TRANSPORTNI UREĐAJI
VJEŽBE - 05

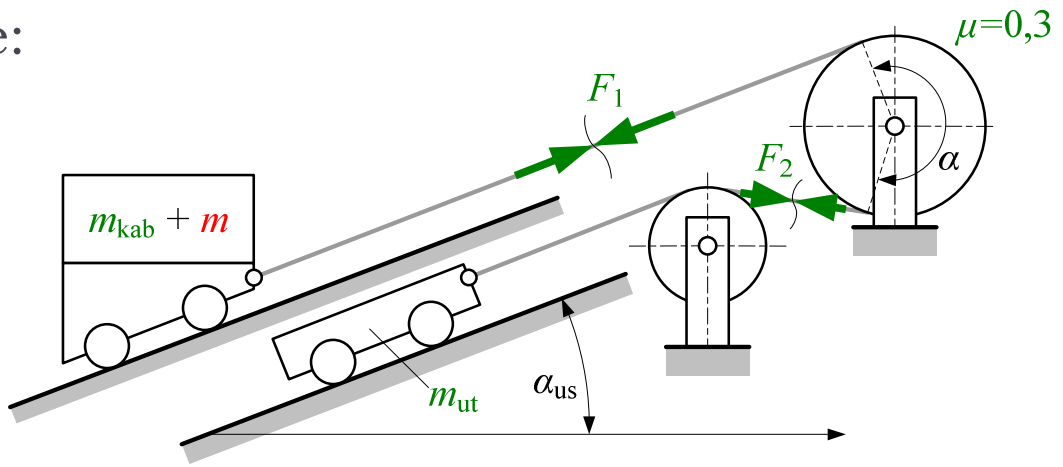
asistent: Matija Hoić, mag. ing. mech.

INFORMACIJE

- rok za predaju programa za studente koji su TU upisali drugi puta je kraj travnja 2011.
- ako do tada programski zadatak nije predan, mora se podići novi
- ukoliko se ne stigne izraditi trenutno zadani zadatak do tog datuma, javiti se da se zada novi
- neovisno o programskom zadatku, kolokviji položeni prošle akademske godine vrijede do kraja ovog semestra, tj. zaključno s posljednjim ispitnim rokom u ovom semestru koji će biti 07.07.2011.

ZADATAK 10 (1)

Za kosi lift prema slici zadano je:



Odrediti (težinu užeta zanemariti):

- optimalnu masu utega iz uvjeta što manje pogonske sile;
- snagu pogona (ukupna iskoristivost $\eta = 0,7$) za izračunatu masu protuutega;

$$m_{ut} = m_{kab} + \frac{m}{2}\left(1 + \frac{f}{\tan\alpha_{us}}\right) = 1600 + \frac{800}{2}\left(1 + \frac{0,02}{0,45}\right) = 2018$$

$$P = \frac{F_p \cdot v}{\eta}$$

$$F_p = F_{p,a} = \left(m_{kab} + m - m_{ut}\right) \cdot g \cdot \sin\alpha_{us} + \left(m_{kab} + m + m_{ut}\right) \cdot g \cdot \cos\alpha_{us} \cdot f$$

ZADATAK 11 (1)

Za mehanizam dizanja auto-granikaprema slici potrebno je odrediti:

