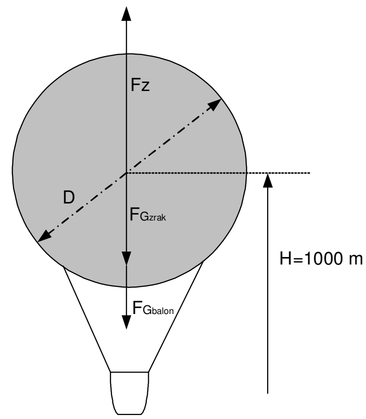
AEROSTATIKA – SILA TLAKA

1. Balon ukupne mase 500 kg i promjera sfere 20 m nalazi se na visini 1000 m u uvjetima standardne atmosfere. Balon je ispunjen zrakom povišene temperature koji se grije plamenom s donje strane (otvoren prema atmosferi). Smatrajući da je zrak u balonu idealno izmiješan odrediti temperaturu zraka da balon bude u ravnoteži.

H = 1000 m
D = 20 m
m = 500 kg



$$V = \frac{1}{6}\pi D^3 = \frac{1}{6}\pi \cdot 20^3 = 4188.8 \quad m^3$$

$$T = T_n - \beta \cdot H = 288.15 - 6.5 \cdot 10^{-3} \cdot 1000 = 281.65 \quad K$$

$$p = p_n \left(1 - 2.256 \cdot 10^{-5} \cdot H\right)^{5.256} = 101325 \cdot \left(1 - 2.256 \cdot 10^{-5} \cdot 1000\right)^{5.256} = 89873 \quad Pa$$

$$\rho = \rho_n \left(1 - 2.256 \cdot 10^{-5} \cdot H\right)^{4.256} = 1.225 \cdot \left(1 - 2.256 \cdot 10^{-5} \cdot 1000\right)^{4.256} = 1.1116 \quad kg/m^3$$

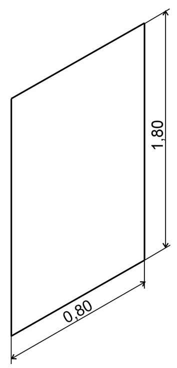
$$F_Z = F_{G_{zrak}} + F_{G_{balon}}$$

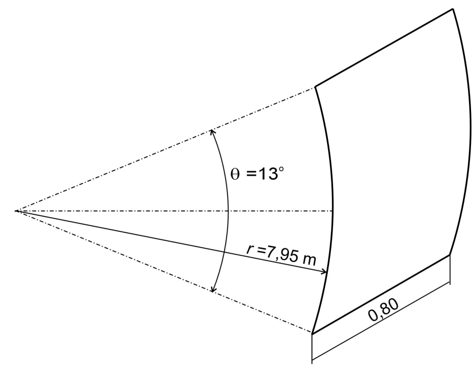
$$\rho g V = \rho_{zrak} g V + mg \,/ \div gV$$

$$\rho_{zrak} = \rho - \frac{m}{V} = 1.1116 - \frac{500}{4188.8} = 0.9922 \quad kg/m^3$$

$$T_{zrak} = \frac{p}{\rho_{zrak} R} = \frac{89873}{0.9922 \cdot 287.053} = 315.5 \quad K \qquad (42.4 \quad °C)$$

2. Izračunaj rezultantnu silu koja djeluje na vrata aviona koji leti na visini 9000 m u uvjetima standardne atmosfere. U unutrašnjosti aviona se, radi udobnosti putnika, održava standardan tlak na razini mora. Oblik i dimenzije vrata su:
   a) pravokutna: $b \times h = 0{,}80 \times 1{,}80$ b) cilindrična prema slici





Rješenje: * standardni tlak na 9000 m: p = 30801 Pa
             * standardni tlak na razini mora: p_n = 101325 Pa

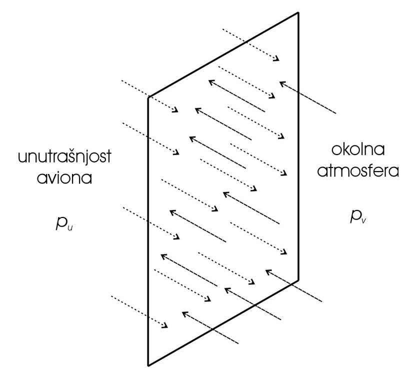
a)

