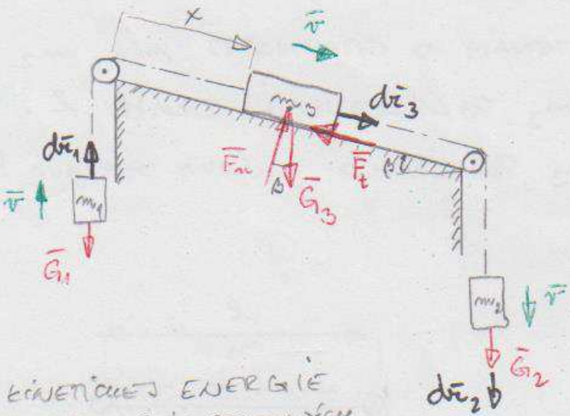
Príklad: Po drsnej naklonenej rovine sa z pokoja pohybuje bremeno m_3 lanom prevlečeným cez kladky je spojené s bremenami m_1 a m_2. Určte rýchlosť bremena m_3 po prejdení dráhy x. Ostatné pasívne odpory zanedbajte.

D: $m_1, m_2, m_3\,[kg]$

$f_3\,[-]$, $x\,[m]$, $\beta\,[°]$

H: v_3



$t_0 = 0\ ;\ \bar v_0 = \bar 0$

VETA O ZMENE KINETICKEJ ENERGIE

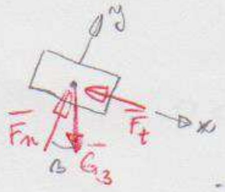
$$E_k - E_{k0} = A_p$$ PRÁCA PRACOVNÝCH SÍL

V ČASE $t_0 = 0$ JE SÚSTAVA V POKOJI $\rightarrow E_{k0} = 0$

$$\Delta E_k = \frac{1}{2}(m_1 + m_2 + m_3)\,v^2$$

F_n – nie je pracovná sila

$$dA_p = \sum_{i=1}^{3} \bar F_i\, d\bar r_i = \bar G_1\, d\bar r_1 + \bar G_2\, d\bar r_2 + (\bar G_3 + \bar F_t)\, d\bar r_3$$



$$\sum F_{iy} = 0: \quad 0 = F_n - G_3 \cos\beta$$

$$F_n = G_3 \cos\beta$$

$$F_t = f\, F_n = f.\, G_3 \cos\beta$$

$$dA_p = G_1 .\, dr_1 \overset{=-1}{\cos\pi} + G_2\, dr_2 \overset{=1}{\cos 0} + G_3\, dr_3 \underbrace{\cos\left(\frac{\pi}{2} - \beta\right)}_{\sin\beta} + F_t\, dr_3 \overset{=-1}{\cos\pi}$$

$$dr_1 = dr_2 = dr_3 = dx$$

$$dA_p = -G_1\, dx + G_2\, dx + G_3\, dx \sin\beta - f.\, G_3 \cos\beta\, dx$$

$$dA_p = (-G_1 + G_2 + G_3 \sin\beta - f\, G_3 \cos\beta)\, dx$$

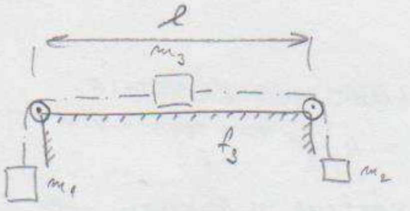
$$\int dA_p = g(-m_1 + m_2 + m_3 \sin\beta - f\, m_3 \cos\beta) \int_0^x dx$$

$$A_p = gx(m_2 - m_1 + m_3 .\sin\beta - f.\, m_3 \cos\beta) = \frac{1}{2}(m_1 + m_2 + m_3)\,v^2$$

$$v_3 = \sqrt{\frac{2gx(m_2 - m_1 + m_3 \sin\beta - f.\, m_3 \cos\beta)}{m_1 + m_2 + m_3}}$$

D.Ú.: BREMENO O HMOTNOSTI m_3 SA POHYBUJE PO DRSNEJ VODOROVNEJ PODLOŽKE PROSTREDNÍCTVOM LÁN, KTORÉ SÚ PREVLEČENÉ CEZ KLADKY A PRIPOJENÉ K BREMENÁM O HMOTNOSTI m_1, m_2. AKÁ BUDE RÝCHLOSŤ BREMENA m_3 PO PREJDENÍ DRÁHY l? AKÁ JE PODMIENKA ABY SA BREMENO m_3 POHYBOVALO Z ĽAVA DOPRAVA?

