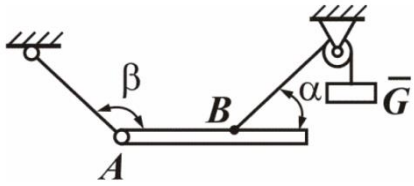
$$-0{,}86R_A + 8{,}46 = 0; \qquad R_A = 9{,}84\ N$$

Mustaqil bajarish uchun vazifalar:

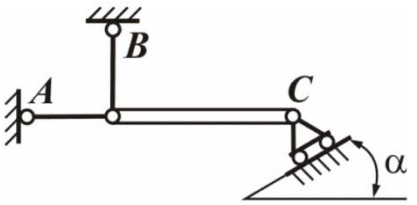
1. Balkaga *F=200 N* kuch ta'sir etsa, tayanchlarning bog'lanish reaksiya kuchlarini toping.[6]
   Javob:



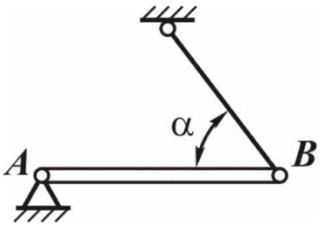
2. Sterjinning *B* nuqtasiga *G* og'irlikdagi tosh arqon yordamida osilgan. Arqon sterjin bilan $a=45^0$ ni tashkil etib, *A* nuqtasi arqon bilan $\beta = 120^0$ ni tashkil etsa, bog'lanishdagi reaksiya kuchlari topilsin.[4]
   Javob:



3. Sterjin bir tomoni *A* va *B* tayanchlar yordamida, ikkinchi uchi esa gorizontga $a=30^0$ burchak ostida joylashgan *C* qo'zg'aluvchi tayanch yordamida mahkamlangan bo'lib, shu tayanchlarning reaksiya kuchlarini aniqlang.[4]
   Javob:



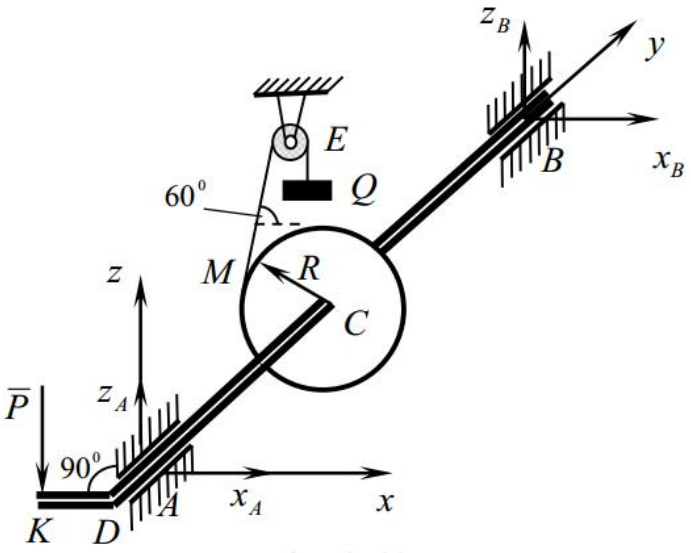
4. *AB* sterjin *A* uchi qo'zg'almas tayanch bilan B uchi esa arqon yordamida mahkamlangan bo'lib, arqon va sterjin orasidagi burchak $a=60^0$ ni tashkil etsa, tayanch reaksiya kuchlarini toping.[6]
   Javob:



4-AMALIY MASHG'ULOT

FAZODAGI KUCHLAR TIZIMI.

4.1-masala. Shakl sxematik tasvirlangan chig'iriq yordamida og'irligi *Q=100kg* bo'lgan yuk tekis ko'tariladi. Baraban radiusi *R=5 sm* dastaning uzunligi *KD=40 sm, AD=30 sm, AC=40 sm, CB=60 sm.* Arqon barabandan urinma bo'ylab gorizontga 60° burchak ostida tushadi. *KD* dastaning gorizontal holatida dastaga tushadigan *P* bosim hamda *A* va *B* tayanchlar reaksiyalari aniqlansin.[2]



Yechish:

Koordinata o'qlarini shaklda ko'rsatilganidek o'tkazamiz va val, barabandan iborat sistemaga ta'sir qilayotgan kuchlarni tasvirlaymiz. Arqon *ME* ning taranglik kuchi miqdor jihatidan *Q* yuk og'irligiga teng bo'lib, *ME* bo'ylab yo'nalgan.

Tayanchlar *A* va *B* lar silindrik sharnirlar. Shuning uchun bu tayanchlardagi reaksiya kuchlarini *X* va *Z* koordinata o'qlari bo'ylab tashkil etuvchilarga ajratamiz va X_A, Z_A lar bo'lgan belgilaymiz. Val barabanlarga ta'sir etayotgan ixtiyoriy joylashgan kuchlar sistemasi o'zaro muvozanatlashadi, fazoda ixtiyoriy kuchlar sistemasining muvozanat tenglamalarini tuzamiz:

$$\sum_{i=0}^{n} F_X = 0; \quad X_A + X_B + Q \cdot \cos 60 = 0;$$

$$\sum_{i=1}^{n} F_Y = 0; \qquad 0 = 0;$$

$$\sum_{i=0}^{n} F_Z = 0; \qquad Z_A + Z_B - P + Q \cdot \sin 60 = 0;$$

$$\sum_{i=1}^{n} m_X(F_X) = 0; \quad P \cdot AD + Q \cdot \sin 60 \cdot AC + Z_B \cdot AB = 0;$$

$$\sum_{i=1}^{n} m_Y(F_Y) = 0; \quad -P \cdot KD + Q \cdot \mathrm{R} = 0;$$

$$\sum_{i=1}^{n} m_Z(F_Z) = 0; \quad -Q \cdot \cos 60 \cdot AC - X_B \cdot AB = 0.$$

Tuzilgan tenglamalar sistemasini ketma-ket yechib quyidagilarni olamiz:

$$P = \frac{Q \cdot R}{KP} = \frac{100 \cdot 5}{40} = 12{,}5\ N;$$

$$X_B = -\frac{Q \cdot \cos 60 \cdot AC}{AB} = -\frac{100 \cdot 0{,}5 \cdot 40}{100} = -20\ N;$$

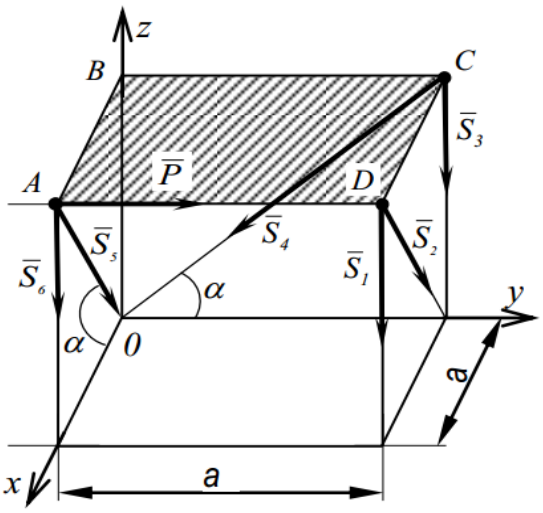
$$X_A = -X_B - Q\cos 60 = 20 - 100 \cdot 0{,}5 = -30\ N;$$

$$Z_B = \frac{P \cdot AD + Q \sin 60 \cdot AC}{AB} = \frac{12{,}5 \cdot 30 + 100 \cdot \frac{\sqrt{3}}{2} \cdot 40}{100} = -38{,}4\ N;$$

$$Z_A = P - Z_B - Q \sin 60 = 12{,}5 + 38{,}5 - 100 \cdot \frac{\sqrt{3}}{2} = -35{,}7\ N.$$

X_A, X_B, Z_A, Z_B lar ishorasi manfiyligidan ularning shaklda ko'rsatilgan yo'nalishiga qarama-qarshi yo'nalishda ekanligini ko'rsatadi.

4.2-masala. *ABCD* kvadrat plitani ko'tarib turuvchi oltita tayanch sterjenlardagi zo'riqishlar aniqlansin. Plitaning *AD* tamoni bo'ylab gorizontal *P* kuch ta'sir qiladi, o'lchovlar shaklda ko'rsatilgan.[3]



Yechish:

Oltita tayanch sterjenlar ta'sirlarini ularning reaksiyalari bilan almashtiramiz. Sterjenlar o'zaro sharnirli bog'langani uchun, ularning reaksiyalarini, sterjenlarni cho'ziladi deb qaralib tugunlardan sterjen bo'ylab qarishi tomonga yo'naltiramiz. Hamma kuchlar fazoda ixtiyoriy

joylashgan. Koordinata boshini ikki noma'lum S_1 va S_5 reaksiyalarni kesishgan nuqtasida tanlab olib, oltita muvozanat tenglamalarini tuzamiz.

$$\sum_{i=0}^{n} F_X = 0;\ \ -S_2 \cos \propto -S_5 \cos \propto = 0;$$

$$\sum_{i=1}^{n} F_Y = 0;\qquad P - S_4 \cos \propto = 0\,;$$

$$\sum_{i=0}^{n} F_Z = 0;\quad -S_1 - S_2 \sin \propto -S_3 - S_4 \sin \propto -S_5 \sin \propto -S_6 = 0;$$

$$\sum_{i=1}^{n} m_X\,(F_X) = 0;\quad S_1 \cdot a - S_2 \cdot \sin \alpha - S_3 \cdot a - P \cdot a = 0;$$

$$\sum_{i=1}^{n} m_Y\,(F_Y) = 0;\quad S_1 \cdot a - S_6 \cdot a = 0;$$

$$\sum_{i=1}^{n} m_Z\,(F_Z) = 0;\quad P \cdot a + S_2 \cos \propto \cdot\, a = 0.$$

Shakldan ko'rinadiki $\propto = 45$ bo'lganda tenglamalar sistemasini ketma-ket yechib quyidagilarni topamiz:

$$S_4 = \frac{P}{\cos \propto} = P\sqrt{2}$$

$$S_2 = -\frac{P}{\cos \propto} = -P\sqrt{2}$$

$$S_5 = -S_2 = P\sqrt{2}$$

$$S_1 + S_6 = 0$$

$$S_5 = -S_2 \sin \propto -S_4 \sin \propto -S_5 \sin \propto = (P\sqrt{2} - P\sqrt{2} - P\sqrt{2})\frac{\sqrt{2}}{2} = -P$$

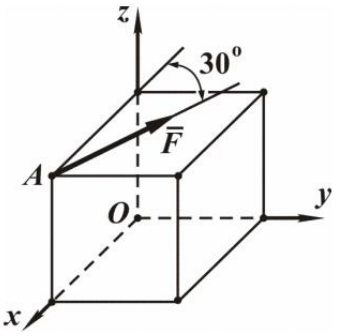
$$S_1 = -P - S_3 - S_2 \sin \propto = -P + P + \sqrt{2} \cdot \frac{\sqrt{2}}{2} = P$$

$$S_6 = -S_1 = -P$$

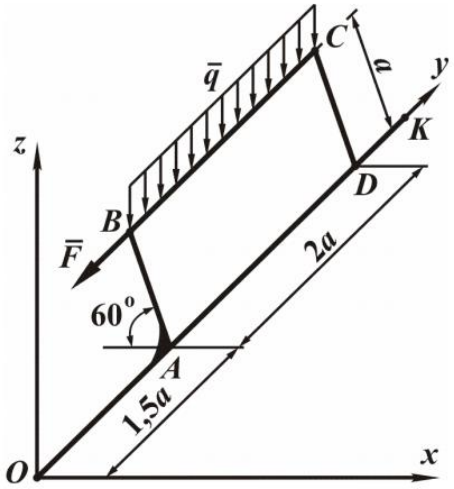
S_1, S_4, S_5 qiymatlarning musbat ishoraliligi ularning cho'zilishini ifodalaydi S_2, S_3, S_6 -sterjenlar siqiladi.

Mustaqil bajarish uchun vazifalar:

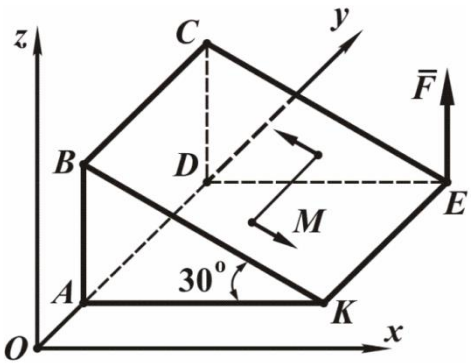
1. Kub chetlari uzunligi *0,4 m*, ta'sir etuvchi kuch *F=200 N*. $M_x(F)$ momentini toping.[4]
   Javob: -40 Nm.



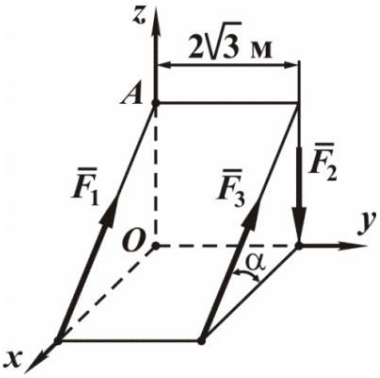
2. $F = 30\sqrt{3}\,N, a = 2m, q = 4\,N/m$ bo'lsa, *OX* o'qiga nisbatan momentlar yig'indisini toping.[4]
   Javob: 10 Nm.



3. *M=4 Nm, F=6N, OD=4 m* bo'lsa, *Ox* o'qiga nisbatan momentlar yig'indisini toping.[2]
   Javob: 26 Nm.



