

**O'ZBEKISTON RESPUBLIKASI OLIIY VA O'RTA MAXSUS TA'LIM
VAZIRLIGI**

ALISHER NAVOIY NOMIDAGI SAMARQAND DAVLAT UNIVERSITETI

MEXANIKA-MATEMATIKA FAKULTETI

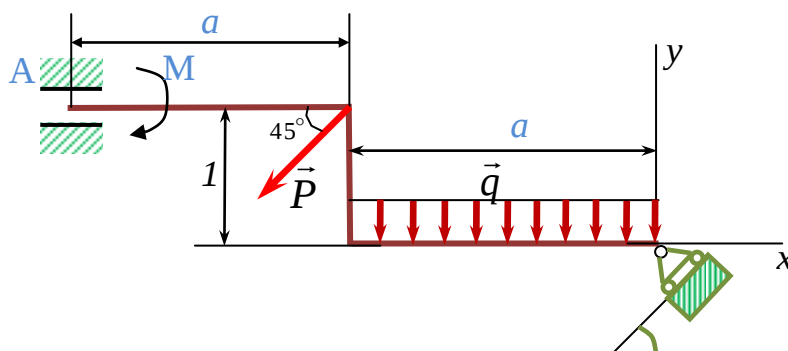
MEXANIKA KAFEDRASI

SMIT – 2 (statika)

NAZARIY MEXANIKA FANIDAN

2-mustaqil ish topshiriqlari va ularni bajarish bo'yicha

USLUBIY QO'LLANMA



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**Samarqand davlat universiteti
o'quv-uslubiy kengashining
2012 yil 4-iyundagi 8-raqamli
majlisi bayonnomasi bilan tavsiya etilgan**

Samarqand – 2012

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Nazariy mexanika fanidan 2-mustaqil ish topshiriqlari va ularni bajarish bo'yicha uslubiy qo'llanma. SMIT – 2 (statika). – Samarqand: SamDU nashri, 2012.

Tayyorlovchilar: t.f.d., prof.Xudoynazarov X.X.,
f.-m.f.n., dots. Buranov X.M.

Mazkur uslubiy qo'llanma mexanika ta'lim yo'nalishida tahsil olayotgan talabalar mustaqil ishlarini tashkil etish, topshiriqlar va ularni bajarish bo'yicha me'yoriy hujjat sifatida amal qiladi.

Uslubiy qo'llanma Mexanika kafedrası professor-o'qituvchilari, magistrant va talabalarga mo'ljallangan.

Mavzu: TEKISLIKDAGI KUCHLAR SISTEMASINING MUVOZANATI

I. Nazariy qism

Tekislikda ixtiyoriy ravishda yo`nalgan kuchlar sistemasi muvozanatda bo`lishi uchun kuchlarning bosh vektori va tekislikning ixtiyoriy nuqtasiga nisbatan bosh momenti nolga teng, ya'ni

$$\begin{cases} \sum_{i=1}^n \vec{F}_i = 0; \\ \sum_{i=1}^n \overrightarrow{mom_0}(\vec{F}_i) = 0. \end{cases} \quad (1)$$

bo`lishi zarur va yetarli.

Keltirilgan (1) tenglamalarni tekislikda dekart koordinatalar sistemasi o`qlariga proyeksiyalab, quyidagi tenglamalar sistemasiga kelimiz:

$$\begin{cases} \sum_{i=1}^n F_{ix} = 0; \\ \sum_{i=1}^n F_{iy} = 0; \\ \sum_{i=1}^n mom_0(\vec{F}_i) = 0. \end{cases} \quad (2)$$

Ushbu (2) munosabatlar tekislikda ixtiyoriy joylashgan kuchlar sistemasining muvozanat shartlarini ifodalaydi. Tekislikda ixtiyoriy yo`nalgan kuchlar sistemasi muvozanatda bo`lishi uchun kuchlar sistemasining koordinata o`qlaridagi proeksiyalari yig`indisi va tekislikdagi ixtiyoriy nuqtaga nisbatan algebraik momentlari yig`indisi alohida-alohida nolga teng bo`lishi zarur va etarli.

Tekislikda ixtiyoriy yo`nalgan kuchlar sistemasining muvozanat shartlarini yana boshqacha ko`rinishda ham berish mumkin: *Bir tekislikda ixtiyoriy yo`nalgan kuchlar sistemasi muvozanatda bo`lishi uchun kuchlar sistemasining bir to`g`ri chiziqda yotmaydigan ixtiyoriy uchta A,B va C nuqtalarga nisbatan algebraik momentlari yig`indisi alohida-alohida nolga teng, ya'ni*

$$\sum_{i=1}^n \text{mom}_A(\vec{F}_i) = 0; \quad \sum_{i=1}^n \text{mom}_B(\vec{F}_i) = 0; \quad \sum_{i=1}^n \text{mom}_C(\vec{F}_i) = 0. \quad (3)$$

bo'lishi zarur va yetarli.

Tekislikda ixtiyoriy ravishda yo'nalgan kuchlar sistemasining uchinchi xil muvozanat shartlarini ham berish mumkin: *tekislikda ixtiyoriy yo'nalgan kuchlar sistemi muvozanatda bo'lishi uchun kuchlar sistemasining tekislikdagi ixtiyoriy ikkita A va B nuqtaga nisbatan olingan algebraik momentlari yig'indisi hamda kuchlar sistemasining shu nuqtalardan o'tuvchi to'g'ri chiziqqa perpendikulyar bo'lmagan o'qdagi proyeksiyalari yig'indisi nolga teng bo'lishi zarur va yetarli, ya'ni*

$$\sum_{i=1}^n \text{mom}_A(\vec{F}_i) = 0; \quad \sum_{i=1}^n \text{mom}_B(\vec{F}_i) = 0; \quad \sum_{i=1}^n (\vec{F}_i)_\ell = 0, \quad (4)$$

bu erda ℓ - AB to'g'ri chiziqqa perpendikulyar bo'lmagan o'q.