– na vrata djeluje sila uslijed razlike tlaka Δp:

$$\Delta p = p_u - p_v = 101325 - 30801 = 70524 \text{ Pa}$$

$$\text{F} = \Delta p \cdot A = 70524 \cdot 0{,}80 \cdot 1{,}80 = 101555 \text{ N}$$

$$\underline{\text{F} = 101555 \text{ N}}$$



b)

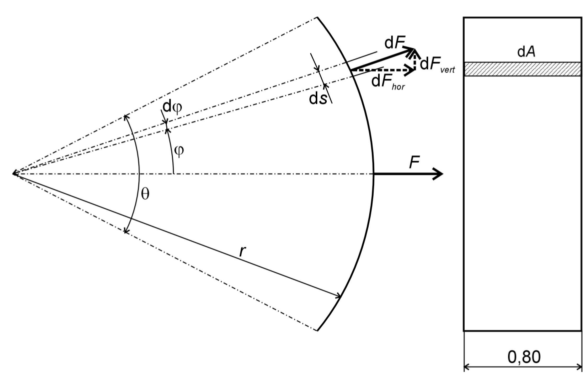
– diferencijalno mala sila dF na diferencijalno malom dijelu vrata dA:

$$\mathrm{d}F = \Delta p \cdot \mathrm{d}A = \Delta p \cdot 0{,}80 \cdot \mathrm{d}s$$
$$\mathrm{d}F = 0{,}80 \cdot \Delta p \cdot r \cdot \mathrm{d}\varphi$$

– komponente diferencijalno male sile dF u horizontalnom i vertikalnom smjeru:

$$\mathrm{d}F_{hor} = \mathrm{d}F \cdot \cos\varphi = 0{,}80 \cdot \Delta p \cdot r \cdot \cos\varphi \cdot \mathrm{d}\varphi$$
$$\mathrm{d}F_{vert} = \mathrm{d}F \cdot \sin\varphi = 0{,}80 \cdot \Delta p \cdot r \cdot \sin\varphi \cdot \mathrm{d}\varphi$$

– integriranjem se dobivaju ukupne komponente sile F_{hor} i F_{vert}:



$$\mathrm{d}A = 0{,}80 \cdot \mathrm{d}s$$

$$\mathrm{d}s = r \cdot \mathrm{d}\varphi$$

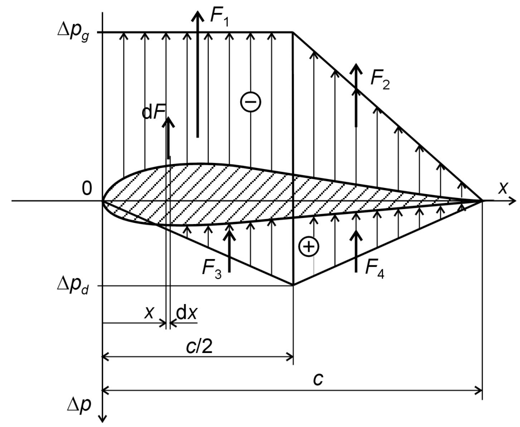
$$F_{hor} = \int_{-\theta/2}^{\theta/2} \mathrm{d}F_{hor} = 0{,}80 \cdot \Delta p \cdot r \cdot \int_{-\theta/2}^{\theta/2} \cos\varphi \, \mathrm{d}\varphi = 0{,}80 \cdot \Delta p \cdot r \cdot \sin\varphi \Big|_{-\theta/2}^{\theta/2} =$$
$$= 0{,}80 \cdot 70524 \cdot 7{,}95 \cdot \left(\sin 6{,}5 - \sin(-6{,}5)\right) = 101551 \text{ N}$$

$$F_{vert} = \int_{-\theta/2}^{\theta/2} \mathrm{d}F_{vert} = 0{,}80 \cdot \Delta p \cdot r \cdot \int_{-\theta/2}^{\theta/2} \sin\varphi \, \mathrm{d}\varphi = -0{,}80 \cdot \Delta p \cdot r \cdot \cos\varphi \Big|_{-\theta/2}^{\theta/2} =$$
$$= 0{,}80 \cdot 70524 \cdot 7{,}95 \cdot (\cos 6{,}5 - \cos(-6{,}5)) = 0 \text{ N}$$