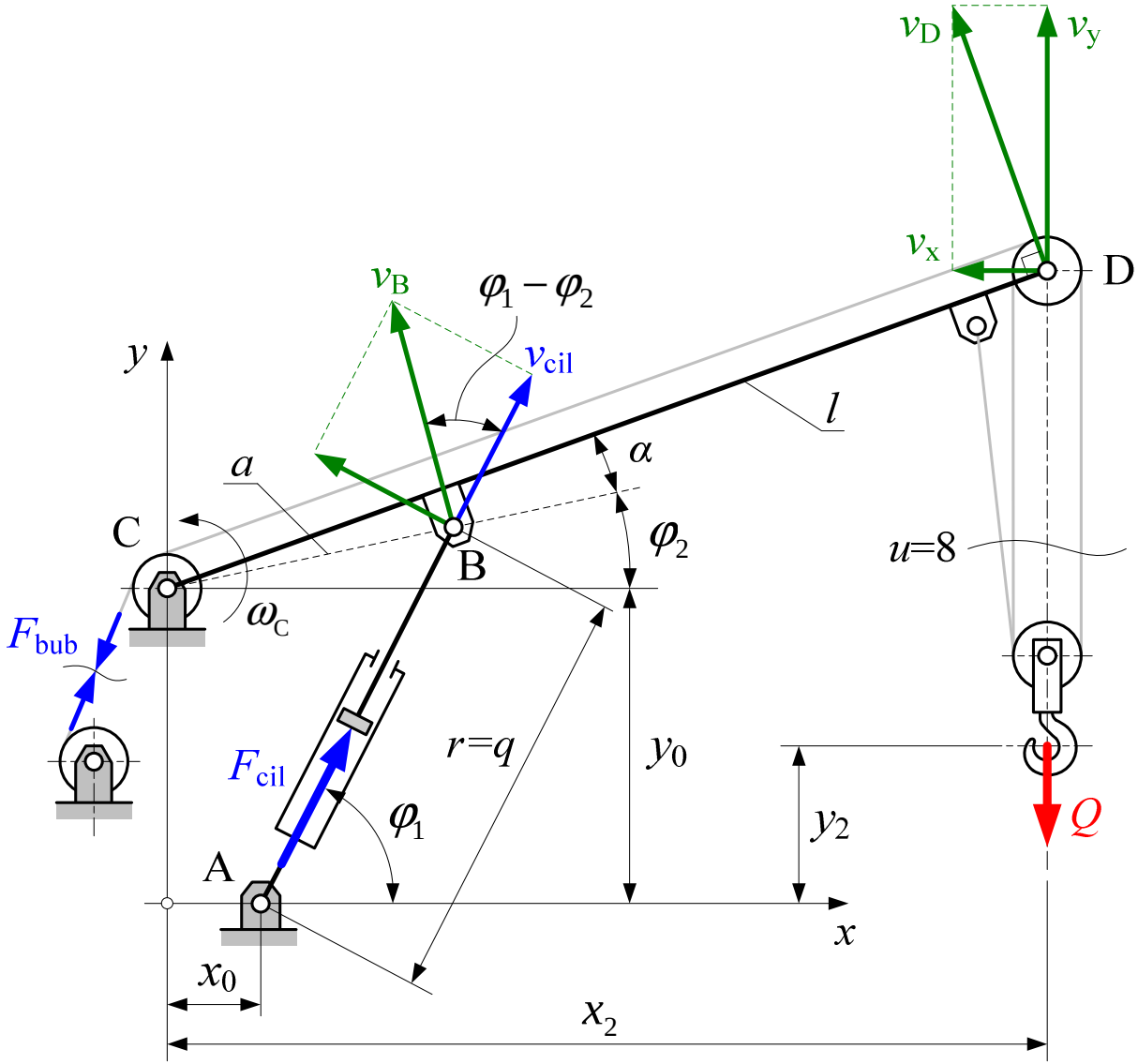
- Odnos pri dizanju i spuštanju tereta (F_{bub}/Q); $\eta_0 = 0,98$
- reduciranu masu tereta na obodu bubnja;

odnos pogonske sile u cilindru i tereta (F_{cil}/Q) pri dizanju kraka, težinu kraka zanemariti;

- reduciranu masu tereta na linijsku ogonsku koordinatu $r = q$

Za referentnu koordinatu pi analizi uzeti kuteve φ_2 i φ_1

ZADATAK 11 (2)


v_D
v_y
v_x
D
v_B
$\varphi_1 - \varphi_2$
v_{cil}
y
l
a
α
C
B
φ_2
u=8
ω_C
F_{bub}
F_{cil}
r=q
y_0
φ_1
y_2
Q
A
x
x_0
x_2

ZADATAK 11 (3)

- ODNOS F_{bub}/Q PRI DIZANJU I SPUŠTANJU TERETA

$$F_{\text{bub}} \cdot \eta_{\text{r}} = \frac{Q}{i_{\text{fk}}} \qquad i_{\text{fk}} = u = 8$$

$$\eta_{0,\text{r}} = \eta_0 = 0,98 \qquad \eta_{\text{fk,r}} = \frac{1}{u} \cdot \frac{1-\eta_0^u}{1-\eta_0} = \frac{1}{8} \cdot \frac{1-0,98^8}{1-0,98} = 0,9327$$

$$\eta_{\text{r}} = \eta_{\text{fk,r}} \cdot \eta_{0,\text{r}}^2 = 0,9327 \cdot 0,98^2 = 0,8957$$

$$\left(\frac{F_{\text{bub}}}{Q} \right)_{\text{r}} = \frac{1}{\eta_{\text{r}} \cdot i_{\text{fk}}} = \frac{1}{0,8957 \cdot 8} = 0,1395$$

ZADATAK 11 (4)