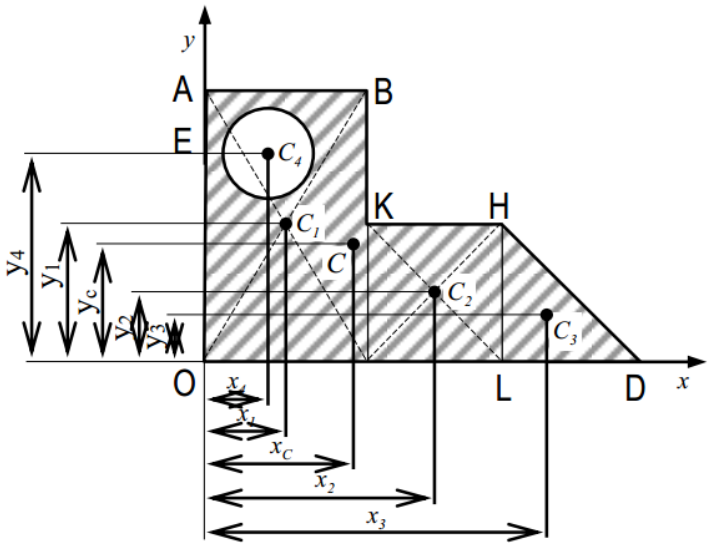
4. $F_1=F_3=60$ *N*, $F_2=30$ *N* bo'lsa, *A* nuqtaga nisbatan kuchning bosh momentini aniqlang.[6]
   Javob: 180.



5-AMALIY MASHG'ULOT

ISHQALANISH KUCHI. OG'IRLIK MARKAZI.

5.1-masala. Shaklda tasvirlangan bir jinsli yupqa plastinka og'irlik markazining koordinatalari aniqlansin.[5]



Yechish:

Plastinkani to'rtta bo'laklarga ajratamiz. Markazga $c_1(x_1, y_1)$ nuqta bo'lgan to'rt burchak markazi $c_2(x_2,y_2)$ nuqta bo'lgan to'rtburchak markazi $c_3(x_3, y_3)$ nuqta bo'lgan uchburchak va markazi $s_4(x_4,y_4)$ nuqta bo'lgan doira (teshik) shakldan c_1, c_2, c_3, c_4 nuqtalarining koordinatalari ma'lum o'lchovlari yordamida aniqlanadi. Bo'lakchalarning yuzalarini S_1, S_2, S_3, S_4 lar bilan belgilaymiz va ular osonlikcha aniqlanadi, formuladan foydalanib, og'irlik markazining koordinatalarini topamiz.

$$X_C = \frac{S_1x_1 + S_2x_2 + S_3x_3 + S_4x_4}{S_1 + S_2 + S_3 + S_4}$$

$$Y_C = \frac{S_1y_1 + S_2y_2 + S_3y + S_4y_4}{S_1 + S_2 + S_3 + S_4}$$

Agar $OA=30$ sm, $OD=36$ sm, $OE=24$sm, $AB=10$ sm, $BK=20$ sm, $x_4=5$ sm, $y_4=24$ sm, $r=3$ sm, $x_1=5$, $x_2=17$, $y_1=15$, $y_2=5$ bo'lsa

$$x_3 = 28$$

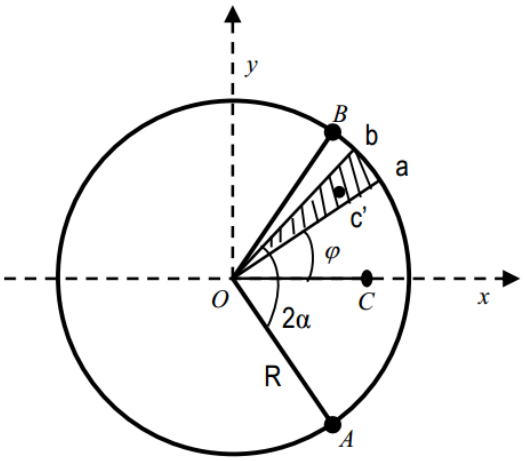
$$y_3 = \frac{10}{3}$$

Agar $S_1=300$, $S_2=140$, $S_3=60$, $S_4=9\pi$ bo'lsa, tenglikdan quyidagilarni topamiz:

$$x_c = \frac{300 \cdot 5 + 140 \cdot 17 + 60 \cdot 28 - 9\pi \cdot 5}{300 + 140 + 60 - 9\pi} \approx 11{,}5\ sm$$

$$y_c = \frac{300 \cdot 15 + 140 \cdot 5 + 60 \cdot \frac{10}{3} - 9\pi \cdot 24}{300 + 140 + 60 - 9\pi} \approx 10\ sm$$

5.2-masala. Doira shaklli sektor yuzaning og'irlik markazi koordinatlarini aniqlang. Ixtiyorimizda R radiusli va markaziy burchagi $2 \propto$ bo'lgan doira sektor yuzi mavjud. sektor yuzasining simmetriya o'qini OX koordinata o'qi sifatida qabul qilib va $OC=x$ masofani quyidagi formula yordamida aniqlaymiz:[4]



$$X_C = \frac{1}{S}\int_S xdS$$

markaziy burchagi $d\varphi$ bo'lgan cheksiz kichik Oab sektor yuzachani ajratamiz. Xuddi teng yonli uchburchak deb qaralgan bu elementar bo'lakchaning og'irlik markazi c' nuqtada bo'lib, bu masofa quyidagiga teng $OC = \frac{2}{3}R$ bu c' markaz nuqtaning koordinatasi quyidagiga teng

$$X = \frac{2}{3} \cdot R \cdot \cos\varphi$$

yuzacha

$$dS = \frac{1}{q} \cdot R^2 d\varphi$$

sektor yuzasi

$$S = \frac{1}{2} \cdot R^2 \cdot 2 \propto = R^2 \propto$$

olingan ifodalar S_1,dS larni formulaga qo'yib va φ bo'yicha integrallab, quyidagini olamiz.

$$X_C = \frac{1}{R^2 \propto}\int_{-\propto}^{\propto} \frac{1}{3}R^3 \cos\varphi d\varphi = \left(\frac{R}{3 \propto} \cdot \sin\varphi\right) \oint_{-\propto}^{\propto} = \frac{2R \sin \propto}{3 \propto}$$

demak,

$$x_c = \frac{2}{3} \cdot R \cdot \frac{\sin \propto}{\propto}$$

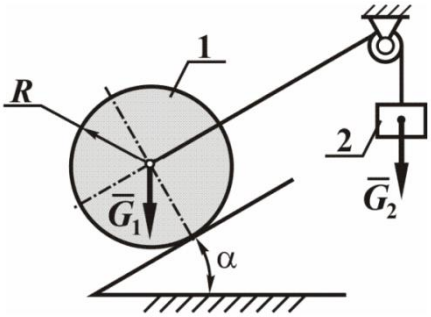
$$\propto = \frac{\pi}{2}$$

bo’lib,

$$X = \frac{4R}{3\pi} = 0{,}2124$$

qiymatga ega,

5.3-masala. G_2 og’irlikka ega bo’lgan tosh arqon yordamida g’ildirakni qiya tekislikda harakatga keltiradi. Radiusi R bo’lgan g’ildirak og’irligi G_1 ga teng bo’lib, qiya tekislik gorizont bilan a burchatashkil etadi va ishqalanish koeffisienti δ ga teng bo’lsa, G_2 yukning og’irligini toping.[3]



$$\sum F_{kx} = -F_{ish} - G_1 \sin \propto + S = 0;$$

$$F_{ish} = S - G_1 sin \propto;$$

$$\sum F_{kx} = N - G_1 \cos \propto = 0;$$

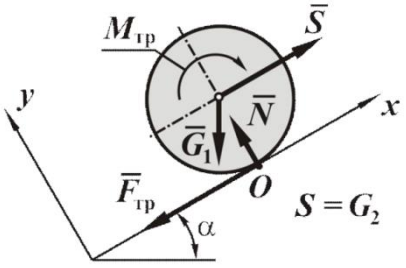
$$N = G_1 \cos \propto;$$

$$\sum M_O = G_1 \sin \propto \cdot R - S \cdot R - M_{ish} = 0;$$

$$M_{ish} = \delta \cdot N = \delta \cdot G_1 \cos \alpha.$$

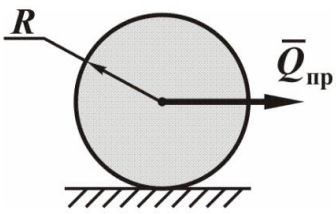
$$S = \frac{G_1 \sin \propto \cdot R - \delta \cdot G_1 \cos \alpha}{R};$$

$$G_2 = G_1(\sin \propto - \frac{\delta}{R} \cdot \cos \alpha)$$

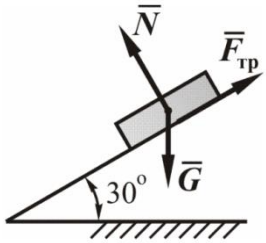


Mustaqil bajarish uchun vazifalar:

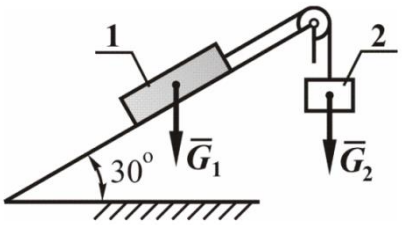
1. *R=2m*, og’irligi *G=4kN* g’ildirak ishqalanish koeffisienti $\delta = 0{,}0005\ m$ bo’lgan sirtagi harakatlantiruvchi Q kuchni toping.[2]
   Javob: 1kN.



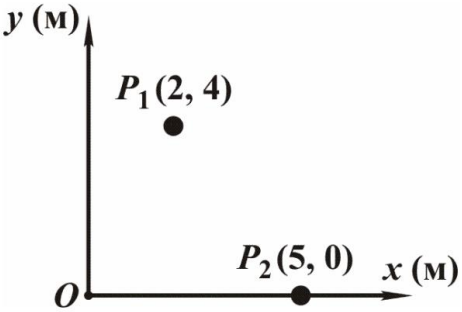
2. Og’irligi *G=1kN* qiya tekislikda muvozanatda turibdi. Ishqalanish koeffisienti *f=0,7* ga teng bo’lsa, ishqalanish kuchini toping.[2]
   Javob: 500 N.



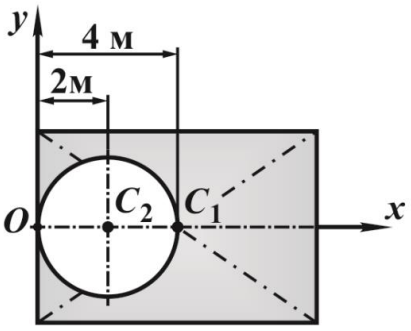
3. Jism og’irligi $G_1=800N$ qiya tekislikda og’irligi $G_2=400N$ bo’lgan tosh bilan arqon yordamida bog’langan. Ishqalanish koeffisienti *f=0,15* ga teng bo’lsa, ishqalanish kuchini toping.[4]
   Javob: 0 N.



4. Og’irligi $P_1=4N$ va $P_2=4N$ bo’lgan ikkita moddiy nuqtaning y_c og’irlik markazini toping.[6]
   Javob: 2m.

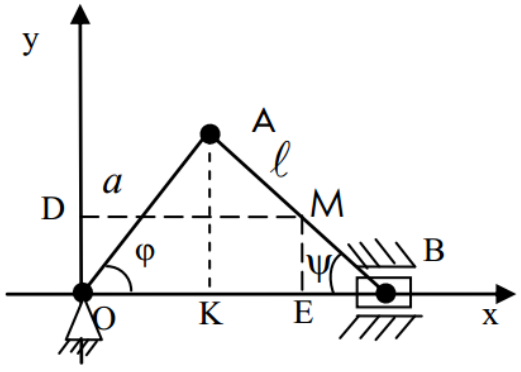


5. Og’irligi $P_1=30N$ bo’lgan bir jinsli plastinadan, og’irligi *P2=10N* bo’lgan aylana kesib olingan. Plastinaning *xc* og’irlik markazini toping.[6]
   Javob: 5m.



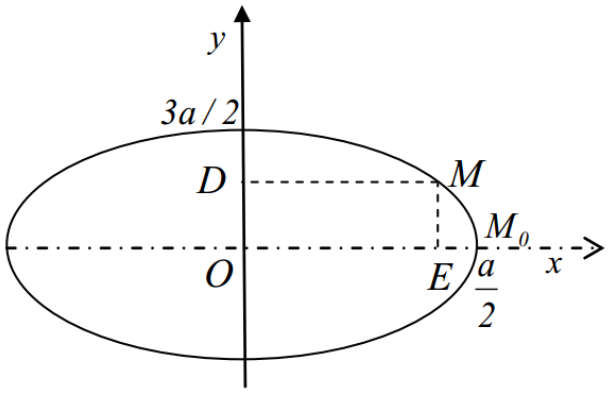
6-AMALIY MASHG’ULOT

NUQTA HARAKATINI BERILISH USULLARI.