Tekislikda ixtiyoriy joylashgan kuchlar sistemasining muvozanatiga doir masalalarni yechish uchun uslubiy tavsiyalar.

1. Koordinatalar sistemi o'qlarini kuchlarning proyeksiyalarini hisoblashga qulay qilib tanlash kerak.

2. Moment markazi sifatida ikkita va undan ortiq noma'lum reaksiya kuchlari kesishgan nuqtani olish maqsadga muvofiq.

3. Masalaning berilishidan kelib chiqqan holda quyidagi 3.1, 3.2 yoki 3.3 harakatlardan birini tanlash va bajarish lozim:

3.1. tanlangan koordinatalar sistemi va moment markaziga nisbatan (2) tenglamalar sistemasini tuzish lozim;

3.2. tekislikda bir to'g'ri chiziqda yotmagan uchta nuqtani tanlab, (3) tenglamalar sistemasini tuzish lozim;

3.3. tekislikda A va B nuqtalarni va AB to'g'ri chiziqqa perpendikulyar bo'lmagan ℓ o'qni tanlab, (4) tenglamalar sistemasini tuzish lozim;

4. Tuzilgan tenglamalar sistemasini yechib, izlanayotgan noma'lumlar topiladi.

II. TOPSHIRIQNI BAJARISH NAMUNASI

TOPSHIRIQ

Sxemalarda (chizmalarda) o'qi siniq chiziqdan iborat bo'lgan brusni mahkamlashning uchta usuli ko'rsatilgan. Berilgan yuklama (1-jadvalga qarang) va o'lchamlar (m) uchala holda ham bir xil.

a) tayanch reaksiyalari tuzuvchilari va reaktiv momentlarning son qiymatlari hisoblansin;

b) tayanch reaksiyalarining kattaligi va yo'nalishi aniqlansin.

c) tayanchlarning topilgan reaksiyalari brusni mahkamlashning shunday usuli uchun ajratilsinki, bunda 1-jadvalda ko'rsatilgan reaksiya eng kichik modulga ega bo'lsin;

Topshiriqni bajarish tartibi.

1) Hisob sxemasini tuzamiz, buning uchun:

a) tayanchlarni olib tashlab, ularning ta'sirini reaksiya kuchlarining tuzuvchilari va reaktiv moment (qistirib mahkamlangan holda) bilan almashtiramiz;

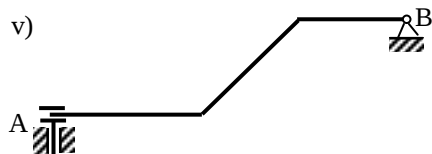
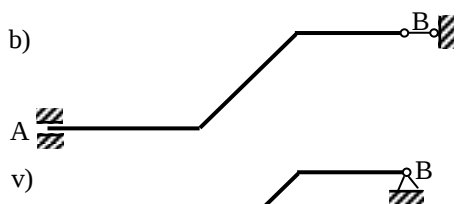
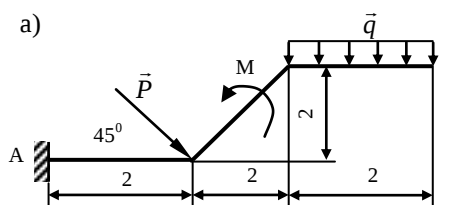
b) tekis taqsimlangan kuchni uning teng ta'sir etuvchisi bilan almashtirib olamiz;

2) Mustaqil ish shartidagi har bir hol uchun hisob sxemasidan foydalanib, kuchlar sistemasi uchun (2), (3) yoki (4) muvozanat tenglamalaridan birini tuzamiz;

3) Har uchala holat uchun tenglamalar sistemalarini yechib, kerakli noma'lumlarni aniqlaymiz;

4) Masala shartida talab qilingan reaksiyaning eng kichik modulli holatini aniqlaymiz;

Berilgan: brusni mahkamlash sxemalari (1-chizma, a, b, c); $R=5$ kN; $M=8$ kN•m; $q=1,2$ kN/m.



1-chizma

1) tayanchlarning reaksiyalari brusni mahkamlashning shunday usuli uchun aniqlansinki, bunda qistirib mahkamlangan tayanchdagi M_A moment eng kichik modulga ega bo'lsin;

2) tayanch reaksiyalari tuzuvchilari, absolyut

qiymatlari, yo'nalishlari va reaktiv momentlarning son qiymatlari hisoblansin.

Yechish. Hisob sxemasini yasaymiz. Buning uchun tayanchlarni (bog'lanishlarni olib tashlab, ularning ta'sirini mos reaksiya kuchlari bilan almashtiramiz:

a hol uchun — X_A, Y_A, M_A (2-chizma);

b hol uchun — Y_A, M_A va R_B (3-chizma);

c hol uchun — M_A, X_B va Y_B (4-chizma).

Intensivligi q bo'lgan tekis taqsimlangan yuklamani uning yelkasi miqdoriga ko'paytirib

$$Q = 2q = 2,4 \text{ kN}$$

teng ta'sir etuvchi bilan almashtiramiz va uni hisob sxemasida aks ettiramiz.