$\underline{F = F_{hor} = 101551 \text{ N}}$

* vertikalna komponenta sile pod b) jednaka je 0 zbog simetričnosti vrata pa je rezultantna sila jednaka horizontalnoj komponenti
* rezultati pod a) i b) su jednaki jer je površina vertikalne projekcije vrata u drugom slučaju jednaka površini vrata pod a):
  $h = 2 \cdot r \cdot \sin(\theta/2) = 2 \cdot 7{,}95 \cdot \sin(13/2) = 1{,}8$ m
* na vrata djeluje sila tlaka koja je jednaka sili težine koju ima masa od preko 10 tona, o čemu treba voditi računa pri dimenzioniranju vrata i šarki

3. Raspored tlaka na gornjaci i donjaci aeroprofila pri nultom napadnom kutu, standardnim uvjetima na razini mora i brzini strujanja od 180 km/h dan je na slici. Relativni tlakovi iznose $\Delta p_g = -100$ mm H_20 i $\Delta p_d = 50$ mm H_20. Duljina tetive je 1 m. Odredi:
   a) silu uzgona po jedinici raspona krila,
   b) koeficijent uzgona,
   c) moment oko napadnog brida,
   d) centar potiska.



Rješenje: $v = 180$ km/h $= 180/3{,}6 = 50$ m/s

$\Delta p_g = -100$ mm H_20 $\rightarrow$

$\Delta p_g = \rho \cdot g \cdot h = 1000 \cdot 9{,}81 \cdot (-0{,}1) = -981$ Pa

$\Delta p_d = 50$ mm H_20 $\rightarrow$

$\Delta p_d = \rho \cdot g \cdot h = 1000 \cdot 9{,}81 \cdot 0{,}05 = 490{,}5$ Pa

$H = 0$ m $\rightarrow$

$p = 101325$ Pa, $\rho = 1{,}225$ kg/m^3

$c = 1$ m

− sila na prvoj polovini gornjake aeroprofila ($0 \le x \le c/2$): $\Delta p_1 = \Delta p_g$

$$F_1 = \int_0^{c/2} \Delta p_1 \cdot 1\mathrm{d}x = \Delta p_g \cdot \int_0^{c/2} \mathrm{d}x = \Delta p_g \cdot \frac{c}{2} = -981 \cdot \frac{1}{2} = -490{,}5 \text{ N}$$

− sila na drugoj polovini gornjake aeroprofila ($c/2 \le x \le c$): $\Delta p_2 = 2 \cdot \Delta p_g \cdot \left(1 - \frac{x}{c}\right)$

$$F_2 = \int_{c/2}^{c} \Delta p_2 \cdot 1\mathrm{d}x = \int_{c/2}^{c} 2 \cdot \Delta p_g \cdot \left(1 - \frac{x}{c}\right)\mathrm{d}x = 2 \cdot \Delta p_g \cdot \left(x - \frac{x^2}{2 \cdot c}\right)_{c/2}^{c} =$$

$$= 2 \cdot \Delta p_g \cdot \left(c - \frac{c^2}{2 \cdot c} - \frac{c}{2} + \frac{c^2}{4 \cdot 2 \cdot c}\right) = 2 \cdot \Delta p_g \cdot \frac{c}{8} = 2 \cdot (-981) \cdot \frac{1}{8} = -245{,}25 \text{ N}$$

− sila na prvoj polovini donjake aeroprofila ($0 \le x \le c/2$): $\Delta p_3 = \frac{2 \cdot \Delta p_d}{c} \cdot x$

$$F_3 = \int_0^{c/2} \Delta p_3 \cdot 1\mathrm{d}x = \Delta p_g \cdot \int_0^{c/2} \frac{2 \cdot \Delta p_d}{c} \cdot x\mathrm{d}x = \frac{2 \cdot \Delta p_d}{c} \cdot \left(\frac{x^2}{2}\right)_0^{c/2} = \frac{2 \cdot \Delta p_d}{c} \cdot \frac{c^2}{4 \cdot 2} = \frac{\Delta p_d \cdot c}{4} =$$