- ODNOS F_{bub}/Q PRI DIZANJU I SPUŠTANJU TERETA

$$F_{\text{bub}} = \frac{Q}{i_{\text{fk}}} \cdot \eta_{\text{k}} \qquad i_{\text{fk}} = u = 8$$

$$\eta_{0,\text{k}} = 2 - \frac{1}{\eta_{0,\text{r}}} = 2 - \frac{1}{0,98} = 0,9796 \qquad \eta_{\text{fk,k}} = 2 - \frac{1}{\eta_{\text{fk,r}}} = 2 - \frac{1}{0,9327} = 0,9278$$

$$\eta_{\text{k}} = \eta_{\text{fk,k}} \cdot \eta_{0,\text{k}}^2 = 0,9278 \cdot 0,9796^2 = 0,8904$$

$$\left(\frac{F_{\text{bub}}}{Q} \right)_{\text{k}} = \frac{\eta_{\text{k}}}{i_{\text{fk}}} = \frac{0,8903}{8} = 0,1111$$

ZADATAK 11 (5)

- REDUCIRANA MASA TERETA NA OBODU BUBNJA

Reducirana masa tereta na obodu bubnja zbog male mase rotirajućih članova (užnica) naspram tereta jednaka je reduciranim translacijskim masama:

$$W = I_R \cdot \frac{\omega_{bub}^2}{2} = \frac{Q}{g} \cdot \frac{v_D^2}{2} \cdot \frac{1}{\eta_r} \quad \Rightarrow \quad I_R = I_{tr} = \frac{Q}{g} \cdot \left(\frac{v_D}{\omega_{bub}} \right)^2 \cdot \frac{1}{\eta_r}$$

$$\frac{v_D}{\omega_{bub}} = \frac{v_D}{v_{bub} / r_{bub}} = \frac{r_{bub}}{u}$$

$$I_R = I_{tr} = \frac{Q}{g} \cdot \left(\frac{r_{bub}}{u} \right)^2 \cdot \frac{1}{\eta_r} = \frac{Q}{9,81} \cdot \frac{r_{bub}^2}{8^2} \cdot \frac{1}{0,8957} = 0,00178 \cdot Q \cdot r_{bub}^2$$

ZADATAK 11 (6)

•ODNOS POGONSKE SILE U CILINDRU I TERETA (REDUKCIJA TERETA NA POGONSKU SILU U CILINDRU)

$$P_{\text{cil}} = P_{\text{t}} \qquad \Rightarrow \qquad F_{\text{cil}} \cdot v_{\text{cil}} = Q \cdot v_y$$

$$\left.\begin{aligned} v_y &= v_{\text{D}} \cdot \cos\left(\alpha + \varphi_2\right) \\ v_{\text{D}} &= \omega_{\text{C}} \cdot l \end{aligned}\right\} \qquad v_y = \omega_{\text{C}} \cdot l \cdot \cos\left(\alpha + \varphi_2\right)$$

$$\left.\begin{aligned} v_{\text{cil}} &= v_{\text{B}} \cdot \sin\left(\varphi_1 - \varphi_2\right) \\ v_{\text{B}} &= \omega_{\text{C}} \cdot a \end{aligned}\right\} \qquad v_{\text{r}} = \omega_{\text{C}} \cdot a \cdot \sin\left(\varphi_1 - \varphi_2\right)$$

$$\frac{F_{\text{c}}}{Q} = \frac{v_y}{v_{\text{r}}} = \frac{l}{a} \cdot \frac{\cos\left(\alpha + \varphi_2\right)}{\sin\left(\varphi_1 - \varphi_2\right)}$$

ZADATAK 11 (7)

- REDUCIRANA MASA TERETA NA LINIJSKU POGONSKU KOORDINATU

$$\frac{1}{2} m_{\text{red}} \cdot v_{\text{cil}}^2 = \frac{1}{2} m_{\text{Q}} \cdot v_{\text{D}}^2 \quad \Rightarrow \quad m_{\text{red}} = m_{\text{Q}} \cdot \left(\frac{v_{\text{D}}}{v_{\text{cil}}} \right)^2$$

Pri čemu se brzina točke D radi lakšeg pisanja jednadžbi rastavlja na horizontalnu i vertikalnu komponentu:

$$m_{\text{red}} = m_{\text{Q}} \cdot \left[\left(\frac{v_x}{v_{\text{cil}}} \right)^2 + \left(\frac{v_y}{v_{\text{cil}}} \right)^2 \right]$$

ZADATAK 11 (8)