2) Endi har bir hol uchun tayanch reaksiyalari va reaktiv momentlarni aniqlaymiz:

a hol uchun

$$\begin{cases} \sum X_i = 0; \\ \sum Y_i = 0; \\ \sum M_A(\vec{F}_i) = 0; \end{cases} \Rightarrow \begin{cases} P \cos 45^\circ + X_A = 0; \\ Y_A - P \cos 45^\circ - Q = 0; \\ M_A - P \cdot 2 \sin 45^\circ + M - Q \cdot 5 = 0. \end{cases}$$

Endi bu tenglamalar sistemasini yechamiz:

(1) tenglamadan

$$X_A = -P \cos 45^\circ = -3,54 \text{ kN};$$

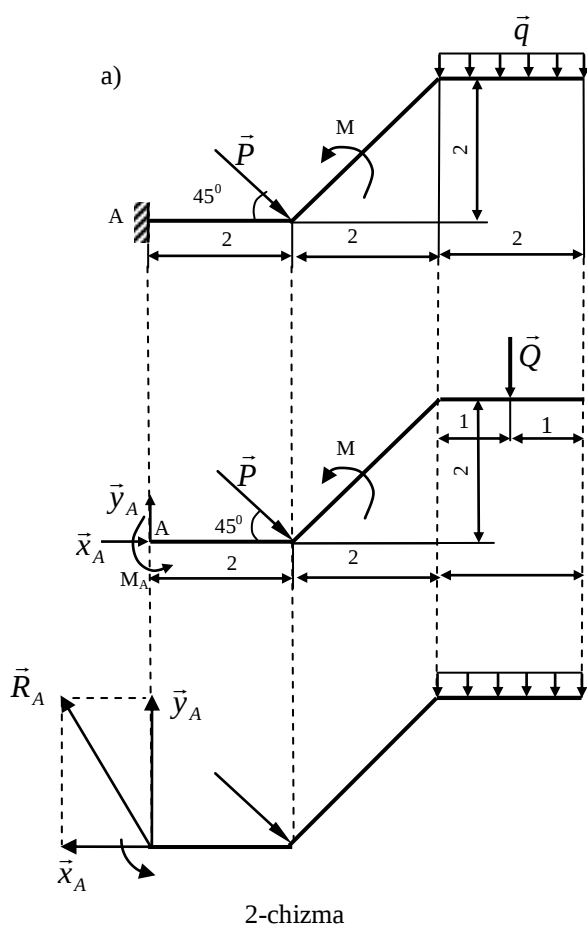
(2) tenglamadan

$$Y_A = P \cos 45^\circ + Q = 5,94 \text{ kN};$$

(3) tenglamadan

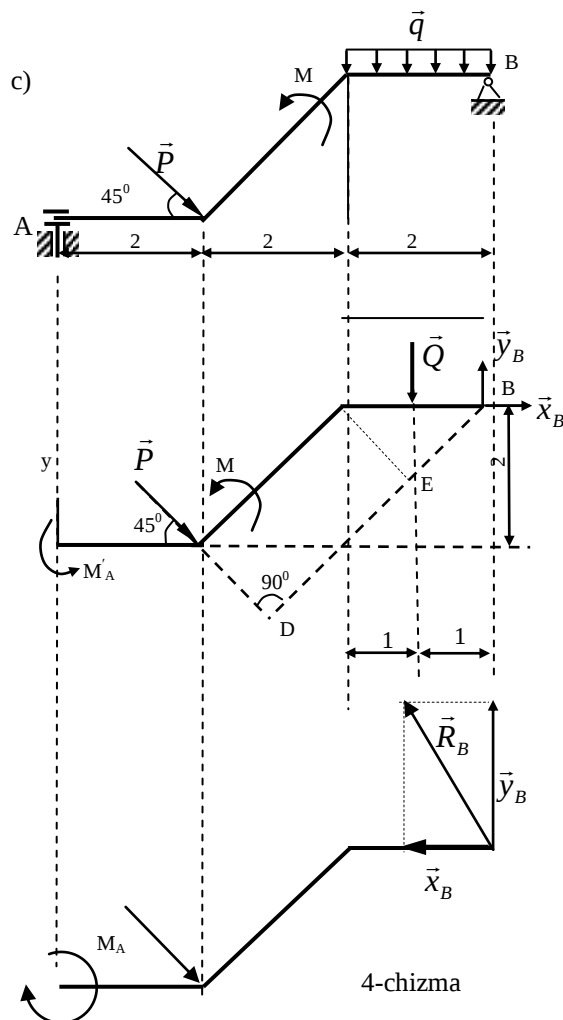
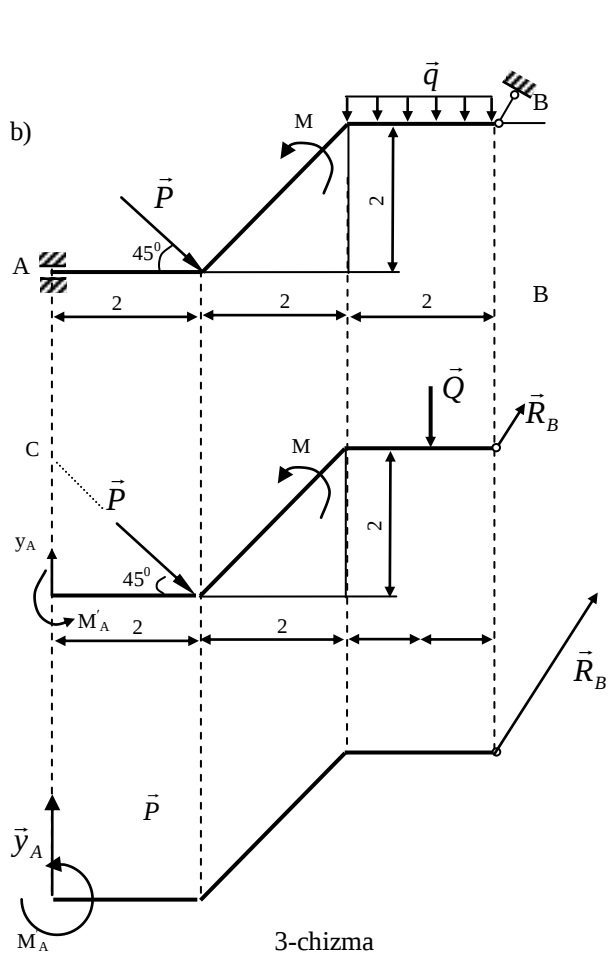
$$M_A = 2P \cos 45^\circ - 5Q - M = 11,07 \text{ kN} \cdot \text{m}.$$