D: m_1, m_2, m_3, l, f_3



H: v_3

viď príklad $\boxed{A=0}$

$$v_3 = \sqrt{\frac{2gx(m_2 - m_1 - f_3 m_3)}{m_1 + m_2 + m_3}}$$

PODMIENKA PRE POHYB Z ĽAVA DO PRAVA

$$v_3 > 0$$

$$(m_2 - m_1 - f_3 m_3) > 0$$

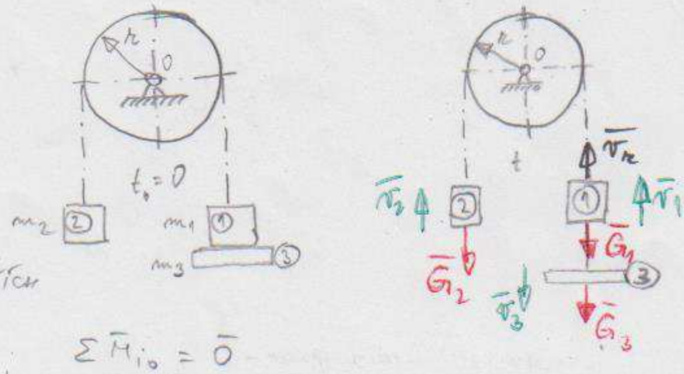
$$m_2 > m_1 + f_3 m_3$$

Príklad: Cez kladku s polomerom r je prevlečené lano, na ktorom je zavesená plošina (3). Na nej stojí človek (1). Plošina s človekom je vyvážená protizávažím (2). Určte výslednú rýchlosť človeka a protizávažia, ak človek začne šplhať po lane ku kladke rýchlosťou $\bar{v}_r$. Pasívne odpory, hmotnosť lana a kladky zanedbajte.

D: $m_1, m_3 [kg]$

$r[m]$, $v_r [ms^{-1}]$

H: v_1, v_2 ✓



MOMENTY VONKAJŠÍCH SÍL

$$\frac{d\bar{L}_0}{dt} = \sum \bar{M}_{i0} \quad ; \quad \sum \bar{M}_{i0} = \bar{0}$$

MOMENT HYBNOSTI SHB k bodu O

$$\frac{dL_0}{dt} = 0 \Rightarrow L_0 = \sum L_{i0} = konšt.$$

$$\left(\bar{L}_0 = \sum \bar{r}_i \times m \bar{v}_i\right)$$

V ČASE $t_0 = 0$ JE SÚSTAVA V POKOJI $\rightarrow L_0 = 0$!

$$L_0 = m_1 v_1 r - m_2 v_2 r - m_3 v_3 r = 0$$

$$m_1 v_1 - m_2 v_2 - m_3 v_3 = 0 \quad ; \quad v_2 = v_3$$

$$m_2 = m_1 + m_3 .$$

$$m_1 v_1 - (m_1 + m_3) v_2 - m_3 v_2 = 0$$

$$v_1 = \frac{(m_1 + 2m_3) v_2}{m_1} \quad ; \quad v_1 = v_r - v_2$$

UNÁŠAVÁ RÝCHLOSŤ

$$v_r - v_2 = \frac{m_1 + 2m_3}{m_1} v_2 \Longrightarrow v_r = \frac{m_1 + 2m_3 + m_1}{m_1} v_2 = \frac{2(m_1 + m_3)}{m_1} v_2$$

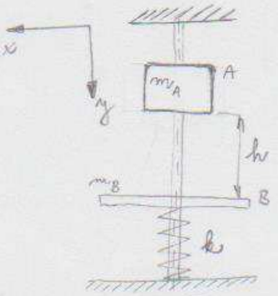
$$v_3 = v_2 = \frac{m_1}{2(m_1 + m_3)} v_r$$

$$v_1 = \frac{(m_1 + 2m_3)}{2(m_1 + m_3)} v_r$$

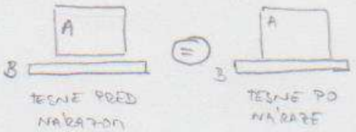
Príklad: Na zvislej tyči je umiestnení posúvač A a doska B. Na dosku, ktorá je v kľude položená na pružine dopadá posúvač z výšky h. Určte rýchlosť posúvača a dosky ihneď po náraze, stratu energie v percentách, impulz sily pri dopade posúvača na dosku a maximálnu výchylku dosky po náraze.

D: $m_A = 4$ kg
$m_B = 2$ kg
$k = 500$ N/m
$h = 1$ m

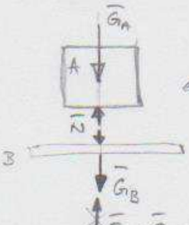
H: $v_A,\ v_B,\ \Delta E_k,\ I,\ y_{max}$



a) v_A, v_B



$\bar{H} = \sum m_i \cdot \bar{v}_i$



$v_{Amax} = \sqrt{2gh} = \sqrt{2 \cdot 9{,}81 \cdot 1} = 4{,}43\ m \cdot s^{-1}$

$y: \quad m_A v_{Amax} + m_B \cdot 0 = (m_A + m_B) v_{A,B}$

$\bar{F}_k = \bar{0}$ – V OKAMIHU NÁRAZU JE NESTLAČENÁ!