6.1-masala. *OA* krivoship doimiy ω burchak tezligi bilan aniqlanadi. Uzunlik *OA=a*, *AB=ℓ*. Shatun o’rtasidagi *M* nuqtaning harakat tenglamasi va trayektoriya tenglamasi aniqlansin. Shuningdek *B* polzunning harakat tenglamasi topilsin. Harakat

boshlanishida B polzun o'ngdagi eng chetki holatda bo'lsin. Koordinata o'qlari shaklda ko'rsatilgan $l = a$ bo'lsin. [4]



Yechish:

M nuqtadan koordinata o'qlariga MD va ME perpendikulyarlar tushiramiz. Shakldan

$$X=OE=OK+KE=OA\cdot\cos\varphi+AM\cdot\cos\psi$$

$$Y = ME = \frac{1}{2}\sin\psi$$

$l = a$ bo'lgani uchun $\varphi=\psi$ bo'ladi, u holda

$$X = a\cos\varphi + \frac{a}{2}\cos\varphi = \frac{3a}{2}\cos\varphi$$

$$Y = \frac{a}{2}\sin\varphi$$

Bizda $\varphi = \omega\cdot t$ u holda

$$\left.\begin{aligned} X &= \frac{3a}{2}\cos\omega\cdot t \\ Y &= \frac{a}{2}\sin\omega\cdot t \end{aligned}\right\}$$

tenglamalar sistemasi M nuqtaning harakat tenglamalari bo'ladi. Bu tenglamalardan vaqt t ni yo'qotsak, trayektoriya tenglamalasini topamiz. *Sinus* va *kosinus* funksiyalarning argumentlari bir xil bo'lsa, vaqt t ni yo'qotish uchun tenglamalarni quyidagi ko'rinishda yozamiz:

$$\left.\begin{aligned} \cos\omega t &= \frac{2}{3}\cdot\frac{x}{a} \\ \sin\omega t &= \frac{2}{a}\cdot y \end{aligned}\right\}$$

tenglamalarning ikkala tomonini kvadratga ko'taramiz

$$\left.\begin{aligned}\cos^2\omega\cdot t &= \frac{4}{9}\cdot\frac{x^2}{a^2}\\ \sin^2\omega\cdot t &= \frac{4}{a^2}\cdot y^2\end{aligned}\right\}$$

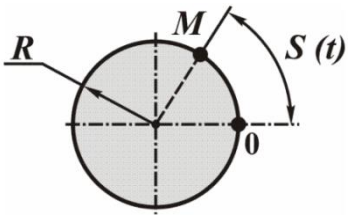
o'zaro qo'shib quyidagini hosil qilamiz:

$$\frac{4x^2}{9a^2}+\frac{4y^2}{a^2}=1 \qquad yoki \qquad \frac{x^2}{\frac{9a^2}{4}}+\frac{y^2}{\frac{a^2}{4}}=1$$

ko'rinishdagi trayektoriya tenglamasini olamiz. *M* nuqtaning trayektoriyasi tenglama yarim o'qlari $\frac{3a}{2}$ *va* $\frac{a}{2}$ ga teng bo'lgan va markazi koordinata boshida bo'lgan ellipsdan iboratdir. Endi *B* polzunning harakat tenglamasini topamiz:

$$X=OB=a\cos\varphi+l\cos\varphi=a\cos\varphi+a\cos\varphi=2a\cos\varphi \quad yoki \quad X_B=2a\cos\varphi$$

Mustaqil bajarish uchun vazifalar:



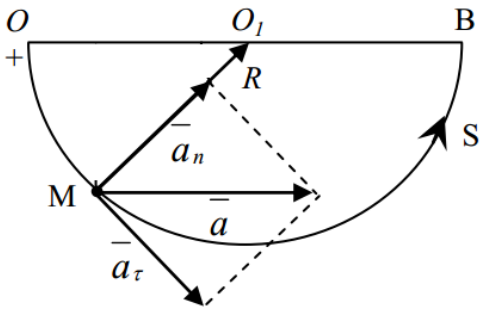
1. Nuqtaning harakat qonuni $S=0{,}25t^2+3t$, $R=4m$ va $t_1=2s$ vaqtdagi normal tezlanishini toping.[2]
   Javob: 4

2. Nuqtaning harakat qonuni $x=2\cos\frac{\pi t}{3}$, $y=2\sin\frac{\pi t}{3}$. Traektoriya tenglamasini tuzing.[2]
   Javob: $x^2+y^2=4$
3. Nuqtaning harakat qonuni: $x=4t^2$, $y=3t^2$. $t_1=1s$ vaqtdagi nuqtaning tezligini toping.[4]
   Javob: 10
4. Nuqtaning harakat qonuni $S=5t^3+8t^2$. $t_1=2s$ vaqtdagi urunma tezlanishini aniqlang.[4]
   Javob: 76

7-AMALIY MASHG'ULOT

NUQTANING TEZLIG VA TEZLANISHINI ANIQLASH.

7.1-masala: Poyezdning boshlang'ich tezligi *15 m/s* bo'lib, birinchi *30 s* da u *600 m* yo'l bosadi. Poyezd, radiusi *R=1 km* bo'lgan aylanma yo'lda tekis o'zgaruvchan harakat qiladi deb hisoblab, uning *30 s* oxiridagi tezligi va tezlanishi aniqlansin.[6]



Yechish:

Tekis o'zgaruvchan harakat tenglamalarini yozamiz:

$$S = S_0 + \vartheta_0 t + \frac{a_\tau t^2}{2}$$

$$\vartheta = \vartheta_0 + a_\tau t$$

Masala shartiga asosan $t=0$ da $S_0=0$

$$S = \vartheta_0 t + \frac{a_\tau t^2}{2}$$

formuladan a_τ – urinma tezlanishni hisoblaymiz:

$$600=450+450a_\tau$$

$$a_\tau=1/3\ m/s^2$$

Tenglamadan:

$$\vartheta = 15 + \frac{30}{3} = 25\ m/s$$

Normal tezlanish esa quyidagicha aniqlanadi:

$$a_n = \frac{\vartheta^2}{\rho};\quad \rho = R$$

$$a_n = \frac{\vartheta^2}{R} = \frac{625}{1000} = 0{,}625\ \ m/s^2$$

tenglamalarni hisobga olgan holda to'la tezlanishni aniqlaymiz:

$$a = \sqrt{a_n^2 + a_\tau^2} = 0{,}708 \;\; m/s^2$$

7.2-masala: *M* nuqtaning harakatlanish qonuni, trayektoriya tenglamasini toping, hamda *t=1* sekundda nuqta holati va berilgan paytga mos keladigan nuqta tezlik va tezlanishi topilsin. [2]

Berilgan:

$$x = 6\sin\left(\frac{\pi}{6}t^2\right) - 2;$$

$$y = 6\cos\left(\frac{\pi}{6}t^2\right) + 3; \qquad t = 1sek.$$

Yechish:

Harakat trayektoriyasi tenglamasini topamiz. Buning uchun berilgan harakat tenglamalaridan vaqt *t* ni yo'qotamiz. Harakat tenglamalaridan quyidagilarni olamiz

$$\sin\left(\frac{\pi}{6}t^2\right) = \frac{x+2}{6}; \quad \cos\left(\frac{\pi}{6}t^2\right) = \frac{y-3}{6}.$$

tenglamaning ikki tomonini kvadratga ko'taramiz

$$\sin^2\left(\frac{\pi}{6}t^2\right) = \frac{(x+2)^2}{6^2}; \qquad \cos^2\left(\frac{\pi}{6}t^2\right) = \frac{(y-3)^2}{6}$$

qo'shib quyidagini hosil qilamiz.

$$\frac{(x+2)^2}{6^2} + \frac{(y-3)^2}{6^2} = 1 \;\; yoki \quad (x+2)^2 + (y-3)^2 = 36$$

tenglamadan ko'rinadiki, trayektoriya tenglamasi radiusi *R=6 SM* bo'lgan va markazi $O_1(-2, 3)$ bo'lgan aylanadan iborat.

Traektoriyani shaklda ko'rsatamiz. Nuqtaning boshlang'ich va $t=t_1=1sek$ bo'lgan paytdagi holatini aniqlaymiz:

t=0s da:

$x_0=-2$ *sm*, $y_0=9$ *sm*

$t_1=1s$ *da:*

$$x_1 = 6\sin\frac{\pi}{6} - 2 = 3 - 2 = 1sm; \quad y_1 = 6\cos\frac{\pi}{3} + 3 = 8.16sm.$$

tezlik vektori koordinata o'qlaridagi proyeksiyalarini hisoblaymiz.

Trayektoriyani shaklda ko'rsatamiz. Nuqtaning boshlang'ich va $t=t_1=1$ *sek* bo'lgan paytdagi holatini aniqlaymiz:

t=0 s da:

x_0*=-2 sm,* y_0*=9 sm*

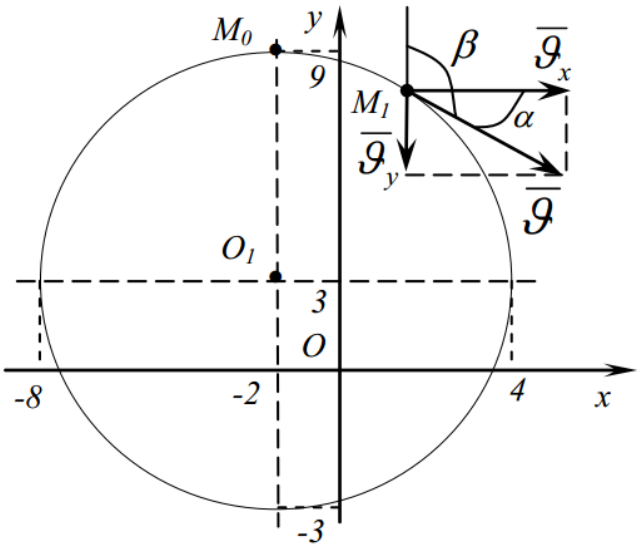
t_1*=1s da:*

$$x_1 = 6\sin\frac{\pi}{6} - 2 = 3 - 2 = 1sm; \; y_1 = 6\cos\frac{\pi}{6} + 2 = 8.16sm;$$

tezlik vektorining koordinata o'qlaridagi proyeksiyalarini hisoblaymiz.

$$\vartheta_x = \frac{dx}{dt} = \frac{d}{dt}\cdot\left(6\sin\frac{\pi}{6}t^2 - 2\right) = 2\pi t\cdot\cos\frac{\pi}{6}t^2$$

$$\vartheta_y = \frac{dy}{dt} = \frac{d}{dt}\cdot\left(6\cos\frac{\pi}{6}t^2 + 3\right) = -2\pi t\cdot\sin\frac{\pi}{6}t^2$$



tezlik vektorining miqdori quyidagicha hisoblanadi:

$$\vartheta = \sqrt{\vartheta_x^2 + \vartheta_y^2} = \sqrt{\left(2\pi t\cdot\cos\frac{\pi}{6}\right)^2 + \left(-2\pi t\cdot\sin\frac{\pi}{6}\cdot t^2\right)^2} = 2\pi t$$

ϑ=2πt; t=1sek

$$\vartheta_x = 2\pi \cdot \cos\frac{\pi}{6} = 2\pi\frac{\sqrt{3}}{2} = \pi\sqrt{3} \approx 5.44 sm/sek$$

$$\vartheta_y = -2\pi \cdot \sin\frac{\pi}{6} = -2\pi\frac{1}{2} = -\pi = -3.14 sm/sek$$

ϑ=6,28 sm/sek

Tezlik vektorining *t=1sek* dagi yo'nalishini aniqlaymiz

$$\cos(\overline{\vartheta}\,\hat{}\,OX) = \cos\alpha = \frac{\vartheta_x}{\vartheta} = \frac{\sqrt{3}}{2} = 0.86;\ \ \alpha = 30^0$$

$$\cos(\overline{\vartheta}\,\hat{}\,OY) = \cos\beta = \frac{\vartheta_y}{\vartheta} = \frac{1}{2} = 0.5;\ \ \beta = 30^0$$

Tezlik vektori va uning proyeksiyalarini shaklda ko'rsatamiz (7.2-shakl). Tezlanish vektorining koordinata o'qlaridagi proyeksiyalarini aniqlaymiz

$$a_x = \frac{d\vartheta_x}{dt} = 2\pi \cdot (\cos\frac{\pi}{6}t^2 - t \cdot \frac{2\pi t}{6} \cdot \sin\frac{\pi}{6} \cdot t^2) = 2\pi(\cos\frac{\pi}{6}t^2 - t \cdot \frac{\pi t}{3} \cdot \sin\frac{\pi}{6} \cdot t^2)$$

$$a_y = \frac{d\vartheta}{dt} = -2\pi \cdot (\sin\frac{\pi}{6}t^2 - t \cdot \frac{\pi t}{3} \cdot \cos\frac{\pi}{6} \cdot t^2)$$

Tezlanish vektorining miqdori

$$a = \sqrt{a_x^2 + a_y^2} = \sqrt{(2\pi)^2 + \left(\frac{2\pi^2 t^2}{3}\right)^2}$$; t=1 sek. da

$$a_x = 2\pi \cdot (\cos\frac{\pi}{6} - \frac{\pi}{3} \cdot \sin\frac{\pi}{6}) = 2\pi(\frac{\sqrt{3}}{2} - \frac{\pi}{3} \cdot \frac{1}{2}) =$$

$$= 2\pi \cdot 0{,}34 = 2{,}14\ \ sm/s^2$$

$$a_x = 2{,}14\ \ sm/s^2;\quad a_y = -2\pi \cdot (-\sin\frac{\pi}{6} + \frac{\pi}{3} \cdot \cos\frac{\pi}{6}) = -2\pi(\frac{1}{2} + \frac{\pi}{3} \cdot \frac{\sqrt{3}}{3}) =$$

$$= -2\pi \cdot 1{,}1 = -6{,}9\ \ sm/s^2;$$

$$a_y = -6{,}9\ \ sm/s^2;$$

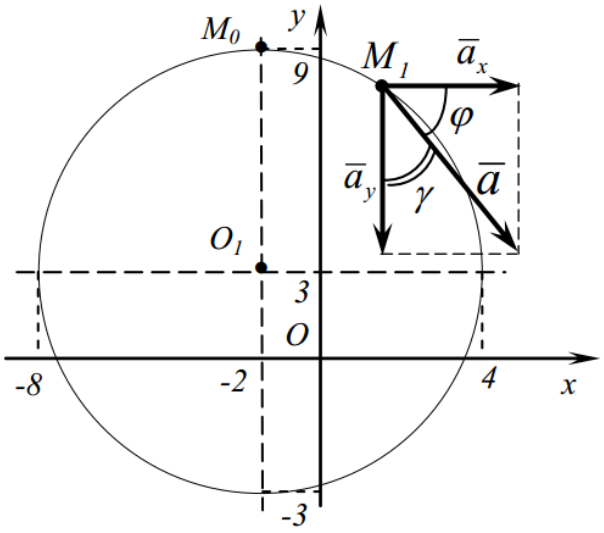
$$a = \sqrt{(2{,}14)^2 + (-6{,}9)^2} = \sqrt{4{,}6 + 47{,}6} = \sqrt{52{,}21};\ a \approx 7{,}22\ \ sm/s^2$$

Tezlanish vektorning $t=t_1=1$ sek paytdagi yo'nalishini aniqlaymiz

$$cos(a\hat{}OX) = \cos\varphi = \frac{a_x}{a} = \frac{2{,}14}{7{,}72} = 0{,}2 \qquad \varphi = 73^o;;$$

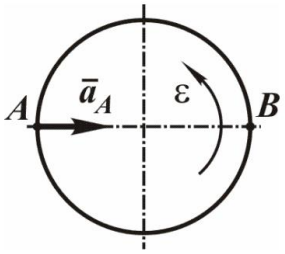
$$cos(a\hat{}OY) = \cos 180^o - \gamma = \frac{a_y}{a} = \frac{-6{,}9}{7{,}22} = -0{,}956; \quad \gamma = 17^o;$$

tezlanish vektori a va uning proyeksiyalari shaklda ko'rsatilgan.