$$= \frac{490{,}5 \cdot 1}{4} = 122{,}625 \text{ N}$$

− sila na drugoj polovini donjake aeroprofila ($c/2 \le x \le c$): $\Delta p_4 = 2 \cdot \Delta p_d \cdot \left(1 - \frac{x}{c}\right)$

$$F_4 = \int_{c/2}^{c} \Delta p_4 \cdot 1\mathrm{d}x = \int_{c/2}^{c} 2 \cdot \Delta p_d \cdot \left(1 - \frac{x}{c}\right)\mathrm{d}x = 2 \cdot \Delta p_d \cdot \left(x - \frac{x^2}{2 \cdot c}\right)_{c/2}^{c} =$$

$$= 2 \cdot \Delta p_d \cdot \left(c - \frac{c^2}{2 \cdot c} - \frac{c}{2} + \frac{c^2}{4 \cdot 2 \cdot c}\right) = 2 \cdot \Delta p_d \cdot \frac{c}{8} = 2 \cdot 490{,}5 \cdot \frac{1}{8} = 122{,}625 \text{ N}$$

a) sila uzgona dobiva se zbrajanjem sila na pojedinim sekcijama površine aeroprofila, negativni predznaci sila na gornjaci uzeti su u obzir na slici i određuju smjer djelovanja sila tako da se u donjoj jednadžbi uvrštavaju apsolutne vrijednosti:

$$F_z = |F_1| + |F_2| + F_3 + F_4 = 490{,}5 + 245{,}25 + 122{,}625 + 122{,}625 = 981\ \mathrm{N}$$

b) $F_z = C_z \cdot \frac{1}{2} \cdot \rho \cdot v^2 \cdot A = C_z \cdot \frac{1}{2} \cdot \rho \cdot v^2 \cdot c \cdot 1 \quad \rightarrow \quad C_z = \frac{2 \cdot F_z}{\rho \cdot v^2 \cdot c} = \frac{2 \cdot 981}{1{,}225 \cdot 50^2 \cdot 1} = 0{,}641$

c) momenti koji povećavaju napadni kut aeroprofila imaju pozitivan predznak, a oni koji ga smanjuju negativan; negativan predznak tlakova Δp_g uzet je u obzir smjerom sila F_1 i F_2 pa se u donjim jednadžama uvrštava njihova apsolutna vrijednost

$$M_0 = -\int_0^{c/2} \Delta p_1(x) \cdot 1 \cdot x\mathrm{d}x - \int_{c/2}^{c} \Delta p_2(x) \cdot 1 \cdot x\mathrm{d}x - \int_0^{c/2} \Delta p_3(x) \cdot 1 \cdot x\mathrm{d}x - \int_{c/2}^{c} \Delta p_4(x) \cdot 1 \cdot x\mathrm{d}x$$

$$M_0 = -|\Delta p_g| \cdot \left(\frac{x^2}{2}\right)\Bigg|_0^{c/2} - \int_{c/2}^{c} 2 \cdot |\Delta p_g| \cdot \left(1 - \frac{x}{c}\right) \cdot x\mathrm{d}x - \int_0^{c/2} \frac{2 \cdot \Delta p_d}{c} \cdot x \cdot x\mathrm{d}x - \int_{c/2}^{c} 2 \cdot \Delta p_d \cdot \left(1 - \frac{x}{c}\right) \cdot x\mathrm{d}x$$

$$M_0 = -|\Delta p_g| \cdot \frac{c^2}{4 \cdot 2} - 2 \cdot |\Delta p_g| \cdot \int_{c/2}^{c} \left(x - \frac{x^2}{c}\right)\mathrm{d}x - \frac{2 \cdot \Delta p_d}{c} \cdot \int_0^{c/2} x^2\mathrm{d}x - 2 \cdot \Delta p_d \cdot \int_{c/2}^{c} \left(x - \frac{x^2}{c}\right)\mathrm{d}x$$