Demak, A tayanchdagi reaksiya bitta



2-chizma

$R_A = \sqrt{X_A^2 + Y_A^2} = 6,91 \text{ kN}$ kuch va bitta $M_A = 11,07 \text{ kN} \cdot \text{m}$ reaktiv momentdan iborat ekan. Bu kattaliklarning topilgan qiymatlarini 3:1 masshtabda chizmaga ko'chiramiz.



b hol uchun

$$\begin{cases} \sum X_i = 0; \\ \sum Y_i = 0; \\ \sum M_C(\vec{F}_i) = 0; \end{cases} \Rightarrow \begin{cases} P \cos 45^\circ + R_B \cos 60^\circ = 0; \\ Y_A - P \cos 45^\circ + R_B \cos 30^\circ - Q = 0; \\ M_A - R_B \cdot 6 \sin 60^\circ + M - Q \cdot 5 = 0. \end{cases}$$

(1) tenglamadan $R_B = -P\sqrt{2} \approx 7,07 \text{ kN}$.

(2) tenglamadan $Y_A = P \cos 45^\circ - R_B \cos 30^\circ + Q = 3,99 \text{ kN}$

(3) tenglamadan $M_A = -M + R_B 3\sqrt{3} + 12 = 34,73 \text{ kN} \cdot \text{m}$.

Demak, A tayanchdagi reaksiya bitta $Y_A = 3,99 kN$ kuch va bitta $M_A = 34,73 kN \cdot m$. reaktiv momentdan iborat ekan. Bu kattaliklarning topilgan qiymatlarini 3:1 masshtabda chizmaga ko'chiramiz.

c hol uchun

$$\begin{cases} \Sigma X_i = 0; \\ \Sigma Y_i = 0; \\ \Sigma M_B(\vec{F}_i) = 0; \end{cases} \Rightarrow \begin{cases} P \cos 45^\circ + X_B = 0; \\ Y_B - P \cos 45^\circ - Q = 0; \\ M_A + P \cdot 3\sqrt{2} + M + Q \cdot 1 = 0. \end{cases}$$

(1) tenglamadan $X_B = -3,54 kN$

(2) tenglamadan $Y_B = 5,94 kN$

(3) tenglamadan $M_A = -31,61 kN m$.

B tayanchdagi reaksiya $R_B = \sqrt{X_B^2 + Y_B^2} = 6,91 kN$ ga teng. Bu kattaliklarning topilgan qiymatlarini 3:1 masshtabda chizmaga ko'chiramiz.

3) Reaktiv momentning har uchala hol uchun topilgan qiymatlaridan ko'rinadiki, brusning a) sxema bo'yicha mahkamlanganda reaktiv moment eng kichik bo'ladi.

6. Mustaqil ish topshiriqlari

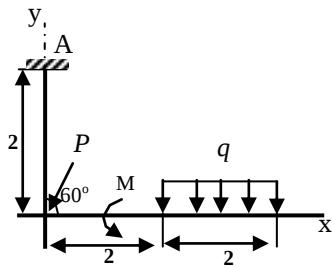
1-jadval

Variant Raqami	P kN	M kN·m	q kN/m	Tekshirilayotgan reaksiya	Variant Raqami	P kN	M kN·m	q kN/m	Tekshirilayotgan reaksiya
1	A	B	2	Y_A	16	A	B	2	M_A
2	A	B	4	M_A	17	A	B	3	Y_A
3	A	B	1	Y_B	18	A	B	2	X_A
4	A	B	1	Y_B	19	A	B	1	R_B
5	A	B	-	X_B	20	A	B	4	Y_A
6	A	B	1	M_A	21	A	B	2	M_A
7	A	B	2	X_A	22	A	B	1	Y_A
8	A	B	4	R_B	23	A	B	2	M_A
9	A	B	-	Y_A	24	A	B	1	Y_A
10	A	B	2	X_A	25	A	B	2	X_A
11	A	B	1	R_B	26	A	B	2	M_A
12	A	B	2	Y_A	27	A	B	1	X_A
13	A	B	2	Y_A	28	A	B	2	Y_A

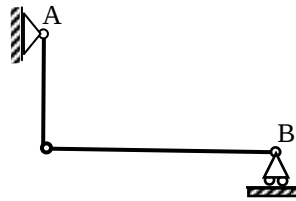
14	A	B	3	Y_A		29	A	B	1	M_A
15	A	B	2	X_A		30	A	B	2	R_B

1)

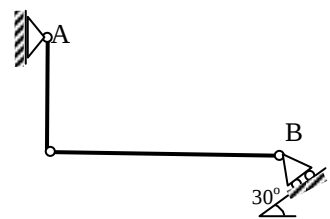
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b)