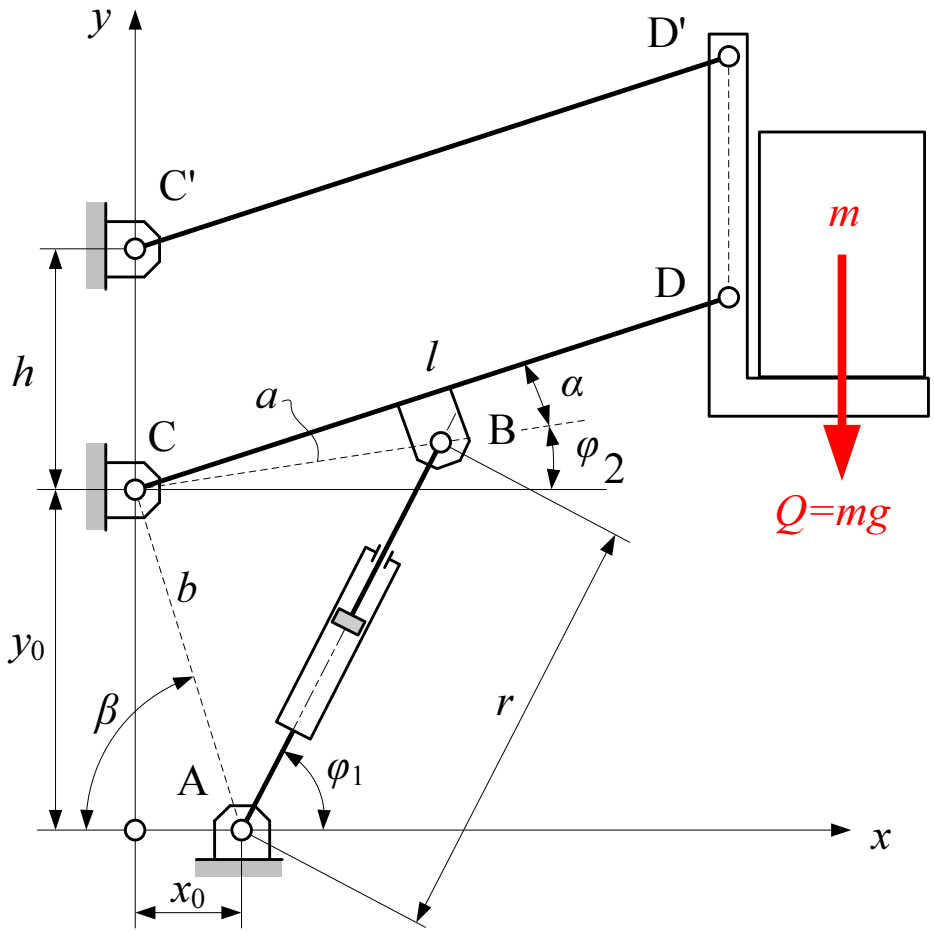
$$\left.\begin{aligned} v_x &= v_{\mathrm{D}} \cdot \sin\left(\alpha+\varphi_2\right) \\ v_{\mathrm{D}} &= \omega_{\mathrm{C}} \cdot l \end{aligned}\right\} \qquad v_x = \omega_{\mathrm{C}} \cdot l \cdot \sin\left(\alpha+\varphi_2\right)$$

$$m_{\mathrm{red}} = m_{\mathrm{Q}} \cdot \left(\frac{l}{a}\right)^2 \cdot \frac{\sin^2\left(\alpha+\varphi_2\right)+\cos^2\left(\alpha+\varphi_2\right)}{\sin^2\left(\varphi_1-\varphi_2\right)}$$

$$m_{\mathrm{red}} = \frac{Q}{g} \cdot \left(\frac{l}{a}\sin\left(\varphi_1-\varphi_2\right)\right)^2$$