$$M_0 = -|\Delta p_g| \cdot \frac{c^2}{8} - 2 \cdot |\Delta p_g| \cdot \left(\frac{x^2}{2} - \frac{x^3}{3 \cdot c}\right)\Bigg|_{c/2}^{c} - \frac{2 \cdot \Delta p_d}{c} \cdot \left(\frac{x^3}{3}\right)\Bigg|_0^{c/2} - 2 \cdot \Delta p_d \cdot \left(\frac{x^2}{2} - \frac{x^3}{3 \cdot c}\right)\Bigg|_{c/2}^{c}$$

$$M_0 = -|\Delta p_g| \cdot \frac{c^2}{8} - 2 \cdot |\Delta p_g| \cdot \left(\frac{c^2}{2} - \frac{c^3}{3 \cdot c} - \frac{c^2}{4 \cdot 2} + \frac{c^3}{8 \cdot 3 \cdot c}\right) - \frac{2 \cdot \Delta p_d}{c} \cdot \left(\frac{c^3}{8 \cdot 3}\right) -$$

$$- 2 \cdot \Delta p_d \cdot \left(\frac{c^2}{2} - \frac{c^3}{3 \cdot c} - \frac{c^2}{4 \cdot 2} + \frac{c^3}{8 \cdot 3 \cdot c}\right) = -|\Delta p_g| \cdot \frac{c^2}{8} - 2 \cdot |\Delta p_g| \cdot \frac{c^2}{12} - \Delta p_d \cdot \frac{c^2}{12} - 2 \cdot \Delta p_d \cdot \frac{c^2}{12}$$

$$M_0 = -981 \cdot \frac{1^2}{8} - 981 \cdot \frac{1^2}{6} - 490{,}5 \cdot \frac{1^2}{12} - 490{,}5 \cdot \frac{1^2}{6} = -408{,}75\ \mathrm{Nm}$$

d) $M_0 = -F_z \cdot x_{CP} \quad \rightarrow \quad x_{CP} = \frac{-M_0}{F_z} = \frac{408{,}75}{981} = 0{,}4167\ \mathrm{m}$

$$\bar{x}_{CP} = \frac{x_{CP}}{c} = \frac{0{,}4167}{1} = 0{,}4167 = 41{,}67\ \%$$

<u>Rješenje na drugi način</u> – zadatak se može riješiti i tako da se izračunaju srednji tlakovi na pojedinim sekcijama aeroprofila:

$$\Delta\overline{p}_1 = \Delta p_g = -981\ \text{Pa}\ ;\quad \Delta\overline{p}_2 = \frac{\Delta p_g}{2} = \frac{-981}{2} = -490{,}5\ \text{Pa}\ ;\quad \Delta\overline{p}_3 = \Delta\overline{p}_4 = \frac{\Delta p_d}{2} = \frac{490{,}5}{2} = 245{,}25\text{Pa}$$

$$F_1 = \Delta\overline{p}_1 \cdot \frac{c}{2} \cdot 1 = -981 \cdot \frac{1}{2} = -490{,}5\ \text{N} \qquad F_3 = \Delta\overline{p}_3 \cdot \frac{c}{2} \cdot 1 = 245{,}25 \cdot \frac{1}{2} = 122{,}625\ \text{N}$$

$$F_2 = \Delta\overline{p}_2 \cdot \frac{c}{2} \cdot 1 = -490{,}5 \cdot \frac{1}{2} = -245{,}25\ \text{N} \qquad F_4 = \Delta\overline{p}_4 \cdot \frac{c}{2} \cdot 1 = 245{,}25 \cdot \frac{1}{2} = 122{,}625\ \text{N}$$

$$F_z = |F_1| + |F_2| + F_3 + F_4 = 490{,}5 + 245{,}25 + 122{,}625 + 122{,}625 = 981\ \text{N}$$

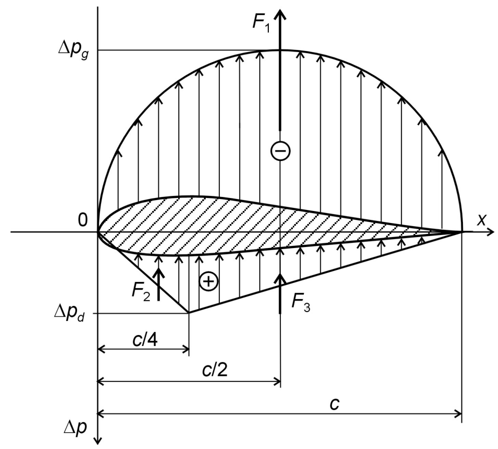
– kod izračuna momenta ili centra potiska treba znati da je hvatište sile u težištu lika koji opisuje raspodjelu tlaka na promatranoj sekciji aeroprofila (to se može pokazati i integriranjem):