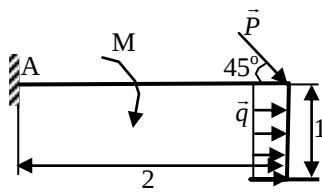


c)

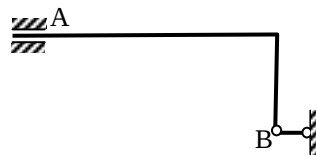


2)

a)



b)

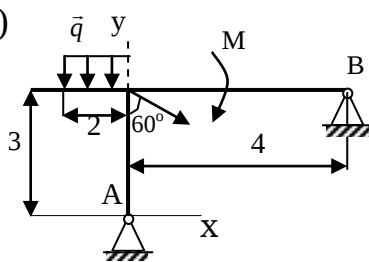


c)



3)

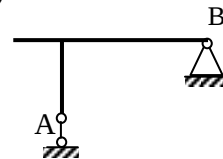
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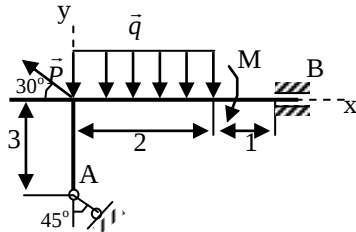


c)



4)

a)



b)

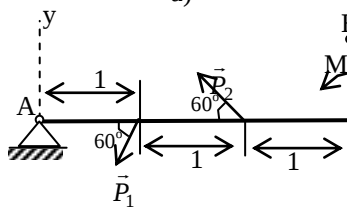


c)



5)

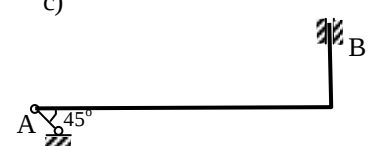
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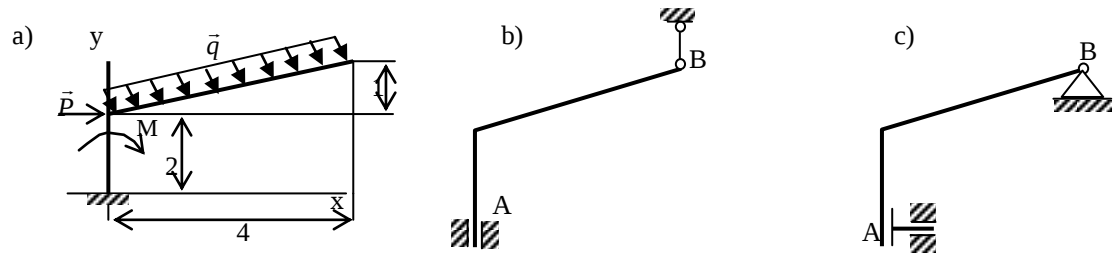


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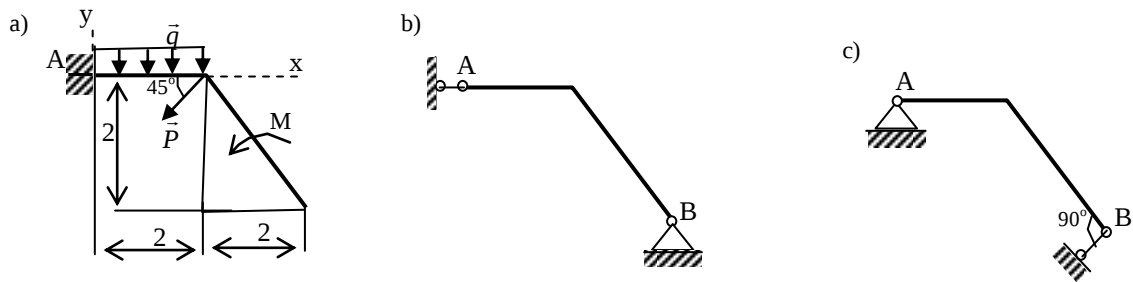