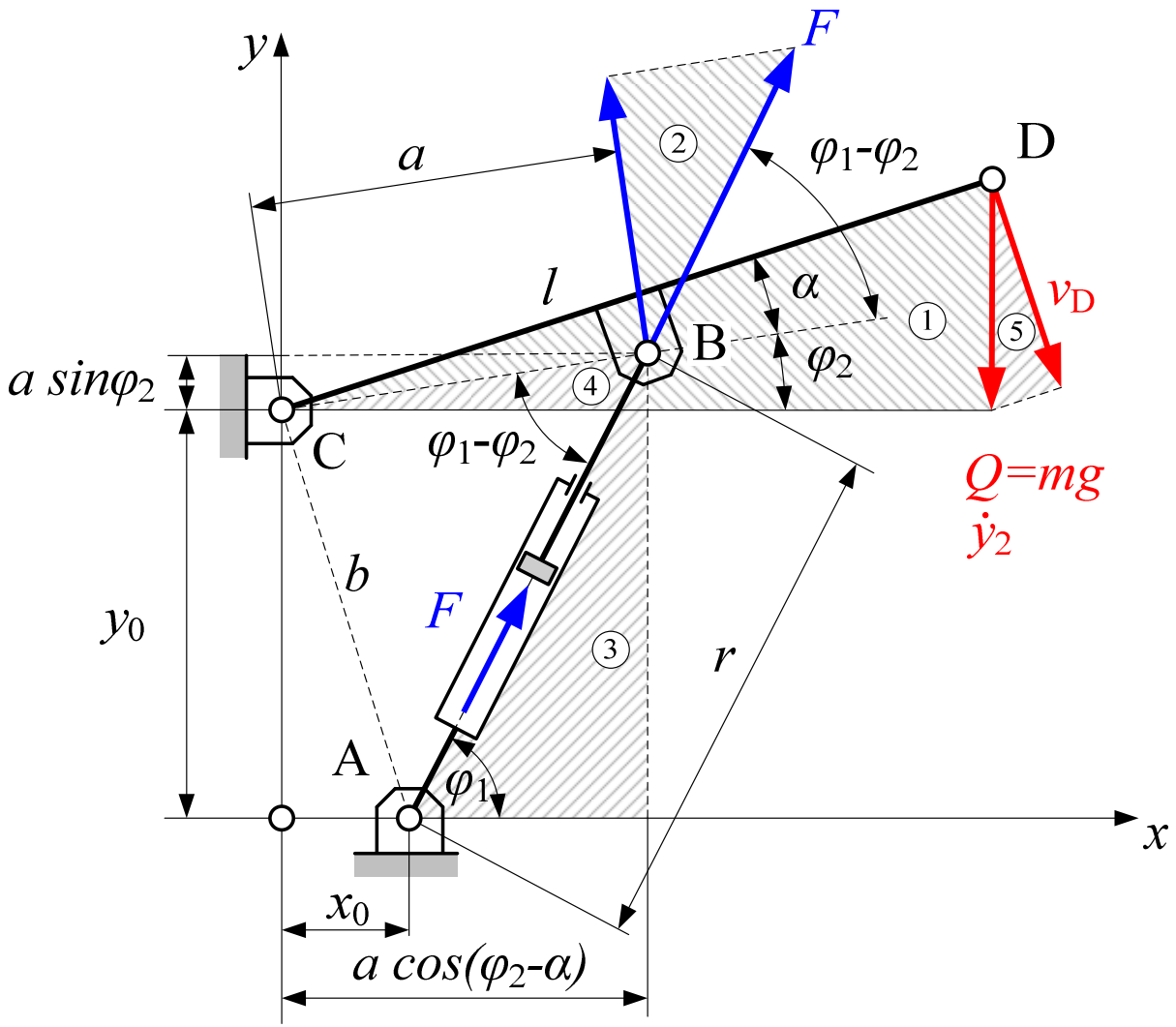
ZADATAK 12 (1)

Izvršiti redukciju tereta i mase tereta na pogonsku koordinatu *r* za zadani mehanizam prema slici. Za referentnu koordinatu uzeti kut φ_2



ZADATAK 12 (2)

REDUKCIJA TERETA (TEŽINA) – PREKO JEDNADŽBI RAVNOTEŽE



ZADATAK 12 (3)

REDUKCIJA TERETA (TEŽINA) – PREKO JEDNADŽBI RAVNOTEŽE

Trokuti (1), (2) i (5)

$$\sum M_C = 0 \qquad \Rightarrow \qquad a \cdot F \sin\left(\varphi_1 - \varphi_2\right) = Q \cdot l \cos\left(\varphi_2 + \alpha\right)$$