$$M_0 = -|F_1| \cdot x_1 - |F_2| \cdot x_2 - F_3 \cdot x_3 - F_4 \cdot x_4 = -|F_1| \cdot \frac{c}{4} - |F_2| \cdot \left(\frac{c}{2} + \frac{1}{3} \cdot \frac{c}{2}\right) - F_3 \cdot \frac{2}{3} \cdot \frac{c}{2} - F_4 \cdot \left(\frac{c}{2} + \frac{1}{3} \cdot \frac{c}{2}\right)$$

$$M_0 = -|F_1| \cdot \frac{c}{4} - |F_2| \cdot \frac{2}{3} \cdot c - F_3 \cdot \frac{1}{3} \cdot c - F_4 \cdot \frac{2}{3} \cdot c = -490{,}5 \cdot \frac{1}{4} - 245{,}25 \cdot \frac{2}{3} \cdot 1 - 122{,}625 \cdot \frac{1}{3} \cdot 1 - 122{,}625 \cdot \frac{2}{3} \cdot 1$$

$$M_0 = -408{,}75\ \text{Nm}$$

4. Raspored tlaka na gornjaci i donjaci aeroprofila pri nultom napadnom kutu, standardnim uvjetima na razini mora i brzini strujanja od 180 km/h dan je na slici. Relativni tlakovi iznose $\Delta p_g = -500$ Pa i $\Delta p_d = 100$ Pa. Duljina tetive je 1 m. Odredi:
   a) silu uzgona po jedinici raspona krila,
   b) koeficijent uzgona,
   c) moment oko napadnog brida,
   d) koeficijent momenta oko napadnog brida,
   e) centar potiska.



Rješenje:
$v = 180$ km/h $= 180/3{,}6 = 50$ m/s
$\Delta p_g = -500$ Pa
$\Delta p_d = 100$ Pa
$c = 1$ m
$H = 0$ m $\rightarrow$
$p = 101325$ Pa, $\rho = 1{,}225$ kg/m^3

– srednji tlak na gornjaci zatvara jednaku površinu iznad tetive kao i dana polukružna raspodjela, polumjer kružnice odgovara tlaku Δp_g i polovini duljine tetive $c/2$: $r \equiv \Delta p_g \equiv c/2$

a) $$\Delta \overline{p}_g \cdot c = \frac{1}{2} \cdot r^2 \cdot \pi \equiv \frac{1}{2} \cdot \Delta p_g \cdot \frac{c}{2} \cdot \pi \quad \rightarrow \quad \Delta \overline{p}_g = \frac{1}{4} \cdot \Delta p_g \cdot \pi = \frac{1}{4} \cdot (-500) \cdot \pi = -392{,}7 \text{ Pa}$$

$$\Delta \overline{p}_1 = \Delta \overline{p}_g = -392{,}7 \text{ Pa} \quad ; \quad \Delta \overline{p}_2 = \Delta \overline{p}_3 = \frac{\Delta p_d}{2} = \frac{100}{2} = 50 \text{ Pa}$$

$$F_1 = \Delta \overline{p}_1 \cdot c \cdot 1 = -392{,}7 \cdot 1 = -392{,}7 \text{ N}$$
$$F_2 = \Delta \overline{p}_2 \cdot \frac{c}{4} \cdot 1 = 50 \cdot \frac{1}{4} = 12{,}5 \text{ N}$$
$$F_3 = \Delta \overline{p}_3 \cdot \frac{3 \cdot c}{4} \cdot 1 = 50 \cdot \frac{3 \cdot 1}{4} = 37{,}5 \text{ N}$$

$$F_z = |F_1| + F_2 + F_3 = 392{,}7 + 12{,}5 + 37{,}5 = 442{,}7 \text{ N}$$

b) $$F_z = C_z \cdot \frac{1}{2} \cdot \rho \cdot v^2 \cdot A = C_z \cdot \frac{1}{2} \cdot \rho \cdot v^2 \cdot c \cdot 1 \quad \rightarrow \quad C_z = \frac{2 \cdot F_z}{\rho \cdot v^2 \cdot c} = \frac{2 \cdot 442{,}7}{1{,}225 \cdot 50^2 \cdot 1} = 0{,}289$$