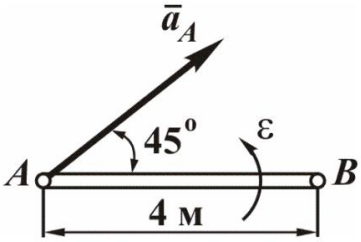


Mustaqil bajarish uchun vazifalar:

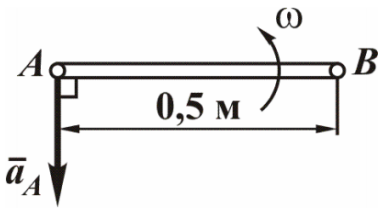
1. Diskning harakati: $a_A=4\ m/c^2$, $AB=1m$, $= 0, \varepsilon = 3\ rad/s^2$. a_B ni toping.[4]
   Javob: 5



2. AB sterjinning tekislikda harakatlanadi va $a_A = 8\sqrt{2}\ m/s^2$, $\omega = \sqrt{2}\ rad/s$, $\varepsilon = 0{,}25\ rad/s^2$. a_B ni toping. [4]
   Javob: 9



3. AB sterjinning tekislikda harakatlanadi va $a_A = 1\ m/s^2$, $t=1s$, $\omega = 2t\ rad/s$. a_B ni toping.[2]
   Javob: 2



8-AMALIY MASHG'ULOT

QATTIQ JISMNING QO'ZG'ALMAS O'Q ATROFIDA AYLANMA HARAKATI

8.1-masala. Bug' turbinasi diskini ishga tushirish davridagi aylanish tenglamasi yozilsin; aylanish burchagi vaqt kubiga proporsional va *t=3 s* bo'lganda, diskning burchak tezligi $\omega=27\pi\ rad/s$ ga to'g'ri keladi.[3]

Yechish:

Masala shartiga asosan $\varphi=kt^3$; $\omega=\dot{\varphi}=3kt^2$ bo'lib, masala shartiga asosan *t=3 s* da $\omega=27\ \pi$ *va* $t=3\ s$ *da* $\omega=3kt^2=27k$ bo'lgani uchun $27k=27\ \pi$ yoki $k=\pi$ bo'ladi.

Demak, bug' turbinasining aylanma harakat tenglamasi ekan.

$$\varphi=\pi t^3\ rad$$

8.2-masala. Tinch holatda bo'lgan jism tekis tezlanish bilan aylana boshlab, birinchi *2* minutda *3600* marta aylanadi. Burchak tezlanish va burchak tezligi aniqlansin.[3]

Yechish: Tekis o'zgaruvchan aylanma harakat tenglamasini yozamiz:

$$\varphi=\varphi_0+\omega_0 t+\frac{\varepsilon t^2}{2}$$

$$\omega=\omega_0+\varepsilon t$$

Bu yerda $\omega_0=0$; $\varphi_0=0$ *va* $t=2\cdot60=120\ s$ bo'lgani uchun

$$\varphi=2\pi N=7200\pi\ rad$$

$$7200\pi=\frac{\varepsilon}{2}\cdot(120)^2 \text{ bo'ladi ;}$$

$$\varepsilon=\pi\ rad/s^2 \text{ va } \omega=\varepsilon t; \quad \omega_1=120\pi\ rad/s.$$

8.3-masala. Radiusi *R=2m* bo'lgan maxovik tinch holatdan boshlab tekis tezlanish bilan aylanadi; tog'inda yotuvchi nuqtalar *t=10s* dan keyin $\vartheta=100\ m/s$

chiziqli tezlikka ega bo'ladi. G'ildirak to'g'inidagi nuqtaning *t=15s* bo'lgan vaqtdagi tezligi, urinma va normal tezlanishi topilsin.[5]

Yechish: Tekis tezlanuvchan harakat tenglamasini yozamiz:

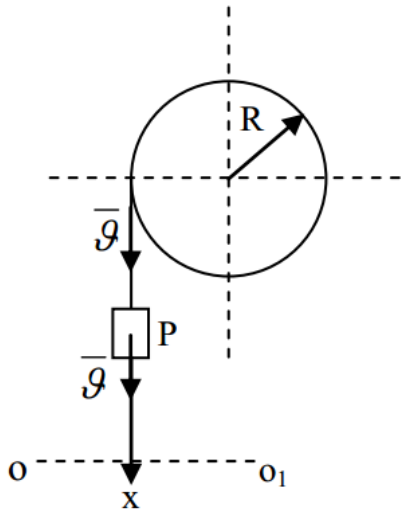
$\omega_0 = 0$ bo'lgani uchun $\omega = \varepsilon t$ bo'lib, $v = \omega R = \varepsilon t R$.

Bu yerdan $\varepsilon = \frac{\vartheta}{Rt} = \frac{100}{2 \cdot 10} = 5\, rad/s^2$

t=15s da

$$\vartheta = 5 \cdot 15 \cdot 2 = 150\, m/s$$
$$\omega = 5 \cdot 15 = 75\, rad/s$$
$$a_\tau = \varepsilon R = 5 \cdot 2 = 10\, m/s^2$$
$$a_n = \omega^2 R = 75^2 \cdot 2 = 11250\, m/s^2$$

8.4-masala. Radiusi *R=10 sm* bo'lgan *A* val unga ipda osilgan *P* tosh bilan aylantiriladi. Toshning harakati $x=100\ t^2$ tenglama bilan ifodalanadi. Bunda *x* toshdan qo'zg'almas OO_1 gorizontalgacha bo'lgan, santimetrlar hisobida ifodalangan masofa, *t*-vaqt (sekund hisobida). *t* paytda valning burchak tezligi ω va burchak tezlanishi ε, shuningdek val sirtidagi nuqtaning to'la tezlanishi *a* aniqlansin.[7]



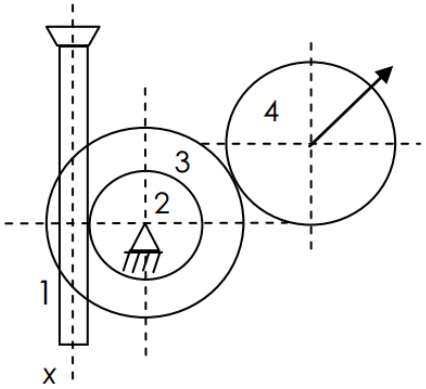
Yechish. *P* tosh ilgarilanma harakatda bo'lgani uchun uning tezligi $\vartheta = \dot{x} = 200t\ sm/s$ formula bilan aniqlanadi. Val to'g'inidagi nuqta ham shu *v* tezlikka ega, chunki tosh bilan val cho'zilmaydigan arqon bilan bog'langan.

$\vartheta = \omega R$ bo'lgani uchun,

$$\omega = \frac{\vartheta}{R} = \frac{200t}{10} = 20t\ rad/s; \quad \varepsilon = \dot{\omega} = 20\ rad/s^2$$
$$a = R\sqrt{\varepsilon^2 + \omega^4} = 10\sqrt{400 + 160000t^4} = 200\sqrt{1 + 400t^4}\ \ sm/s^2$$

8.4-masala. Strelkali indikator mexanizmida harakat o'lchov shtiftining *1* reykasidan *2* shesternyaga uzatiladi; *2* shesternyaning o'qiga *3* tishli g'ildirak o'rnatilgan, 3 g'ildirak esa strelka biriktirilgan *4* shesternya bilan tishlashadi. Agar

shtiftning harakati $x=asinkt$ tenglama bilan berilgan bo'lsa va tishli g'ildiraklarning radiuslari tegishlicha r_2, r_3 va r_4 bo'lsa, strelkaning burchak tezligi aniqlansin.[7]

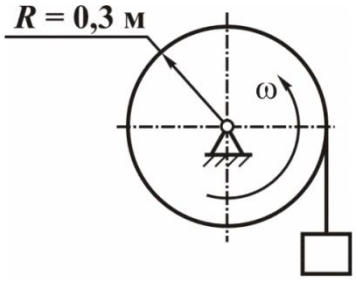


Yechish:

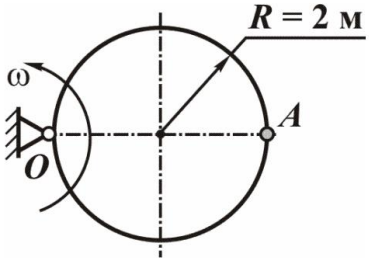
1 shkiv ilgarilanma harakatda bo'lib, uning tezligi $\vartheta = \dot{x} = ak\cos kt$ ga teng. *1* shkiv bilan *2* g'ildirak o'zaro bog'langani uchun $\vartheta = \omega_2 r_2$ bo'ladi va $\omega_2 = \frac{\vartheta}{r_2} = \frac{ak}{r_2}\cos kt$ *2* va *3* g'ildiraklar bitta valda o'rnatilganidan $\omega_3 = \omega_2 = \frac{ak}{r_2}\cos kt$ bo'ladi. *3* va *4* g'ildiraklar esa umumiy nuqtaga ega bo'lib, bu nuqtada $\omega_3 r_3 = \omega_4 r_4$ bo'ladi va $\omega_4 = \frac{r_3}{r_4}\omega_3 = \frac{r_3}{r_2 r_4} ak\cos kt$ strelkaning burchak tezligi ham ω_4 ga tengdir.

Mustaqil bajarish uchun vazifalar:

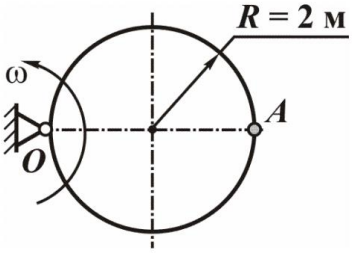
1. Barabanning aylanish harakat qonuni $\varphi = 6t + 2t^3$ *rad.* t_1*=2s* vaqtdagi yukning tezligini toping.[2]
   Javob: 9



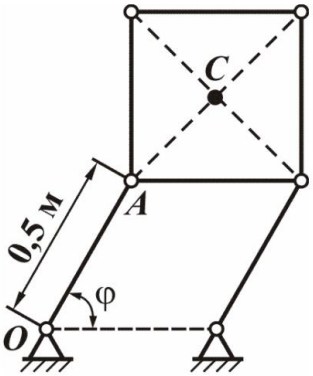
2. Diskning burchak tezligi $\omega = 4t^2 + 2t\ rad/s.$ t_1*=2s* vaqtdagi *A* nuqtaning tezligini toping.[4]
   Javob: 80



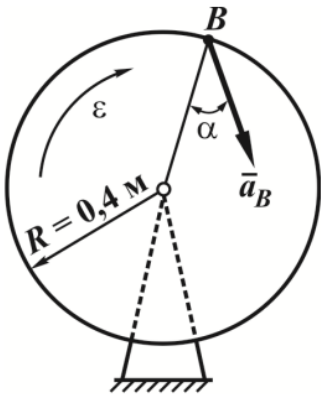
3. Diskning burchak tezligi $\omega = 6t^2 + 8t\ rad/s.$ t_1*=2s* vaqtdagi *A* nuqtaning tezligini toping.[6]
   Javob: 128



4. Plastinaning *C* nuqtasi tezligi $v=(6t^2+5t)$ *m/s*. $t_1=1s$ vaqtdagi *OA* krivoshipning burchak tezligini toping.[6]
   Javob: 22



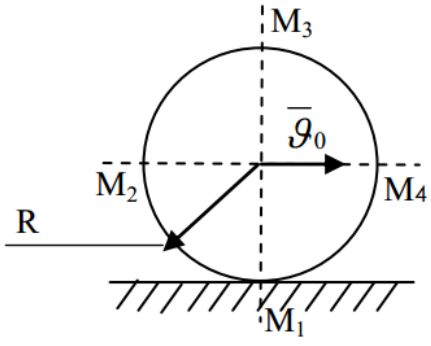
5. Diskning burchak tezlanishi $\varepsilon = 5\,rad/s^2$, $\propto = 30^\circ$ bo'lsa, B nuqtaning to'la tezlanishini aniqlang.[6]
   Javob: 4



9-AMALIY MASHG'ULOT

QATTIQ JISMNING PARALLEL HARAKATI

9.1-masala. *R=0,5 m* radiusli g'ildirak to'g'ri chiziqli yo'l uchastkasida sirg'anmay g'ildiraydi; g'ildirak markazining tezligi o'zgarmas bo'lib, $\vartheta_o = 10\,m/s$ ga teng. G'ildirakning vertikal va gorizontal diametrlarining uchlari bo'lmish M_1, M_2, M_3 va M_4 nuqtalarning tezliklari va g'ildirakning burchak tezligi aniqlansin.[5]



Yechish: *O* nuqtani qutb deb tanlab olamiz

$$\omega = \frac{\vartheta_0}{R} = \frac{10}{0{,}5} = 20\ rad/s$$

O qutb atrofida *M* nuqtaning aylanma harakat chiziqli tezligi

$$\vartheta_{MO} = \omega \cdot R = 10\ m/s$$

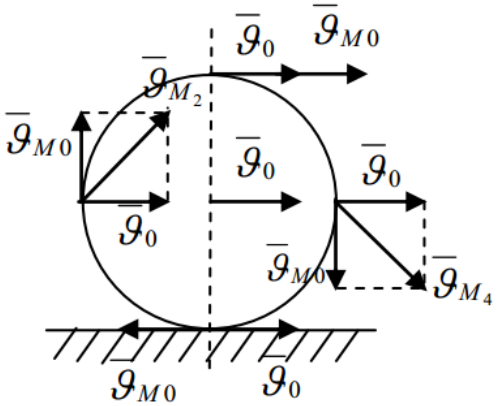
Tekis shakl ixtiyoriy nuqtasi tezligini qutb usulda quyidagi formula bilan aniqlanadi

$$\vartheta_{M_1O} = \vartheta_{M_2O} = \vartheta_{M_3O} = \vartheta_{M_4O} = \vartheta_{MO}$$

$$\overline{\vartheta}_M = \overline{\vartheta}_0 + \overline{\vartheta}_{M0}$$

Shunga asosan, chizmadan foydalanib (8.1-shakl)

$$\vartheta_{M1} = \vartheta_0 - \vartheta_{M0} = 0$$
$$\vartheta_{M2} = \sqrt{\vartheta_0^2 + \vartheta_{M0}^2} = 10\sqrt{2}\ m/s = 14{,}14\ m/s$$
$$\vartheta_{M3} = \vartheta_0 + \vartheta_{M0} = 20\ m/s$$
$$\vartheta_{M4} = \sqrt{\vartheta_0^2 + \vartheta_{M0}^2} = 10\sqrt{2}\ m/s = 14{,}14\ m/s$$



Shu masalani tezliklar oniy markazi yordamida aniqlaymiz. Ma'lumki, g'ildirakning qo'zg'almas sirtga tegib turgan nuqtasi tezliklar oniy markazi (tom) bo'ladi.