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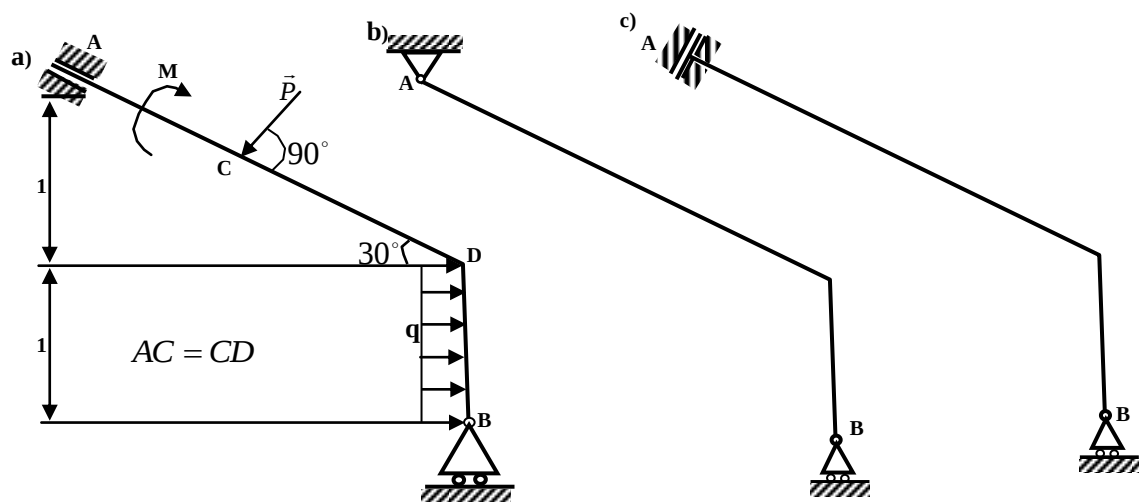
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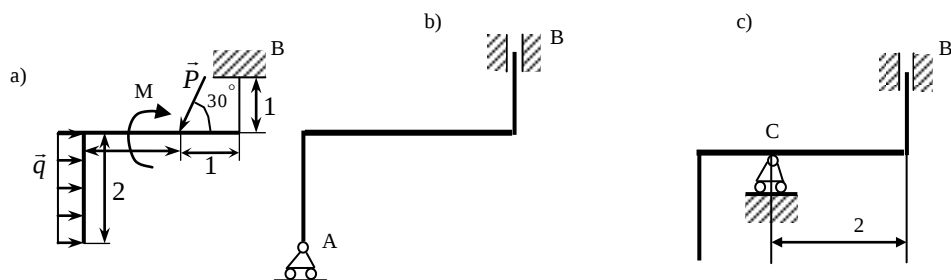
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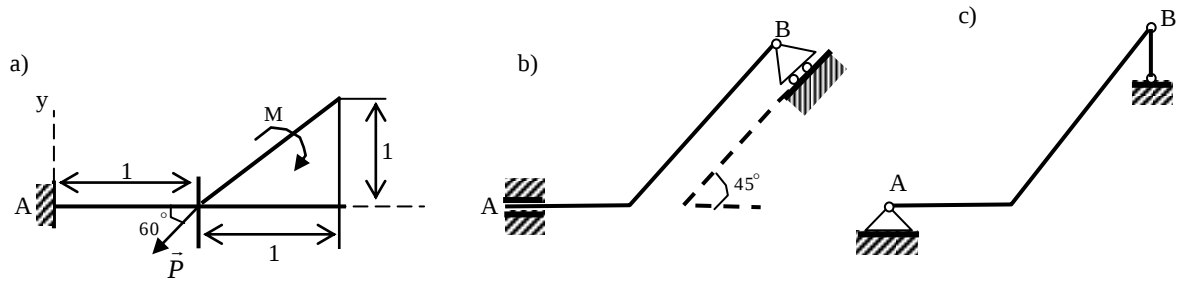
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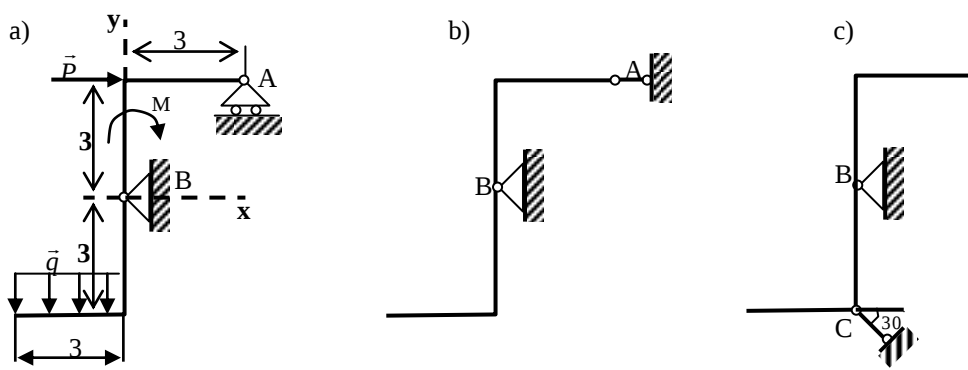
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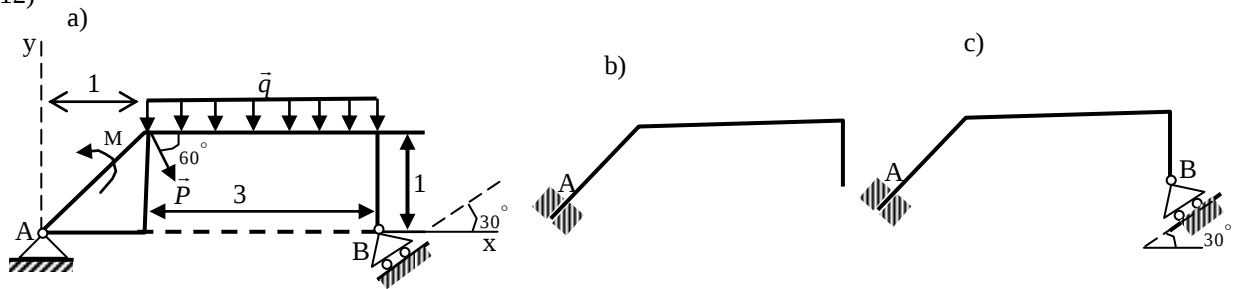
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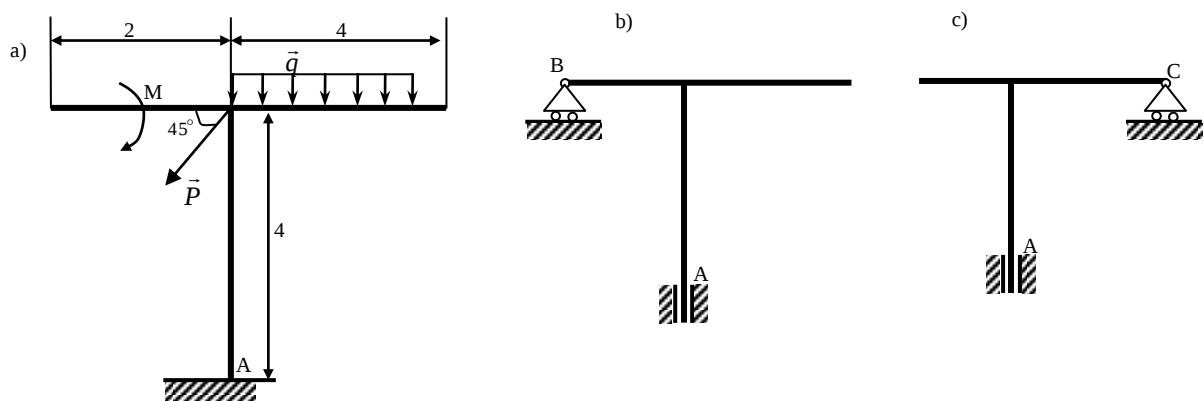
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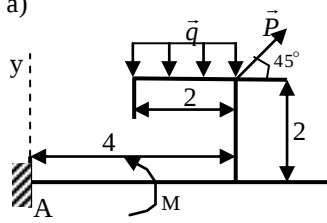