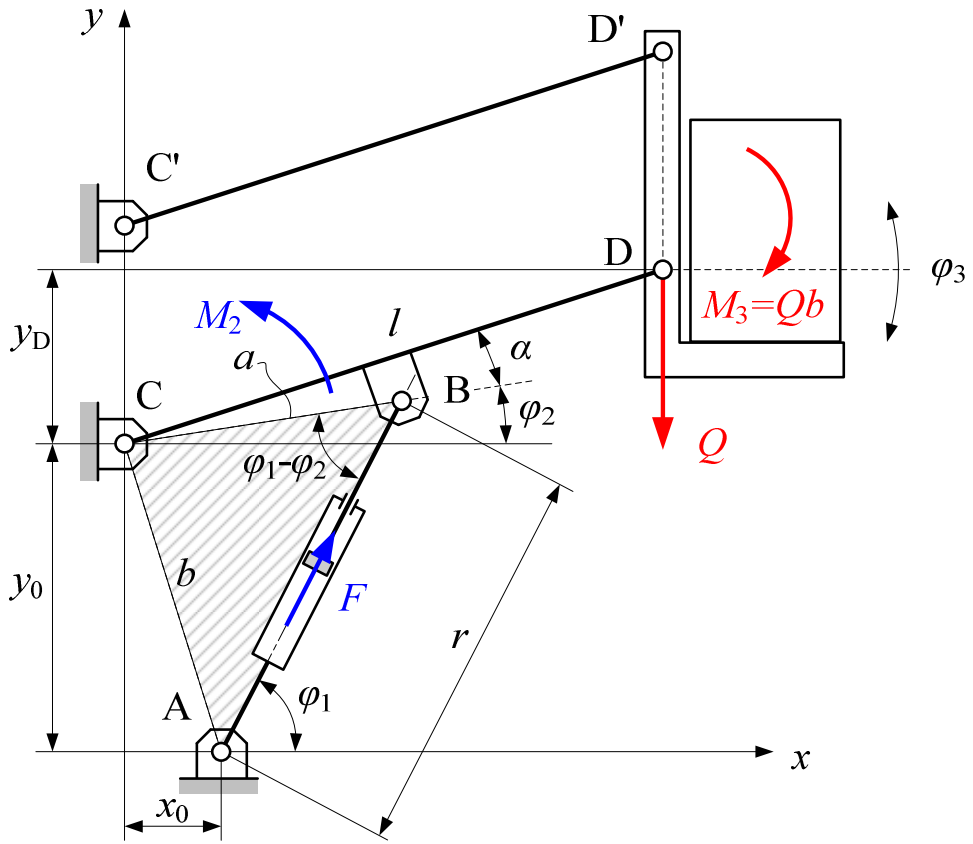
$$F = Q \cdot \frac{l \cos\left(\varphi_2 + \alpha\right)}{a \sin\left(\varphi_1 - \varphi_2\right)} = Q \cdot \frac{\mathrm{d}y_2}{\mathrm{d}r} = Q \cdot \frac{\dot{y}_2}{v_r}$$

Trokuti (3) i (4)

$$tg\varphi_1 = \frac{y_0 + a \sin\varphi_2}{a \cos\varphi_2 - x_0}$$

ZADATAK 12 (4)

REDUKCIJA TERETA (TEŽINA) – PREKO SNAGE



$$M_2 \mathrm{d}\varphi_2 = Q \mathrm{d}y_D + M_3 \mathrm{d}\varphi_3$$

$$M_2 = Q \frac{\mathrm{d}y_D}{\mathrm{d}\varphi_2} + M_3 \frac{\mathrm{d}\varphi_3}{\mathrm{d}\varphi_2}$$

ZADATAK 12 (5)

REDUKCIJA TERETA (TEŽINA) – PREKO SNAGE

$$M_2 \mathrm{d}\varphi_2 = F \mathrm{d}r \qquad \Rightarrow \qquad M_2 = F \frac{\mathrm{d}r}{\mathrm{d}\varphi_2}$$

Iz kosinusovog poučka za naznačeni trokut slijedi

$$b^2 = r^2 + a^2 - 2ra\cos\left(\varphi_1 - \varphi_2\right) \quad \Rightarrow \quad 0 = 2r\mathrm{d}r - 2ra\sin\left(\varphi_1 - \varphi_2\right)\mathrm{d}\varphi_2$$

$$\frac{\mathrm{d}r}{\mathrm{d}\varphi_2} = a\sin\left(\varphi_1 - \varphi_2\right)$$

$$y_\mathrm{D} = l\sin\left(\alpha + \varphi_2\right) \quad \Rightarrow \quad \frac{\mathrm{d}y_\mathrm{D}}{\mathrm{d}\varphi_2} = l\cos\left(\alpha + \varphi_2\right) \qquad \frac{\mathrm{d}\varphi_3}{\mathrm{d}\varphi_2} = 0$$

ZADATAK 12 (6)

REDUKCIJA TERETA (TEŽINA) – PREKO SNAGE

$$F\frac{\mathrm{d}r}{\mathrm{d}\varphi_2}=Q\frac{\mathrm{d}y_\mathrm{D}}{\mathrm{d}\varphi_2}+M_3\frac{\mathrm{d}\varphi_3}{\mathrm{d}\varphi_2}$$

$$F\cdot a\sin\left(\varphi_1-\varphi_2\right)=Q\cdot l\cos\left(\alpha+\varphi_2\right)+M_3\cdot 0$$

$$F=Q\cdot\frac{l\cos\left(\varphi_2+\alpha\right)}{a\sin\left(\varphi_1-\varphi_2\right)}$$

ZADATAK 12 (7)