Shuning uchun, P (tom) M_1 ga joylashadi va $\vartheta_{M_1} = 0$ bo'ladi.

M_2, M_3, M_4 nuqtalarni P bilan tutashtiramiz

$$M_2P = R\sqrt{2} = 0{,}5\sqrt{2}$$
$$M_3P = 2R = 1\ m$$
$$M_4P = R\sqrt{2} = 0{,}5\sqrt{2}$$

Burchak tezligi esa

$$\omega_p = \frac{\vartheta_0}{R} = \frac{10}{0{,}5} = 20\ rad/s$$

ga teng.

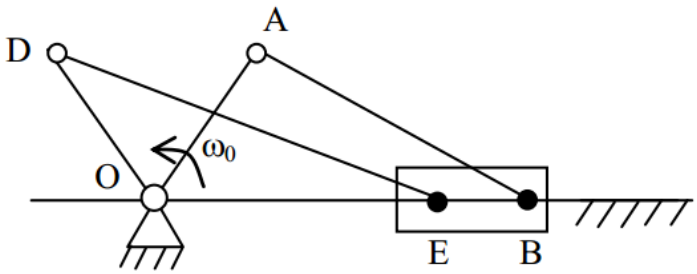
M_2, M_3, M_4 nuqtalarning tezliklari

$$\vartheta_{M2} = \omega_p \cdot M_2P = 20 \cdot 0{,}5\sqrt{2} = 14{,}14\ m/s$$
$$\vartheta_{M3} = \omega_p \cdot M_3P = 20 \cdot 1 = 20\ m/s$$
$$\vartheta_{M4} = \omega_p \cdot M_4P = 20 \cdot 0{,}5\sqrt{2} = 14{,}14\ m/s$$

qiymatlarga ega bo'lib, M_2P, M_3P, M_4P larga perpendikulyar yo'naladi.

9.2-masala. Juftlangan krivoship-polzun mexanizmining *B* va *E* polzunlari *BE* sterjen bilan biriktirilgan. *OA* yetakchi krivoship va *OD* yetaklanuvchi krivoship shakl tekisligiga tik bo'lgan umumiy qo'zg'almas o'q atrofida aylanadi. Oniy burchak tezligi $\omega_0 = 12\ rad/s$ bo'lgan *OA* yetakchi krivoship polzunlar yo'naltiruvchisiga perpendikulyar bo'lgan paytga *OD* yetaklanuvchi krivoship va *DE* shatun oniy burchak tezliklari qancha bo'lishi aniqlansin.[7]

OA=10 sm, OD=12 sm, AB=26 sm, EB=12 sm, $DE = 12\sqrt{3}\ sm$.



Yechish:

A nuqta *O* atrofida aylanma harakatda bo'lgani uchun, uning chiziqli tezligi

$$\vartheta_A = \omega_O \cdot OA = 12 \cdot 10 = 120\ sm/s$$

ga teng.

B va *E* nuqtalar tezliklari o'zaro teng bo'lib, ularning yo'nalishlari gorizontal tekislik bo'ylab yo'naladi. ϑ_B va ϑ_A lar o'zaro parallel bo'lgani uchun, ularning qiymatlari teng. Demak,

$$\vartheta_E = \vartheta_B = \vartheta_A = 120\ sm/s$$

bo’ladi.

Endi *DE* zvenosini ko’ramiz.

D nuqta *O* atrofida aylangani uchun $\bar{\vartheta}_D$ *OD* ga perpendikulyar yo’naladi. $\bar{\vartheta}_D$ ga *D* nuqta orqali perpendikulyar, ϑ_E ga *E* nuqta orqali perpendikulyar o’tkazamiz, bu perpendikulyarlar kesishgan nuqta *DE* zveno uchun tezliklar oniy markazi bo’ladi.

$$\Delta OAB\, dan \quad OB = \sqrt{AB^2 - AO^2} = \sqrt{26^2 - 12^2} = 24\ sm$$

$$OE = OB - EB = 24 - 12 = 12\ sm$$

Kosinuslar teoremasiga asosan

$$\cos\alpha = \frac{OD^2 + OE^2 - DE^2}{2OD \cdot OE} = \frac{12^2 + 12^2 - 12^2 \cdot 3}{2 \cdot 12 \cdot 12} = -\frac{1}{2}$$

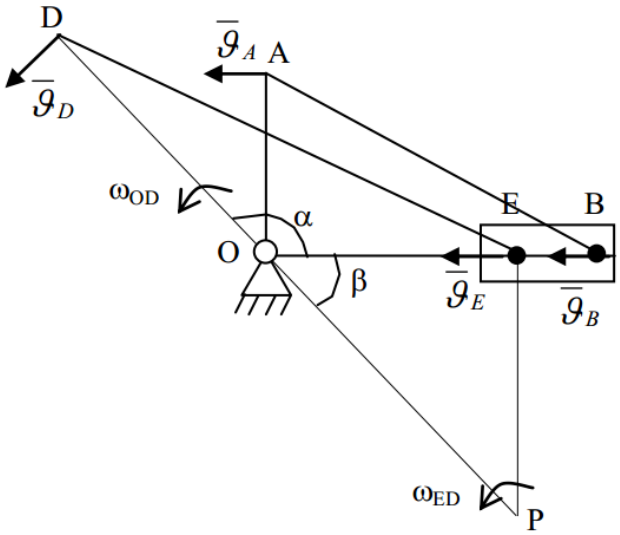
α=120° bo’ladi, β=180–α=60° bo’lgani uchun *OP=24 sm*;

$EP = OP\cos 30^o = 24\frac{\sqrt{3}}{2} = 12\sqrt{3}$

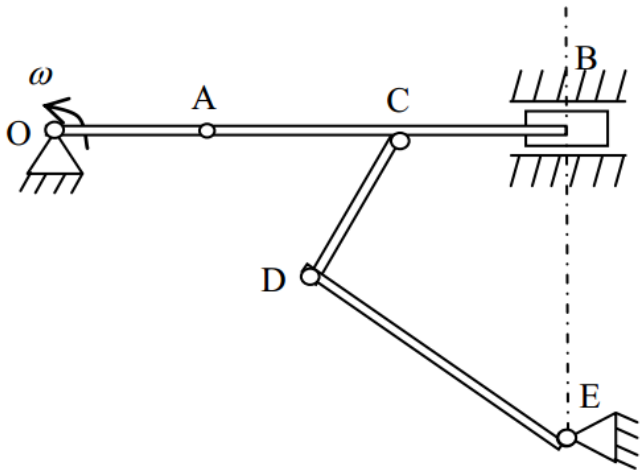
$$\omega_{ED} = \frac{\vartheta_E}{EP} = \frac{120}{12\sqrt{3}} = \frac{10\sqrt{3}}{3} = 5{,}77\ rad/s$$

$$\vartheta_D = \omega_{ED} \cdot DP = \frac{10\sqrt{3}}{3} \cdot 36 = 120\sqrt{3} = 207{,}6\ sm/s$$

$$\omega_{OD} = \frac{\vartheta_E}{OD} = \frac{120\sqrt{3}}{12} = 10\sqrt{3} = 17{,}3\ rad/s$$

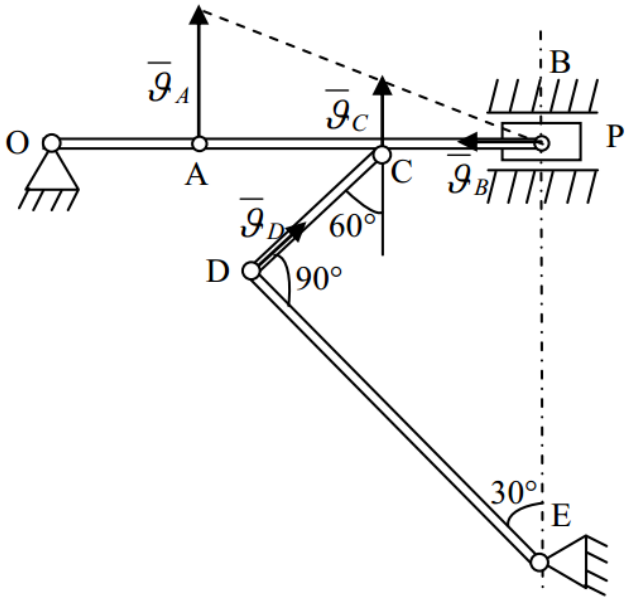


9.3-masala. Krivoship mexanizmi shatunning o'rtasidagi *C* nuqtada *CD* sterjen bilan sharnir yordamida bog'langan; CD sterjen esa *E* nuqta atrofida aylana oladigan *DE* sterjenga *D* sharnir vositasida bog'langan. Agar *B* va *E* nuqtalar bir vertikalda joylashgan bo'lsa, krivoship mexanizmining shaklda ko'rsatilgan holatida *DE* sterjen burchak tezligi aniqlansin; *OA* krivoshipning burchak tezligi ω=8 *rad/s, OA=25 sm, DE=100 sm,* $\angle CDE=90°$ va $\angle BED=30°$.[2]



Yechish:

OB zvenoni ko'ramiz. *A* nuqta *O* atrofida aylanma harakat chiziqli tezligi $\vartheta_A=\omega\cdot OA=8\cdot 25=200$ *sm/s*. *AB* tekis parallel harakat qiladi. *B* nuqta tezligi gorizontal yo'nalishda bo'ladi. *A* nuqtadan ϑ_A ga *B* nuqtadan ϑ_B ga perpendikulyar o'tkazamiz, ular kesishgan nuqta tezliklar oniy markazi bo'ladi.



Bu nuqta *B* bilan ustma-ust tushadi. Demak, $\vartheta_B=0$ va $\vartheta_A/AP=\vartheta_C/CP$ o'rinli bo'ladi.

$$\frac{\vartheta_A}{\vartheta_C} = \frac{AP}{CP}$$

$$AP = 2CP$$

$$\frac{\vartheta_A}{\vartheta_C} = 2$$

$$\vartheta_C = \frac{\vartheta_A}{2} = 100 \ \ sm/s$$

D nuqtaning tezligi *DE* ga perpendikulyar yo'naladi, chunki *D* nuqta *E* dan o'tuvchi o'q atrofida aylanma harakat qiladi.

CD zvenosi uchun proyeksiyalar teoremasidan foydalanamiz

$$pr_{CD}\overline{\vartheta}_C = pr_{CD}\overline{\vartheta}_D$$

Bundan:

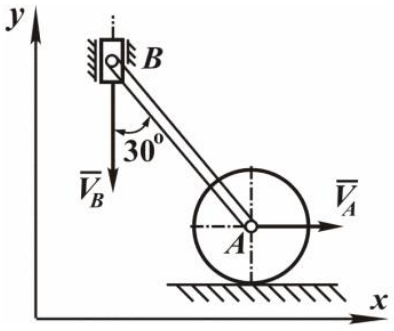
$$\vartheta_D = \vartheta_C \, Cos60^o = 50 \ sm/s$$

$$\vartheta_D = \omega_{DE} DE \ \text{dan}$$

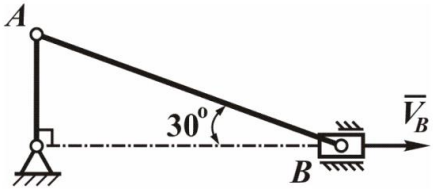
$$\omega_{DE} = \frac{\vartheta_D}{DE} = \frac{50}{100} = 0{,}5 \ rad/s$$

Mustaqil bajarish uchun vazifalar:

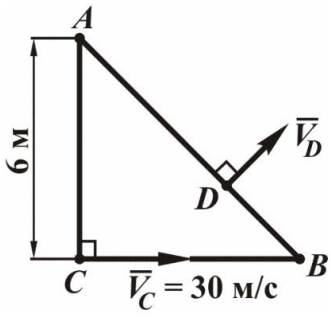
1. *A* nuqtaning tezligi $V_A = 7\sqrt{3}$ *m/s* bo'lsa, *B* nuqtaning tezligini toping.[2]
   Javob:7



2. *B* nuqtaning tezligi $V_B = 7\sqrt{3}$ *m/s* bo'lsa, *A* nuqtaning tezligini toping.[2]
   Javob:6



3. Tasvirlangan uchburchakning burchak tezligini toping.[4]
   Javob: 5

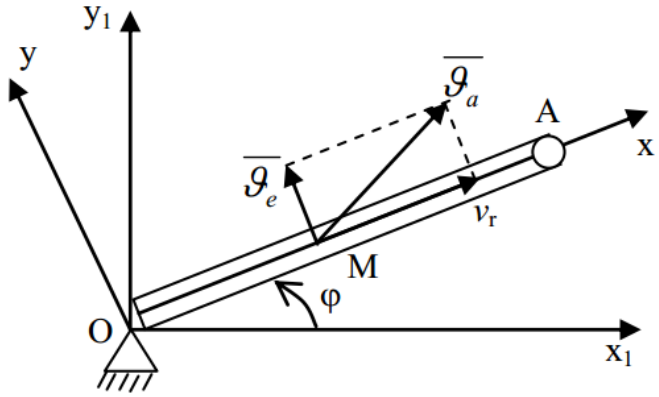


4. *AB=0,3m* sterjin tekislikda $V_A=0,4$ *m/s*, $V_B=0,7$ *m/s* tezlik bilan harakatlansa, burchak tezliklarini toping.[4]
   Javob: 1