13)



14)

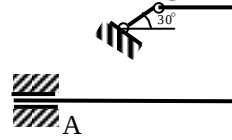
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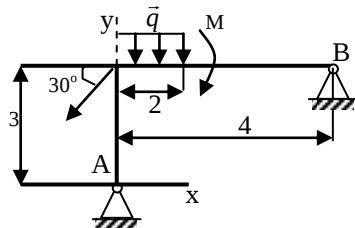


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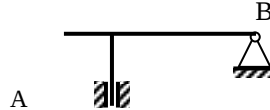


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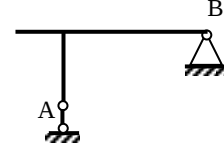
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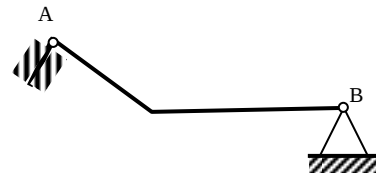
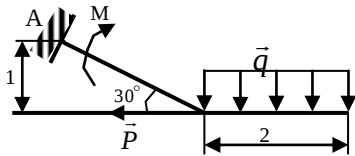
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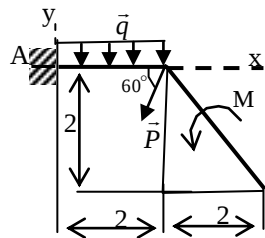
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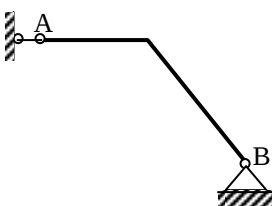
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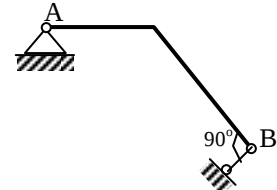
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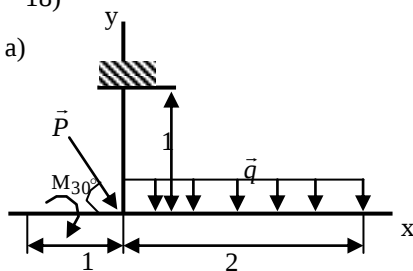


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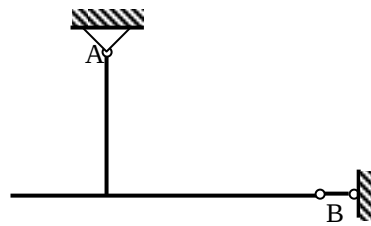


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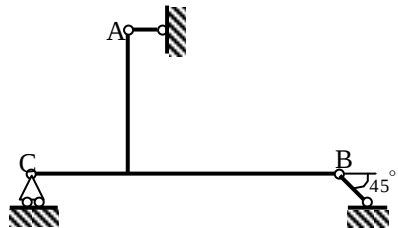
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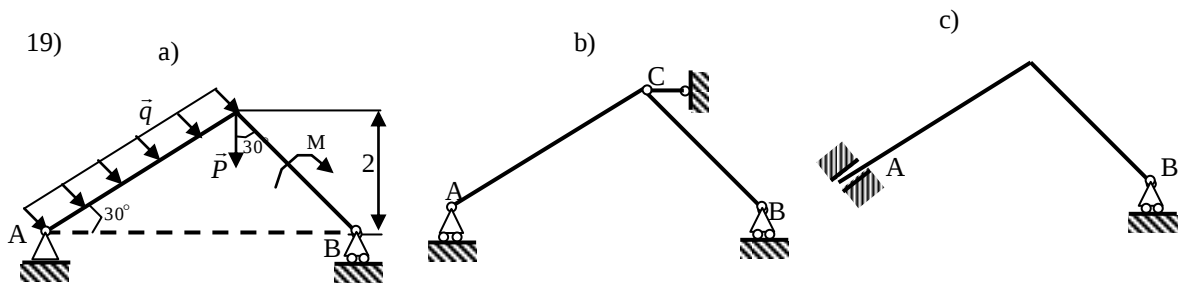
b)



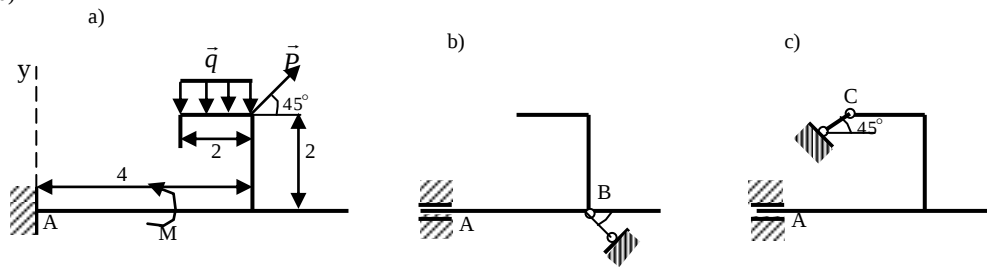
c)