c) $$M_0 = -|F_1| \cdot x_1 - |F_2| \cdot x_2 - F_3 \cdot x_3 = -|F_1| \cdot \frac{c}{2} - |F_2| \cdot \frac{2}{3} \cdot \frac{c}{4} - F_3 \cdot \left(\frac{c}{4} + \frac{1}{3} \cdot \frac{3 \cdot c}{4} \right)$$

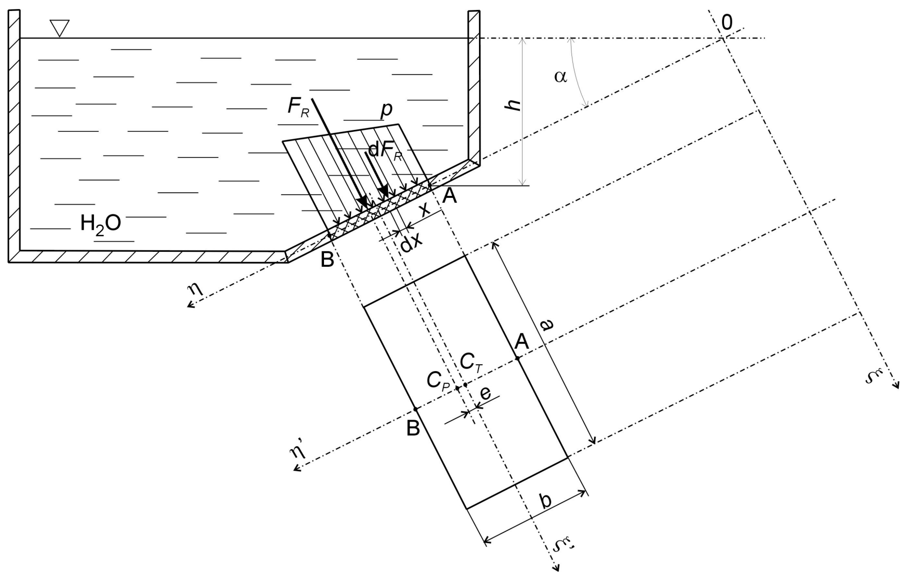
$$M_0 = -392{,}7 \cdot \frac{1}{2} - 12{,}5 \cdot \frac{2}{3} \cdot \frac{1}{4} - 37{,}5 \cdot \left(\frac{1}{4} + \frac{1}{3} \cdot \frac{3 \cdot 1}{4} \right) = -217{,}2 \text{ Nm}$$

d) $$M_0 = C_{M0} \cdot \frac{1}{2} \cdot \rho \cdot v^2 \cdot A \cdot c = C_{M0} \cdot \frac{1}{2} \cdot \rho \cdot v^2 \cdot c \cdot 1 \cdot c \quad \rightarrow$$

$$C_{M0} = \frac{2 \cdot M_0}{\rho \cdot v^2 \cdot c^2} = \frac{2 \cdot (-217{,}2)}{1{,}225 \cdot 50^2 \cdot 1^2} = -0{,}142$$

e) $$M_0 = -F_z \cdot x_{CP} \quad \rightarrow \quad x_{CP} = \frac{-M_0}{F_z} = \frac{217{,}2}{442{,}7} = 0{,}491 \text{ m}$$

4. Pri dnu spremnika nalazi se pravokutni otvor dimenzija a x b = 2 x 1 m koji se zatvara poklopcem prema slici. Odredi silu tlaka vode na poklopac i hvatište sile.