10-AMALIY MASHG'ULOT

NUQTA VA QATTIQ JISMNING MURAKKAB HARAKATI

10.1-masala. To'g'ri chiziqli *OA* quvur qo'zg'almas nuqtadagi (shakl tekisligiga tik) o'tgan o'q atrofida $\varphi=\frac{\pi}{4}t^2$ qonuniga muvofiq aylanadi. Bu yerda φ - trubkani qo'zg'almas gorizontal *OX* o'qi bilan tashkil etgan burchagi. Quvur bo'ylab *M* shar $OM=\frac{bt^2}{2}$ sm qonuni bo'yicha harakatlanadi. *M* sharchaning *t=l sek* dagi mutlaq tezligi topilsin:[2]



OXY-qo'zg'aluvchi sistemaning *OX* o'qini quvur bo'ylab *OY* o'qining unga tik yo'naltiramiz. U holda nuqtaning nisbiy harakat tenglamasi

$$x = OM = \frac{bt^2}{2}; \qquad b = const; \qquad y = 0$$

bo'ladi. Nisbiy tezligi $\vartheta_r = \dot{x} = bt$

ϑ_r tezlik *O* dan quvur bo'ylab yo'naladi. Quvurning *O* nuqta atrofidagi *M* shar bilan birgalikda harakati ko'chirma harakat bo'lib, tezligi $\vartheta_e = \omega \cdot OM$ ga teng. Ko'chirma harakat tenglamasi $\varphi = \frac{\pi}{4}t^2$ dan vaqtga nisbatan hosila olib, ko'chirma harakat burchak tezligini topamiz $\omega = \frac{\pi}{2}t$ .1/sek.

$$\vartheta_e = \omega \cdot OM = \frac{\pi}{2}t \cdot \frac{bt^2}{4} = \frac{\pi b}{4}t^3 \text{ m/s.}$$

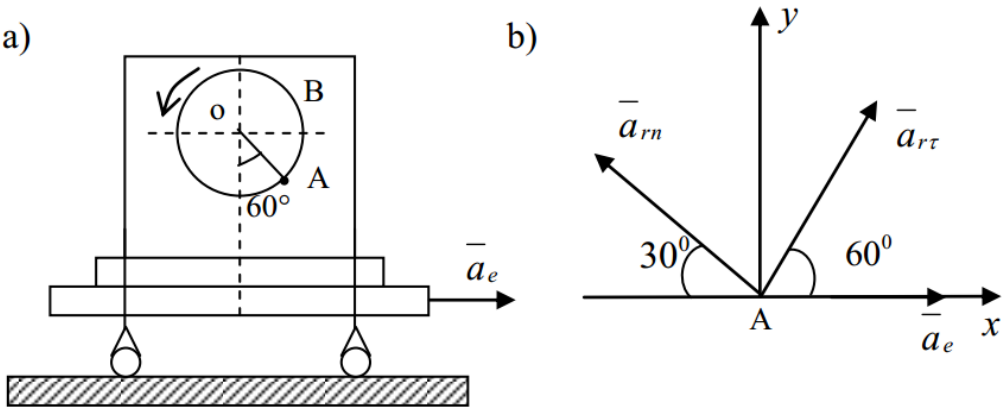
Bu tezlik *M* nuqtada *MO* ga tik $\bar{\vartheta}_e \perp \bar{OM}$ yo'naladi. tenglikdan foydalanib $\bar{\vartheta}_a$ ni topamiz: $\bar{\vartheta}_a = \bar{\omega} \times \bar{OM} + \bar{\vartheta}_r$

Uning moduli

$$\vartheta_a = \sqrt{\vartheta_e^2 + \vartheta_r^2 + 2\vartheta_e\vartheta_r \cos 90^0} = \frac{bt^2}{4}\sqrt{16 + \pi^2 t^4} \ sm/sek.$$

t=1 sek. $\vartheta_a = \frac{b}{4}\sqrt{16+\pi^2}$ *sm/s* = 1,09*b sm/s.*

10.2-masala



O’ng tomoniga gorizontal bo’ylab a_e=49,28 *sm/s* tezligi bilan harakat qiluvchi aravaga elektr motori o’rnatilgan, uning rotori harakatga keltirish vaqtida $\varphi = t^2$ tenglamasiga muvofiq aylanadi, bunda φ burchak radianlar bilan o’lchanadi. Rotorning radiusi *20 sm* ga teng. Rotor to’g’inidagi *A* nuqtaning *t=l sek* bo’lganidagi mutlaq tezlanishi aniqlansin. Shu paytda *A* nuqta shaklda ko’rsatilgan vaziyatda turadi. [4]

Yechish: *A* nuqta murakkab harakatda, ya’ni rotorni *O* o’qi atrofida nisbiy aylanma harakatda va arava bilan birga ilgarilanma ko’chirma harakatda ishtirok qiladi. Ko’chirma harakat ilgarilanma harakat bo’lgani uchun *A* nuqtaning mutlaq tezlanishi nisbiy va ko’chirma tezlanishlarning geometrik yig’indisiga tengdir. Rotor nisbiy aylanma harakatining burchak tezligi va burchak tezlanishini topamiz:

$$\omega = \frac{d\varphi}{dt} = 2t; 1/s$$

$$\varepsilon = \frac{d\omega}{dt} = 2; 1/s$$

t=1 sek bo’lgan paytda

$$\omega = 2t = 2;\ \ 1/\text{sek}$$

Rotor bir tekislikda aylangani uchun *A* nuqtaning nisbiy tezlanishi urinma $a_{r\tau}$ nisbiy normal a_{rn} tezlanishlar yig’indisidan iborat.

$$a_{r\tau} = r \cdot |\varepsilon| = 20 \cdot 2 = 40; sm/sek^2$$

ε -burchak tezlanish musbat bo’lgani uchun $a_{r\tau}$ rotor aylanasining aylanish tomoniga yo’nalgan normal tezlanishi quyidagi formuladan topiladi:

$$a_{rn} = r \cdot \omega^2 = 20 \cdot 2^2 = 80 sm/sek^2$$

A nuqtaning to’la nisbiy tezlanishi quyidagiga teng:

$$\bar{a}_r = \bar{a}_{r\tau} + \bar{a}_{rn}$$

A nuqtaning mutlaq tezlanishi esa

$$\bar{a}_a = \bar{a}_e + \bar{a}_r = \bar{a}_e + \bar{a}_{r\tau} + \bar{a}_{rn}$$

bo'ladi. A nuqtaning $a_{r\tau}, a_{rn}, a_e$ tezlanishlari shaklda ko'rsatilgan. A nuqtadan shaklda ko'rsatilgandagidek qilib A_x va A_y o'qlar o'tkazamiz va bu o'qlarga tezlanish vektorlarini proyeksiyalaymiz.

$$a_{ax} = a_{r\tau x} + a_{rnx} + a_e = a_{r\tau}\cos 60^o - a_{rn}\cos 30^o + a_e =$$
$$= 40 \cdot 0{,}5 - 80 \cdot 0{,}866 + 49{,}28 = 0 \ sm/s^2$$

$$a_{ay} = a_{r\tau y} + a_{rny} = a_{r\tau}\cos 30^o + a_{rn}\cos 60^o =$$
$$= 40 \cdot 0{,}866 + 80 \cdot 0{,}5 = 74{,}64 \ sm/s^2.$$

A nuqtaning mutlaq tezlanishining moduli a_a quyidagichadir

$$a_a = \sqrt{a_{ax}^2 + a_{ay}^2} = \sqrt{(0{,}08)^2 + (74{,}64)^2} = 74{,}64 \ sm/s^2.$$

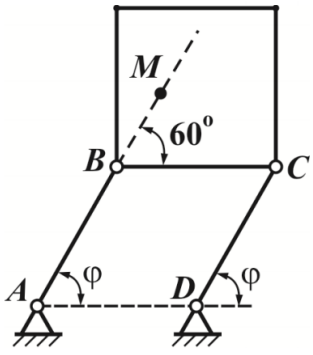
Mutlaq tezlanishning yo'naltiruvchi kosinuslarini topamiz

$$\cos(\overline{a}_a, \overline{i}) = \frac{a_{ax}}{a_a} = \frac{0}{74{,}64} = 0; \quad \cos(\overline{a}_a, \overline{j}) = \frac{74{,}64}{74{,}64} = 1.$$

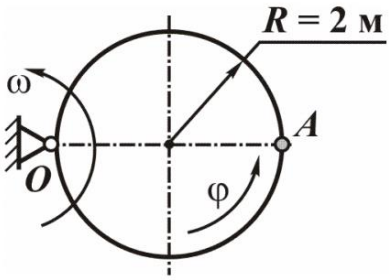
Demak, mutlaq tezlamish $\overline{a}_a$ vertikal bo'ylab yuqoriga yo'naladi.

Mustaqil bajarish uchun vazifalar:

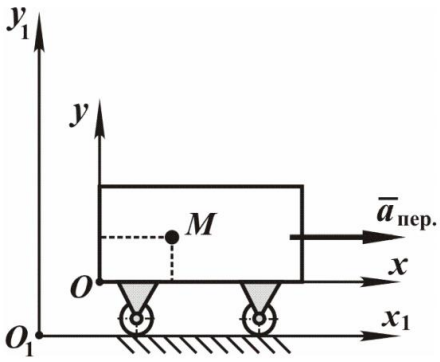
1. $\varphi = \frac{\pi}{3} t \ rad, BM = 3\pi t^2 sm, AB = CD = 24 \ sm$ bo'lsa, $t_1=1s$ vaqtdagi $M=k\pi \ sm/s$ ga teng bo'lsa, k ni toping.[2]
   Javob: 10



2. G'ildirak O nuqta atrofida $\omega = 4 \ rad/s$ bilan aylanadi. A nuqtaning g'ildirak cheti bilan harakat qonuni $\varphi = 1{,}5 \ t \ rad$ bo'lsa, nuqtaning absolyut tezligini toping.[2]
   Javob: 19



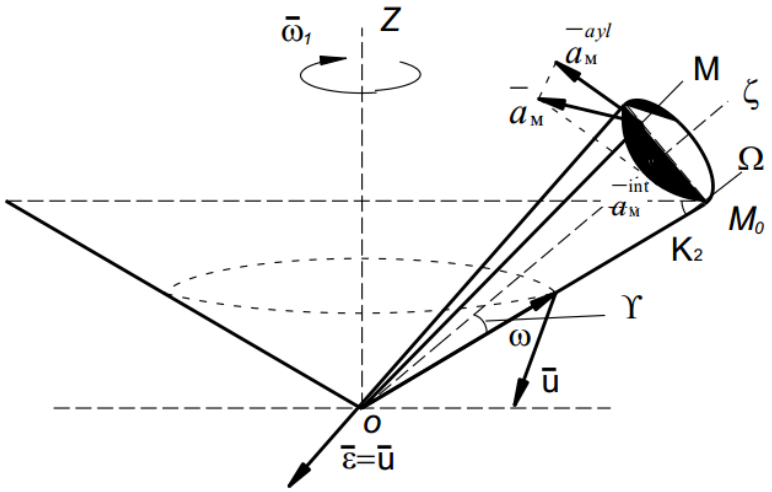
3. Aravachaning tezlanishi $3m/s^2$ ga teng. Uning kuzovida joylashgan M nuqtaning harakat tenglamasi $x = -4{,}5\,t^2, y = 4t^2$ bo'lsa, Nuqtaning absolyut tezlanishini toping.[2]
Javob: 10



11 - AMALIY MASHG'ULOT

QATTIQ JISMNING SFERIK HARAKATI

11.1-masala. *A* konus qo'zg'almas B konusning ichida sirg'anmay g'ildiraydi; bunda *A* konusning $O\zeta$ simmetrik o'qi qo'zg'almas *OZ* o'q atrofida o'zgarmas $\omega_1=2s^{-1}$ burchak tezlik bilan aylanib, *O* nuqta qo'zg'almay qoladi.



Konuslarning o'q kesimlari shakl tekisligida joylashgan hamda $OM_0 = l = 50sm$, $M_0M = 20\ sm$ deb olib, A konusning burchak tezligi, burchak tezlanishi, M nuqtasining tezlik va tezlanishi topilsin. Kerakli burchaklar shaklda ko'rsatilgan.[3]

Yechish: Bu masala qo'yilishi bo'yicha yuqorida ko'rsatilgan hollarning ikkinchisiga mos keladi; shuningdek burchak tezlikning miqdori o'zgarmay qoladi. Shuni e'tiborga olib, ko'rsatilgan ketma- ketlik asosida masalani hal qilamiz.

1. *OXYZ* qo'zgalmas koordinata sistemasini qo'zg'almas konusga bog'lab, qo'zg'aluvchi sistemaning *OZ* o'qini esa *A* konus simmetriya o'qi bo'ylab yo'naltiramiz.

2. *A* konusning oniy burchak tezligini aniqlaymiz. *A* konus qo'zg'almas *B* konus ichki sirtida sirg'anmasdan dumalagani uchun aylanish oniy o'qi $O\Omega$ bu konuslar yasovchilarining urinish chizigi OM_0 bo'ylab yo'naladi.

A konusning *S* nuqtasini bir tomondan *OZ* o'q atrofida $\bar{\omega}_1$ burchak tezlik bilan, ikkinchi tomondan $O\Omega$ oniy o'q atrofida $\bar{\omega}$ burchak tezlik bilan aylanishini e'tiborga olib, bu nuqta tezligini quyidagicha ifodalay olamiz:

$$\vartheta_e = \omega_1 \cdot K_1C\ ,\ \vartheta_c = \omega \cdot h_\Omega = \omega \cdot KC$$

Bu tengliklarda K_1C va KC mos ravishda *C* nuqtadan *OZ* va $O\Omega$ o'qlargacha bo'lgan masofadan iborat:

$$K_1C = OS\ sin45^0 = l \cdot cos15^0 \cdot sin45^0 = 34{,}15\ sm,$$

$$KC = l \cdot sin15^0 = 12{,}94\ sm,$$

u holda,

$$\vartheta_e = 68{,}3\ sm/s,\ \omega = \vartheta_s/KC = 5{,}28\ s^{-1}$$

C nuqta tezligi yo'nalishiga ko'ra $\bar{\omega}$ vektori $O\bar{M}_0$ bo'yicha yo'nalgan. ω_1=const bo'lganidan $\vartheta_c = const$, binobarin $\omega = const$.