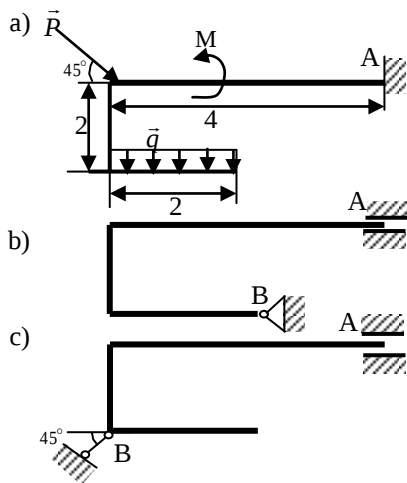
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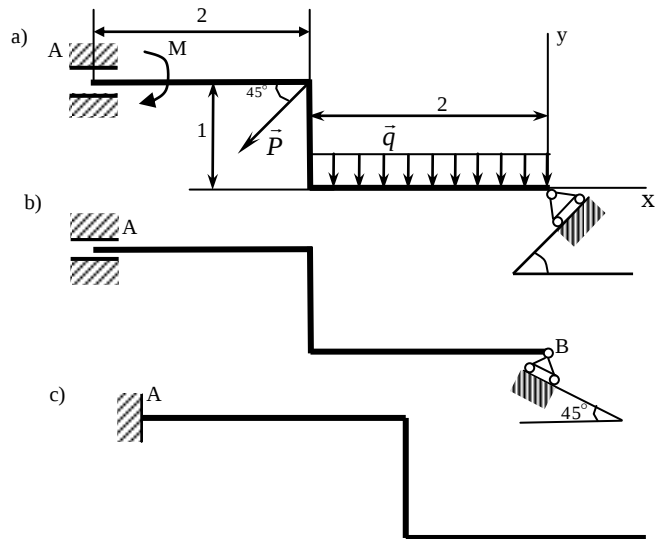
20)



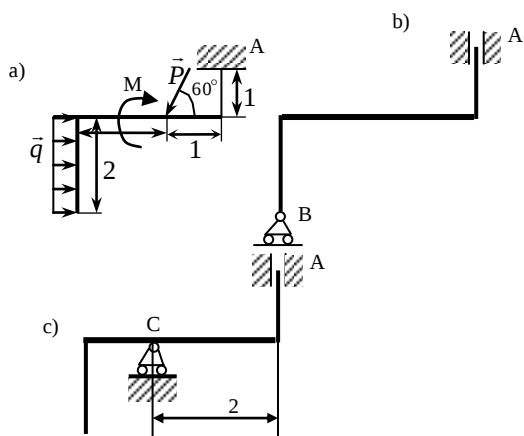
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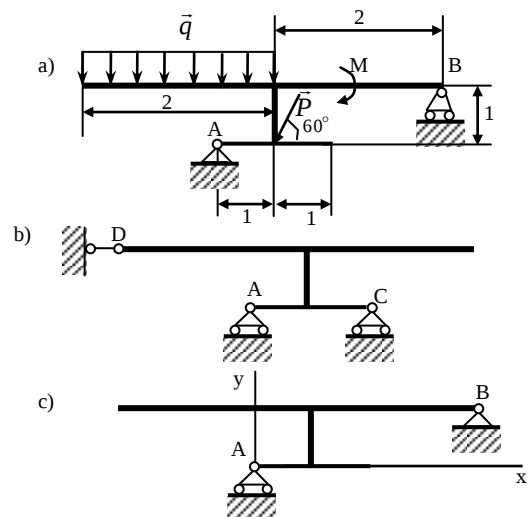
22)



23)

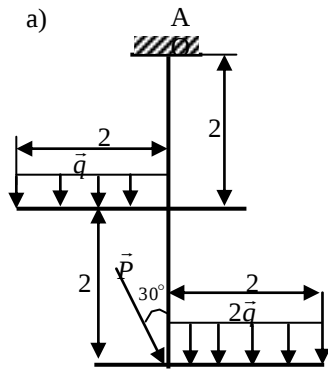


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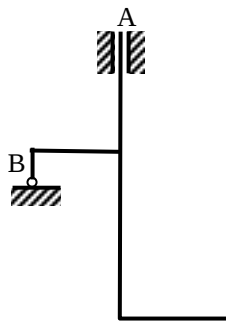


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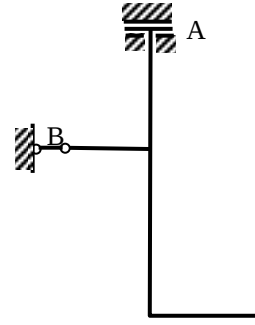
a)



b)

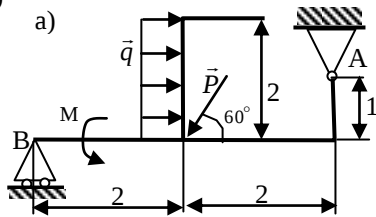


c)

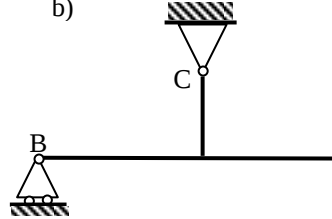


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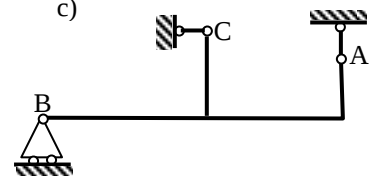
a)



b)



c)



Adabiyotlar

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