REDUKCIJA MASE TERETA

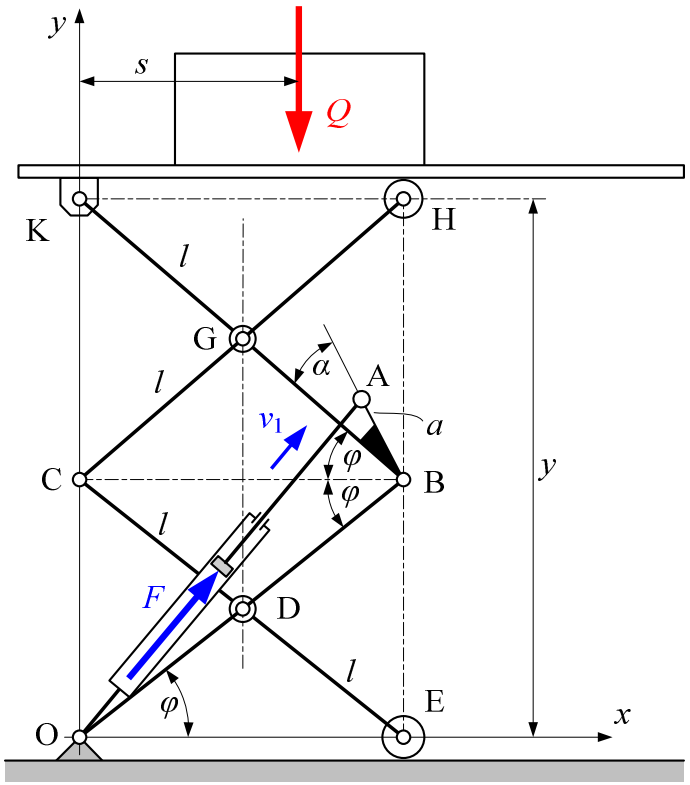
$$\frac{1}{2} m_{\mathrm{r}} \cdot v_{\mathrm{r}}^2 = \frac{1}{2} m \cdot v_{\mathrm{D}}^2$$

$$\frac{\dot{y}_2}{v_{\mathrm{D}}} = \cos\left(\alpha + \varphi_2\right) \quad \Rightarrow \quad v_{\mathrm{D}} = \frac{\dot{y}_2}{\cos\left(\alpha + \varphi_2\right)}$$

$$m_{\mathrm{r}} = m \cdot \left(\frac{v_D}{v_{\mathrm{r}}} \right)^2 = m \cdot \left(\frac{\dot{y}_2}{v_{\mathrm{r}}} \cdot \frac{1}{\cos\left(\alpha + \varphi_2\right)} \right)^2$$

$$m_{\mathrm{r}} = m \cdot \left(\frac{l \cos\left(\varphi_2 + \alpha\right)}{a \sin\left(\varphi_1 - \varphi_2\right)} \cdot \frac{1}{\cos\left(\alpha + \varphi_2\right)} \right)^2 = m \cdot \left(\frac{l}{a \sin\left(\varphi_1 - \varphi_2\right)} \right)^2$$

ZADATAK 13 (1)



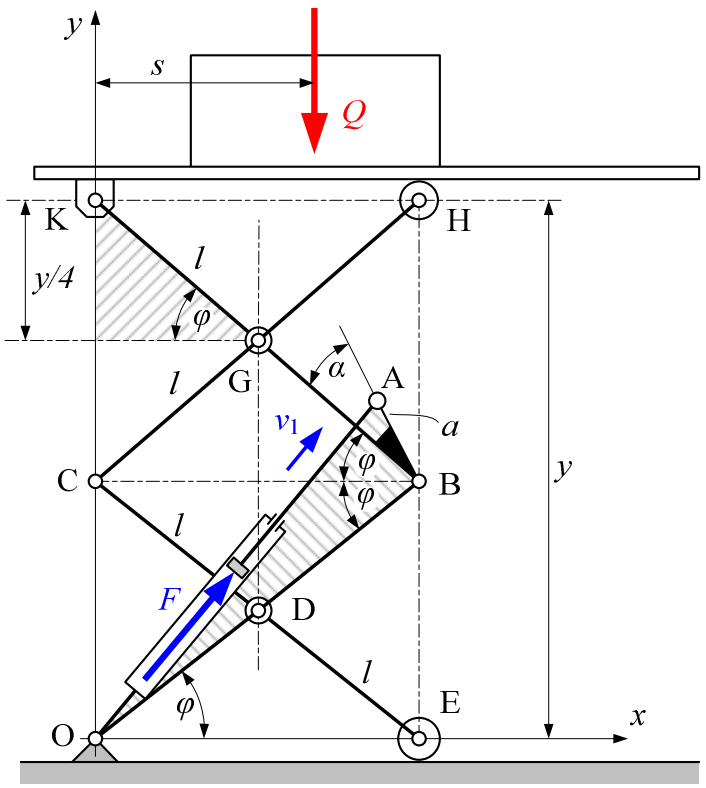
$$F/Q = f(\varphi) = ?$$

$$15° \le \varphi \le 60°$$

$$\alpha = 20°$$

$$l/a = 2$$

ZADATAK 13 (2)



$$\frac{F}{Q}=\frac{\mathrm{d}y}{\mathrm{d}r}=\frac{v_y}{v_1}$$

$$y=4l\sin\varphi \qquad \Rightarrow \qquad \mathrm{d}y=4l\cos\varphi\mathrm{d}\varphi$$