3. *A* konus *M* nuqtasining tezligini topamiz. Konusning harakatini $O\Omega$ aylanish oniy o'qi atrofida oniy aylanma harakat deb qarasak, formulaga binoan:

$$\vartheta_M = \omega \cdot MK_2 = \omega \cdot M_0M \cdot \sin 75^o = 101{,}97\ sm/s.$$

$\bar{\vartheta}_M$ vektor MK_2 ga tik ravishda shakl tekisligidan o'tuvchi tomon yo'nalgan.

4. *A* konus burchak tezlanishini aniqlaymiz. Oniy burchak tezlanishini formula asosida topamiz, ya'ni miqdor jihatdan o'zgarmas bo'lgan $\bar{\omega}$ vektor uchining tezligini aniqlaymiz. $\bar{\omega}$ vektorning uchi «radiusi» $\omega sin60^0$ ga teng, simmetriya o'qi *OZ* bo'lgan aylana bo'ylab ω_1 burchak tezlikda harakatlanadi.

Shunga ko'ra

$$\varepsilon = u = \omega_1 \cdot \omega \cdot sin60^0 = 9{,}15\ s^{-2}$$

$\bar{\varepsilon}$ vektori $\bar{u}$ vektorga parallel ravishda shakl tekisligiga tik yo'nalgan va *O* nuqtaga qo'yilgan.

5. *A* konus *M* nuqtasining tezlanishini topamiz. Bunda Rivals teoremasini ifodalovchi formuladan foydalanamiz:

$$\bar{a}_M = \bar{a}_M^{ayl} + \bar{a}_M^{\text{int}}$$

$$a_M^{ayl} = \varepsilon \cdot OM \cdot \sin\left(\bar{\varepsilon}, \widehat{\overline{OM}}\right) = \varepsilon \cdot OM$$

(chunki $\bar{\varepsilon}, \widehat{\overline{OM}} = 90^o$).

Shakldan:

$$OM = \sqrt{(OM_0)^2 + (M_0M)^2 - 2OM_0 \cdot M_0M \cdot \cos 75^o} = 48{,}81 \ sm.$$

Binobarin, $a_M^{ayl} = \varepsilon \cdot OM = 446{,}6 \ sm/s^2$ $\bar{a}_M^{ayl}$ vektor shakl tekisligida joylashgan va *MO* ga tik yo'nalgan.

$$a_M^{\text{int}} = \omega^2 \cdot MK_2 = 538{,}4 \ sm/s^2$$

$\bar{a}_M^{\text{int}}$ vektor ham shakl tekisligida joylashib, MK_2 bo'ylab aylanish oniy o'qi tomon yo'nalgan.

Tezlanish modulini aniqlashdan avval $\bar{a}_M^{ayl}$ va $\bar{a}_M^{\text{int}}$ vektor tashkil qilgan burchakni topamiz. $\bar{a}_M^{ayl} \perp OM$, $\bar{a}_M^{\text{int}} \perp OM_0$ bo'lgandan $\left(\widehat{\bar{a}_M^{ayl}, \bar{a}_M^{\text{int}}}\right) = M\hat{O}M_0 = \gamma$

ΔMOK_2 dan:

$$\cos\gamma = \frac{OK_2}{OM} = \frac{OM_2 - K_2M_0}{OM} = \frac{50 - M_0M \cdot \sin 15^o}{48{,}81} = 0{,}92.$$

Tezlanishlar parallelogramiga kosinuslar teoremasini qo'llaymiz:

$$a_M = \sqrt{\left(a_M^{ayl}\right)^2 + \left(a_M^{\text{int}}\right)^2 - 2\,a_M^{ayl} \cdot a_M^{\text{int}} \cdot \cos\gamma} =$$
$$= \sqrt{46899{,}16} = 216{,}57 \ sm/s^2$$

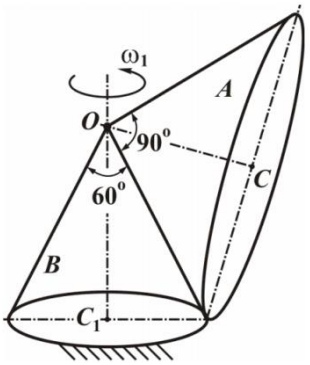
$\bar{a}_M$ vektor yo'nalishini aniqlash uchun bu vektorning MK_2 bilan tashkil qilgan α burchakni topamiz. Sinuslar teoremasiga binoan:

$$\frac{a_M}{\sin\gamma} = \frac{a_M^{ayl}}{\sin\alpha}; \quad \sin\alpha = \frac{a_M^{ayl} \cdot \sin\gamma}{a_M} = 0{,}808; \quad \alpha \approx 54^o.$$

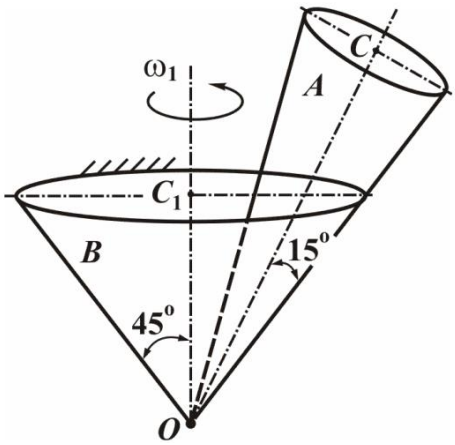
Shunday qilib, berilgan paytda *M* nuqta tezlanishi miqdori *216,57 sm/s*^{2} ga teng, shakl tekisligida yotadi va MM_0 kesma bilan $54^0 + 15^0 = 69^0$ burchak tashkil etadi.

Mustaqil bajarish uchun vazifalar:

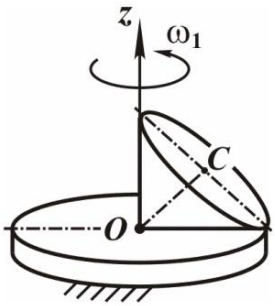
1. *A* konus *OC* o'q bo'yicha *B* konusning sirtida OC_1 o'qi atrofida $\omega = 10\,rad/s$ bilan aylanadi. *OC* o'q atrofida aylanishdagi konusning burchak tezligini toping.[4]
   Javob: 10



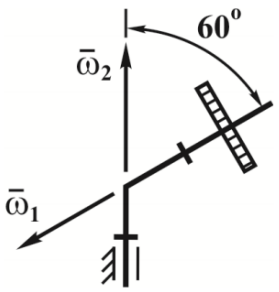
2. *A* konus *OC* o'q bo'yicha *B* konusning ichida OC_1 o'qi atrofida $\omega = 5{,}2\,rad/s$ bilan aylanadi. A konusning absolyut burchak tezligini toping.[4]
   Javob: 10



3. *OC* o'qiga ega konus tekislikda *Oz* o'qi atrofida $\omega = 9\,rad/s$ aylanadi. Konusning absolyut burchak tezligini toping.[4]
   Javob: 9



4. Podshipnik yordamida aylanadigan valga nisbatan 60^0 bo'yicha disk aylanma harakat qilsa, ularning burchak tezliklari $\omega_1 = \omega_2 = 3\,rad/s$ bo'lsa, diskning absolyut burchak tezligini toping.[4]
   Javob: 3



12-AMALIY MASHG'ULOT

MODDIY NUQTANING HARAKAT DIFFERENTSIAL TENGLAMALARI

Nazariy ma'lumotlar

1. Erkin moddiy nuqtaning harakat differensial tenglamalari, Nyutonning ikkinchi qonuniga asoslangan:[7]

$$m\bar{W} = \sum \bar{F}_k \quad \text{yoki} \quad m\frac{\bar{dv}}{dt} = \sum \bar{F}_k \quad \text{yoki} \quad m\frac{d^2r}{dt^2} = \sum \bar{F}_k$$

2. Erkin moddiy nuqtaning Dekart koordinatalar sistemasidagi harakat differensial tenglamalari:[7]

$$mx = \sum F_k$$

$$my = \sum F_k$$

$$mz = \sum F_k$$

3. Erkin moddiy nuqtaning tabiiy koordinatalar sistemasidagi harakat differensial tenglamalari:[7]

$$mW_\tau = \sum F_{k\tau}$$

$$mW_n = \sum F_{kn}$$

$$mW_b = \sum F_{kb}$$

4. Bog'lanishdagi nuqtaning harakat differensial tenglamalari:[7]

$$m\bar{W} = \sum \bar{F} + \bar{N}$$

5. Bog'lanishdagi jismning Dekart koordinatalar sistemasidagi harakat differensial tenglamalari:[7]

$$mx = \sum F_{kx} + N_x$$

$$my = \sum F_{ky} + N_y$$

$$mz = \sum F_{kz} + N_z$$

6. Bog'lanishdagi nuqtaning tabiiy koordinatalari sistemasidagi harakat differensial tenglamalari:[5]

$$m\frac{dv}{dt} = F_\tau$$

$$m\frac{v^2}{\rho} = F_n + N_n$$

$$0 = F_b + N_b$$

7. Agarda berilgan egri chiziq bir tekislikda yotsa, bu tekislik uchun egrilik tekisligi olinadi, u holda

$$m\frac{dv}{dt} = F_\tau \qquad m\frac{d^2S}{dt^2} = F_\tau$$

$$m\frac{v^2}{\rho} = F_n + N \qquad m\frac{v^2}{\rho} = F_b + N$$

Bu tenglamalarni har birining chap tomoniga nuqta massasini kinematikadan ma'lum bo'lgan uning tezlanishining mos o'qlardagi proeksiyasiga ko'paytmasi ko'rinishida had qatnashadi.

12.1-Masala. Massasi *100t* bo'lgan, V_0*=18 km/c* tezlik bilan gorizontal yo'lda harakatlanayotgan samosvalni boshlang'ich tormozlanish davri $0 \le t \le t_1$ da tormozlanish kuchi tormozlanish kuchi $F = F_0\frac{t}{t_1}$ qonuniyat bilan o'zgaradi, bu yerda F_0 - tormozlanish kuchining maksimal (eng katta) qiymati; *F=400 kN;* t_1*=0,3c* - tormozlanish davri; Samosvalni shu davrda *(*t_1*=0,3 c)* da bosib o'tgan yo'li S_1 va samosvalni shu yul oxiridagi tezligi aniqlansin.[6]

Yechimi: Samosvalga, uni tormozlanish davrida, vertikal og'irlik kuchi *mg* gorizontal yo'lga normal reaksiya kuchi F_n va tezlikka qarama-qarshi yo'nalgan tormozlanish kuchi F ta'sir qiladi. Tormozlanish davri boshlanish vaqtini boshlanishi bilan bir deb olib, koordinat boshini samosval massalar markaziga joylashtirib x o'qini gorizont bo'yicha joylashtiramiz. Shu holda tormozlanish davrini boshlanish sharti t_0*=0;* x_0*=0;* V_0*=18 км/с=5 м/s* bo'ladi

Samosvalni shu davr oxiridagi (*t=0,3 s*) dagi tezligi tenglamani quyidagi ko`rinishda yozib, uni integrallab harakatini topib olamiz.

$$\frac{dx}{dt} = V_0 - \frac{F_0}{2mt_1}(t^2)$$

$$x_0 = 0; \quad t_0 = 0$$

$$x = V_0 t - \frac{F_0}{6mt_1} t^3$$

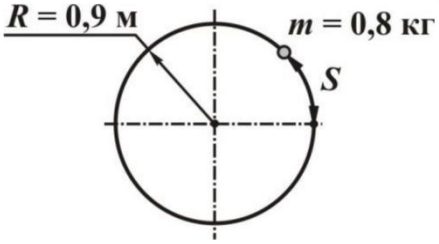
o' tilgan yo'l esa

$$S_1 = x_1 = V_0 t_1 - \frac{F_0}{6mt_1} \cdot t_1^3 = V_0 t - \frac{F_0 t_1^2}{6m} = 5 \cdot 0{,}3 - \frac{400 \cdot 0{,}3^2}{6 \cdot 100} = 1{,}44\ m$$

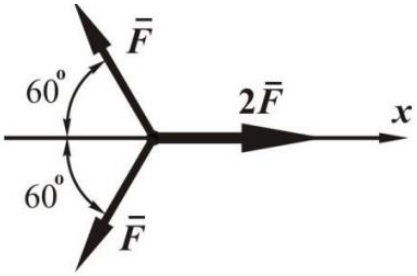
Javob: $b = \frac{F_0}{(mt_1)}$; $k = \frac{\mu}{m}$

Mustaqil bajarish uchun vazifalar:

1. Kuch ta'sirida moddiy nuqtaning harakat tenglamasi *S=9t* bo'lsa, kuch modulini toping.[4]
   Javob: 72

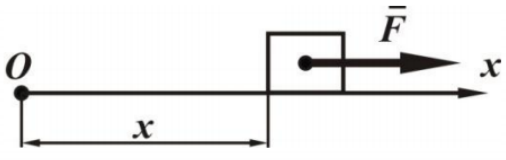


2. $F = 6\tau + 8n$ kuch ta'sirida moddiy nuqta $a=5m/c^2$ tezlanish olsa, moddiy nuqtaning massasini toping.[4]
   Javob: 2



3. *F=6N* dan bo'lgan kuchlar sistemasi massasi *m=3kg* bo'lgan moddiy nuqtaga ta'siri natijasidagi tezlanishini toping.[4]
   Javob: 2

4. *m=2kg* li jism kuch ta'sirida harakat tenglamasi $x = \frac{32\sqrt{2}}{\pi} \cdot \sin\frac{\pi t}{4}$ ga teng bo'lsa, $t_1=1s$ vaqtdagi kuchni toping.[4]
   Javob: 4



13- AMALIY MASHG'ULOT

MODDIY TIZIMNING KINETIK MOMENTINING O'ZGARISHI HAQIDAGI TEOREMANINQO'LLAB DINAMIKANING IKKINCHI MASALASINI YECHISH.

Material nuqta harakat miqdorining biror *O* markazga nisbatan momenti $M_0(mv)$- vektor kattalik bo'lib, u $M_0(mv) = r \cdot mv$ tenglik bilan aniqlanadi.