Podaci:
$a = 2$ m
$b = 1$ m
$\alpha = 30^{\circ}$
$h = 4$ m
$\rho_v = 1000$ kg/m^3

Rješenje:

$$\mathrm{d}F_R = p \cdot \mathrm{d}A$$

$$p = \rho \cdot g \cdot h + \rho \cdot g \cdot x \cdot \sin\alpha$$
$$\mathrm{d}A = a \cdot \mathrm{d}x$$

$$\mathrm{d}F_R = (\rho \cdot g \cdot h + \rho \cdot g \cdot x \cdot \sin\alpha) \cdot a \cdot \mathrm{d}x = \rho \cdot g \cdot (h + x \cdot \sin\alpha) \cdot a \cdot \mathrm{d}x$$

$$F_R = \int_0^b \rho \cdot g \cdot (h + x \cdot \sin\alpha) \cdot a \cdot \mathrm{d}x = \rho \cdot g \cdot a \cdot \int_0^b (h + x \cdot \sin\alpha)\mathrm{d}x = \rho \cdot g \cdot a \cdot \left(h \cdot x + \frac{x^2}{2} \cdot \sin\alpha \right)\Bigg|_0^b =$$

$$= \rho \cdot g \cdot a \cdot \left(h \cdot b + \frac{b^2}{2} \cdot \sin\alpha \right) = 1000 \cdot 9{,}81 \cdot 2 \cdot \left(4 \cdot 1 + \frac{1^2}{2} \cdot \sin 30 \right) = 83385\ \mathrm{N}$$

– ili, jednostavnije, ako se odredi srednji tlak na poklopcu: $\overline{p} = \rho \cdot g \cdot \left(h + \frac{b}{2} \cdot \sin\alpha \right)$

$$F_R = \overline{p} \cdot A = \rho \cdot g \cdot \left(h + \frac{b}{2} \cdot \sin\alpha \right) \cdot a \cdot b = 1000 \cdot 9{,}81 \cdot \left(4 + \frac{1}{2} \cdot \sin 30 \right) \cdot 2 \cdot 1 = 83385\ \mathrm{N}$$

– ekscentricitet (udaljenost hvatišta sile od težišta površine poklopca):

$$e = \frac{I_{\xi'}}{A \cdot \eta_t} = \frac{\dfrac{a \cdot b^3}{12}}{a \cdot b \cdot \left(\dfrac{h}{\sin\alpha} + \dfrac{b}{2} \right)} = \frac{b^2}{12 \cdot \left(\dfrac{h}{\sin\alpha} + \dfrac{b}{2} \right)} = \frac{1^2}{12 \cdot \left(\dfrac{4}{\sin 30} + \dfrac{1}{2} \right)} = 0{,}00980\ \mathrm{m} = 9{,}8\ \mathrm{mm}$$

($I_{\xi'} = \dfrac{a \cdot b^3}{12}$ – moment inercije (tromosti) pravokutne površine)

– hvatište sile tlaka na poklopac: $\eta_p = \eta_t + e = \left(\dfrac{h}{\sin\alpha} + \dfrac{b}{2} \right) + e = \dfrac{4}{\sin 30} + \dfrac{1}{2} + 0{,}00980 = 8{,}5098\ \mathrm{m}$

– moment oko točke A: $\mathrm{d}M_A = x \cdot \mathrm{d}F_R = p \cdot x \cdot \mathrm{d}A = p \cdot a \cdot x \cdot \mathrm{d}x = \rho \cdot g \cdot (h + x \cdot \sin\alpha) \cdot a \cdot x \cdot \mathrm{d}x$

$$M_A=\int_0^b \rho\cdot g\cdot(h+x\cdot\sin\alpha)\cdot a\cdot x\cdot \mathrm{d}x=\rho\cdot g\cdot a\cdot\int_0^b (h+x\cdot\sin\alpha)\cdot x\cdot \mathrm{d}x=\rho\cdot g\cdot a\cdot\left(h\cdot\frac{x^2}{2}+\frac{x^3}{3}\cdot\sin\alpha\right)\Bigg|_0^b=$$

$$=\rho\cdot g\cdot a\cdot\left(h\cdot\frac{b^2}{2}+\frac{b^3}{3}\cdot\sin\alpha\right)=1000\cdot 9{,}81\cdot 2\cdot\left(4\cdot\frac{1^2}{2}+\frac{1^3}{3}\cdot\sin 30\right)=42510\ \mathrm{Nm}$$

– provjera: $M_A=F_R\cdot\left(\frac{b}{2}+e\right)=83385\cdot\left(\frac{1}{2}+0{,}0098\right)=42510\ \mathrm{Nm}$