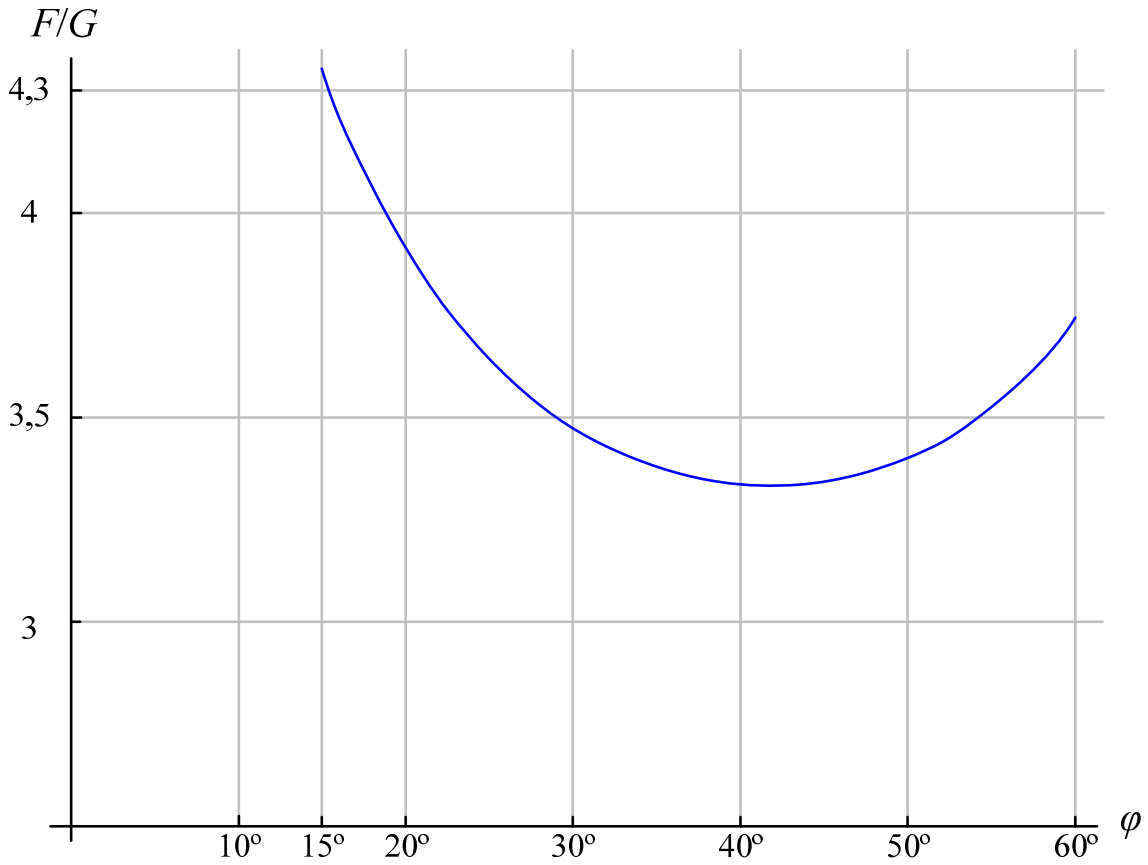
$$r^2=\left(2l\right)^2+a^2-4a\cdot l\cos\left(2\varphi+\alpha\right)$$

$$2r\mathrm{d}r=-4al\left(-\sin\left(2\varphi+\alpha\right)\right)\cdot 2$$

$$\mathrm{d}r=\frac{4a\cdot l}{r}\cdot\sin\left(2\varphi+\alpha\right)\mathrm{d}\varphi$$

ZADATAK 13 (3)

$$\frac{F}{Q}=\frac{\mathrm{d}y}{\mathrm{d}r}=\frac{\cos\varphi}{\sin(2\varphi+\alpha)}\sqrt{1+4\left(\frac{l}{a}\right)^2-4\frac{l}{a}\cos(2\varphi+\alpha)}$$



HIDRAULIČNI POGON

F je uvijek veći od Q –

MULTIPLIKACIJA SILE !!!

ZADATAK 14 (1)

Za vježbu....

Za podizni mehanizam prema slici odrediti:

- sile u pogonskim cilindrima kao funkciju položaja radne košare;
- sile u štapovima $\overline{A_1B_1}$ i $\overline{B_2C_1}$

Za referentne koordinate uzeti : φ_2 i φ_1

Težine polužja mehanizma zanemariti.