Bu yerda ***r*** - material nuqtaning harakatini aniqlab va *O* markazdan o'tuvchi radius vektor. Sistema harakat miqdorining berilgan *O* markazga nisbatan bosh kinetic momenti shu sistemani tashkil etuvchi hamma nuqtalar harakat miqdorlarining shu markazga nisbatan momentlarini geometrik yig'indisiga teng, ya'ni [7]

$$K_0 = \sum_{i=1}^{n} M_0\,(mv) = \sum_{i=1}^{n} r \cdot mv$$

Bu momentlarning har biri sistemani tashkil etuvchi nuqtalarni mos o'qlardagi harakat miqdorlari momentlarining algebraik yig'indisiga teng.

$$K_X = \sum_{i=1}^{n} M_X\,(mv)$$

$$K_y = \sum_{i=1}^{n} M_y\,(mv)$$

$$K_z = \sum_{i=1}^{n} M_z\,(mv)$$

Jismning qo'zg'amas *O* markaz atrofidagi sferik harakatida K_0 kinetik momentini proeksiyasi [7]

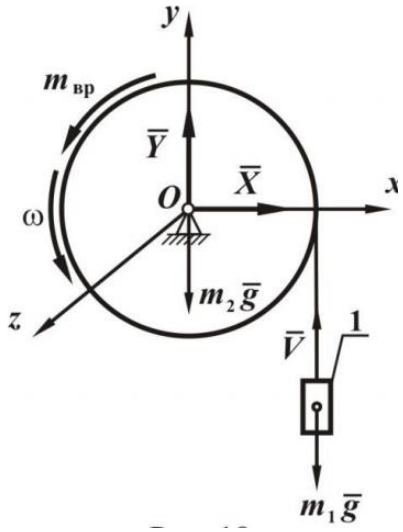
$$K_X = I_X\omega_X - I_{XY}\omega_Y - I_{ZX}\omega_Z$$

$$K_Y = -I_{XY}\omega_X - I_Y\omega_Y - I_{YZ}\omega_Z$$

$$K_Z = -I_{ZX}\omega_X - I_{ZY}\omega_Y + I_X\omega_Z$$

13.1-masala. Agar barabanni massasi *m=0,7t*; uni diametri *D=0,5 m*, aylanish o'qiga nisbatan inersiya radiusi *i=0,23 m*; aylantiruvchi momenti *M=0,75 kN m*; lentaning taranglik kuchi S_1*=5 kN* va S_2*=2,7 kN* bo'lsa baraban aylana

boshlangandan keyin *3s* o'tgandan keyin lentali konveyerni yuritish barabani qanaqa burchak tezlik bilan aylanadi. [4]



Yechish.

Yuritish barabani *OY* qo'zg'almas o'q atrofida aylanayotgan jism bo'lganligi sababli uning harakat differensial tenglamasi formula bilan aniqlanadi va shu holdagi aylanma harakat uchun

$$I_X \cdot \varepsilon = \sum M_Y\,(F_K)$$

ko'rinishni oladi.

Barabanga quyidagi tashqi kuchlar va momentlar ta'sir etadi: mg og'irlik kuchi, *M* aylantiruvchi moment, *Ms* qarshilik kuchining momenti lentaning kirishdagi S_1 va chiqishdagi S_2 taranglik kuchlari va rasmda x_0 va y_0 tashkil etuvchilari orqali ko'rsatilgan podshipnikni R_0 reaksiya kuchi.

R_0 *Oy* aylanish o'qiga nisbatan barabanni inersiya momenti

$$I_Y = mi^2$$

formula bilan aniqlanadi.

Tashqi kuchlarni shu o'qqa nisbatan momentlari esa

$$\sum M_Y\,(F_K) = M - M_e - S_1 \cdot \frac{D}{2} + S_2 \cdot \frac{D}{2} = M - M_e - 0{,}5(S_1 - S_2)D$$

barabanni burchak tezlanishini topamiz:

$$\varepsilon = \frac{\sum M_Y(F_K)}{mi^2} = \frac{M - M_C - 0{,}5(S_1 - S_2)D}{mi^2} = const$$

Bu esa barabanni burchak tezlanishi o'zgarmas ekanligini va teng tezlanuvchan qonuniyat bilan aylanishini ko'rsatadi. Bundan uning burchak tezligi

$$\omega = \omega_0 + \varepsilon t$$

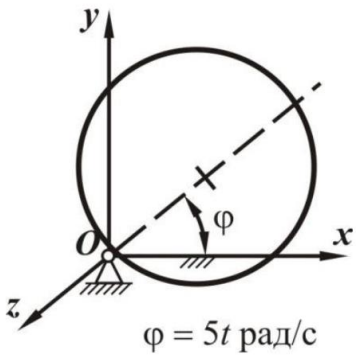
Ifoda bilan harakatlanishi kelib chiqadi. Ammo barabanni harakati noldan boshlanganligi sababli boshlang'ich burchak tezlik $\omega_0 = 0$ bo'ladi va

$$\omega = \varepsilon t = \frac{M - M_C - 0{,}5(S_1 - S_2)D}{mi^2} t =$$

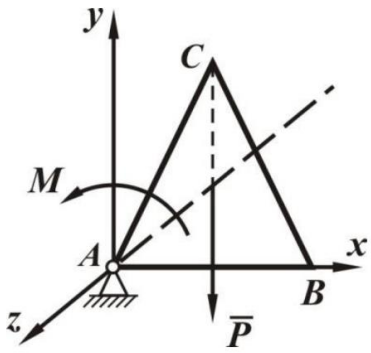
$$= \frac{0{,}75 - 0{,}025 - 0{,}5 \cdot (5 - 2{,}7) \cdot 0{,}5}{mi^2} \cdot 3 = 12{,}15 \cdot c^2$$

Mustaqil bajarish uchun vazifalar:

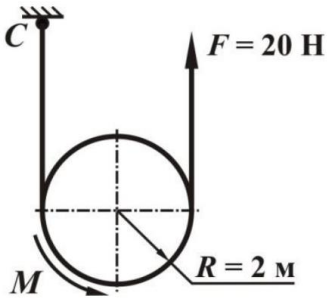
1. Diskni *O* nuqtaga nisbatan inertsiya momenti $J_0 = 4kg \cdot m^2$. *Oz* o'qiga nisbatan diskning kinetic momentini toping.[2]
   Javob: 20



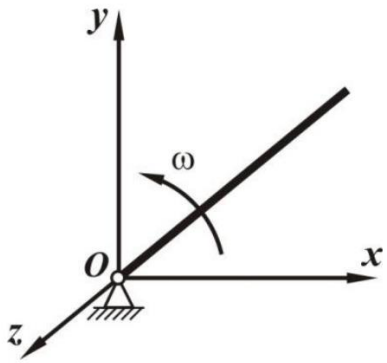
2. *ABC* plastinaning z o'qiga nisbatan kinetic momenti $K_z = 8t \cdot kg \cdot m/s^2$ ga teng bo'lsa, *z* o'qiga nisbatan kuch vektorining bosh momentini toping.[4]
   Javob: 8



3. *C* markazga nisbatan kinetic momenti $K_z = 25t^2 \cdot kg \cdot m/s^2$ ga teng bo'lsa, t_1=2*s* vaqtdagi aylantirish momentini toping.[2]
   Javob: 20



4. Massasi *m=3kg* va uzunligi *l=0,4 m* bo'lgan bir jinsli sterjinning *Oz* o'qiga nisbatan kinetic momenti $K_z = 3{,}2 \cdot kg \cdot m/s^2$ bo'lsa, aylanma harakatdagi burchak tezligini toping.[2]
   Javob: 20



14- AMALIY MASHG'ULOT

MEXANIK TIZIMNING KINETIK ENERGIYASI O'ZGARISHI

Sistema kinetik energiyasi quyidagi formula orqali aniqlanadi:[7]

$$T = \sum \frac{mv^2}{2}$$

Ilgarilanma harakatdagi jismning kinetik energiyasi quyidagi formula orqali aniqlanadi:[6]

$$T = \frac{Mv_c^2}{2}$$

Aylanma harakatdagi jismning kinetik energiyasi:[6]

$$T_{ay} = \frac{I_Z \cdot \omega^2}{2}$$

Tekis parallel harakatdagi jismning kinetik energiyasi:[6]

$$T = \frac{Mv_c^2}{2} + \frac{I_Z \cdot \omega^2}{2}$$

Og'irlik kuchining bajargan ishi:[7]

$$A = \pm p \cdot h$$

aylanayotgan jismga qo'yilgan kuchning bajargan ishi: [7]

$$A = M_Z \cdot \varphi$$

bunda aylantiruvchi moment:[7]

$$M_Z = m_Z(F)$$

tenglama sistema kinetik energiyasining o'zgarishi haqidagi teoremani ifodalaydi:[7]

$$T_1 - T_0 = \sum A_k^e + \sum A_k^i$$

14.1-masala. Uchta *AB, BC* va *CD* sterjenlar *A* va *D* silindrik sharnirlar bilan shipga biriktirilgan bo'lib, o'zaro *B* va *S* sharnirlar vositasida bog'langan; hosil qilingan tekis mexanizmning kinetik energiyasi hisoblansin. *L* uzunlikdagi *AB* va *CD* sterjenlar har birining massasi M_1, *BC* sterjen massasi M_2 bo'lib, *BS=AD; AB* va *CD* sterjenlar ω burchak tezlik bilan aylanadi.[6]

Yechish:

$$T_{AB} = T_{BC} = \frac{1}{2} I_Z \omega^2$$

$$I_Z = M_1 \frac{l^2}{3} = \frac{M_1 l^2}{3}$$

$$T_{AB} = \frac{1}{2} \cdot \frac{M_1 l^2}{3} \cdot \omega^2 = \frac{M_1}{6} l^2 \omega^2$$

$$T_{BC} = \frac{1}{2} M_2 v_1^2 + \frac{1}{2} I_Z \omega^2 = \frac{1}{2} M_2 l^2 \omega^2$$

$$v = l \cdot \omega \qquad I_Z = I_{kz} = I_{kc} - I_{CB} = 0$$

$$T = T_{AB} + T_{BC} + T_{CD} = \frac{M_1 l^2 \omega^2}{6} + \frac{1}{2} M_2 l^2 \omega^2 + \frac{M_1 l^2 \omega^2}{6} = \frac{1}{3} M_1 l^2 \omega^2 + \frac{1}{2} M_2 l^2 \omega^2$$
$$= \frac{2M_1 + 3M_2}{6} l^2 \omega^2$$

14.2-masala. v_0 tezlik bilan harakat qiluvchi traktor gusenisasining kinetic energiyasi hisoblansin. g'ildirak o'qlari orasidagi masofa l ga teng, g'ildirak radiuslari r ga teng, gusenisa zanjiri har metrining massasi γ ga teng.[5]

Berilganlar: v_0, l, r, γ, T topilsin.

Yechish:

Gusinisa og'irligi $Q = \gamma L$

$$L = 2l + 2\pi r = 2(l + \pi r)$$

L - gusinisa uzunligi

$$m = \frac{Q}{g} = \frac{2\gamma(l + \pi r)}{g} v_0^2$$

Gusinisaning yerga tegib turgan qismlari absolyut tezligi nolga teng.

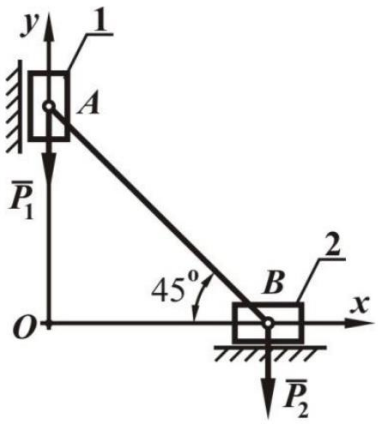
$v_r = v_0$ - gusinisaning nisbiy harakat tezligi.

$$T_{kuch} = T_{nis} = \frac{m v_0^2}{2} = \frac{\gamma L v_0^2}{2g}$$

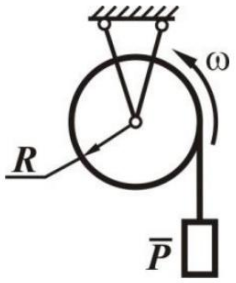
$$T = T_{kuch} + T_{nis} = \frac{\gamma L v_0^2}{g} \qquad yoki \qquad T = \frac{2\gamma(l+\pi r)}{g} v_0^2$$

Mustaqil bajarish uchun vazifalar:

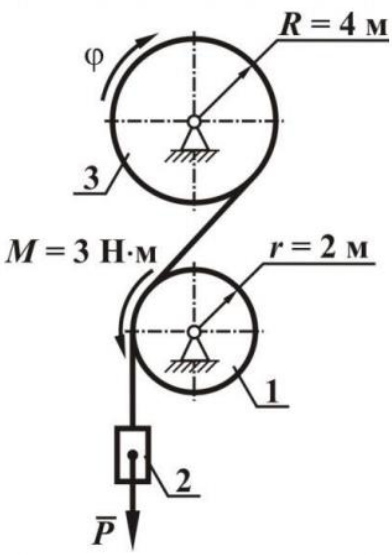
1. *AB* sterjinga *B* polzun $P_2=5N$ va *A* polzun $P_1=4N$ mahkamlangan. *AO* masofaga yurishi uchun kuchning bajargan ishini toping.[6]
   Javob: 8



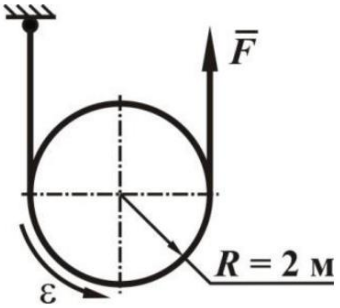
2. Baraban inertsiya momenti $J = 2kg \cdot m^2$, $\omega = 4rad/s$, $R=1m$ yuk massasi $m = \frac{P}{g} = 2kg$. Sistemaning kinetic energiyasini toping.[6]
   Javob: 32



3. *3* g'ildirak *M=3Nm* moment va *P=2N* kuch ta'sirida bajarilgan ishni toping.[6]
   Javob: 84



4. Og'irligi *P=20N* va kinetic energiyasi $T = 6\omega^2 J$ ta'siridagi diskning burchak tezlanishi $\varepsilon = 6rad/s^2$ ga teng bo'lsa, kuchni qiymatini toping.[6]
   Javob: 28



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