$v_{A,B} = \frac{m_A}{m_A + m_B} \cdot v_{Amax} = \frac{4}{4+2} \cdot 4{,}43 = 2{,}953\ m \cdot s^{-1}$

b) $\Delta E_k = ?$

STRATA E_k v % $= \left| \frac{\Delta E_k}{E_{k0}} \right| \cdot 100 = \left| \frac{E_{k1} - E_{k0}}{E_{k0}} \right| \cdot 100$; $E_k = \sum E_{ki}$

$E_{k0} = \frac{1}{2} m_A v_A^2 + 0 = \frac{1}{2} \cdot 4 \cdot 4{,}43^2 = 39{,}25\ J$

$E_{k1} = \frac{1}{2} (m_A + m_B) v_{AB}^2 = \frac{1}{2} (4+2) \cdot 2{,}953^2 = 26{,}16\ J$

$\left| \frac{26{,}16 - 39{,}25}{39{,}25} \right| \cdot 100 = 33{,}35\ \%$

c) $I = ?$ $\quad \bar{H}_1 - \bar{H}_0 = \int_{t_0}^{t} \sum \bar{F}_i\, dt = I$

A $\quad y: \quad I_A = -\int_0^t N\, dt = (m_A v_{A,B} - m_A v_{Amax})$

$I_A = m_A (v_{Amax} - v_{AB}) = 4 \cdot (4{,}43 - 2{,}953)$

$I_A = 5{,}91\ Ns$

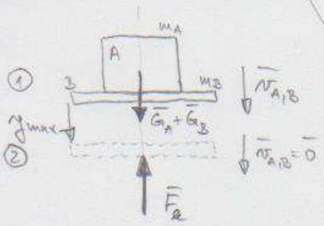
B $\quad y: \quad I_B = \int_0^t N\, dt = m_B \cdot v_{A,B} - m_B \cdot 0$

$I_B = m_B \cdot v_{AB} = 2 \cdot 2{,}953$

$I_B = 5{,}91\ Ns$

d) $y_{max} = ?$ $\quad E_{k2} - E_{k1} = A$; $dA = (G_A + G_B - F_k)\, dy$; $F_k = k \cdot y$

$A = \int_0^{y_{max}} [g(m_A + m_B) - ky]\, dy = -\frac{1}{2} k y_{max}^2 + g(m_A + m_B) y_{max}$



$\frac{1}{2}(m_A + m_B) 0^2 - \frac{1}{2}(m_A + m_B) v_{A,B}^2 = -\frac{1}{2} k y_{max}^2 + g(m_A + m_B) y_{max}$

$\underbrace{k}_{a} y_{max}^2 \underbrace{- 2g(m_A + m_B)}_{b} y_{max} \underbrace{- (m_A + m_B) v_{AB}^2}_{c} = 0$

$a\, y_{max}^2 + b\, y_{max} + c = 0$

$a = k = 500$

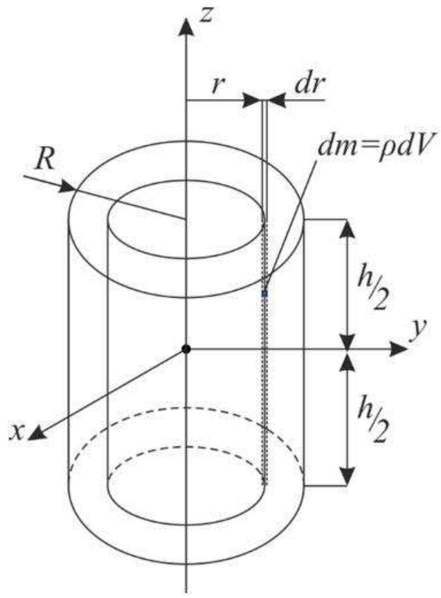
$b = -2g(m_A + m_B) = -2 \cdot 9{,}81 (4+2) = -117{,}72$

$c = -(m_A + m_B) v_{AB}^2 = -(4+2) \cdot 2{,}953^2 = -52{,}32$

$y_{max} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{117{,}72 \pm \sqrt{(-117{,}72)^2 - 4 \cdot 500 (-52{,}32)}}{2 \cdot 500}$

$y_{max} = \frac{117{,}72 \pm 344{,}32}{1000} = \begin{cases} 0{,}462\ m \ ✓ \\ -0{,}226\ m \ ✗ \end{cases}$

GEOMETRIA HMÔT



$$dI_z = r^2\,dm \; ; \qquad dm = \rho\,dV = \rho\,dA\,h = \rho\,2\pi r\,dr\,h \; ; \; m = \rho\pi R^2 h$$

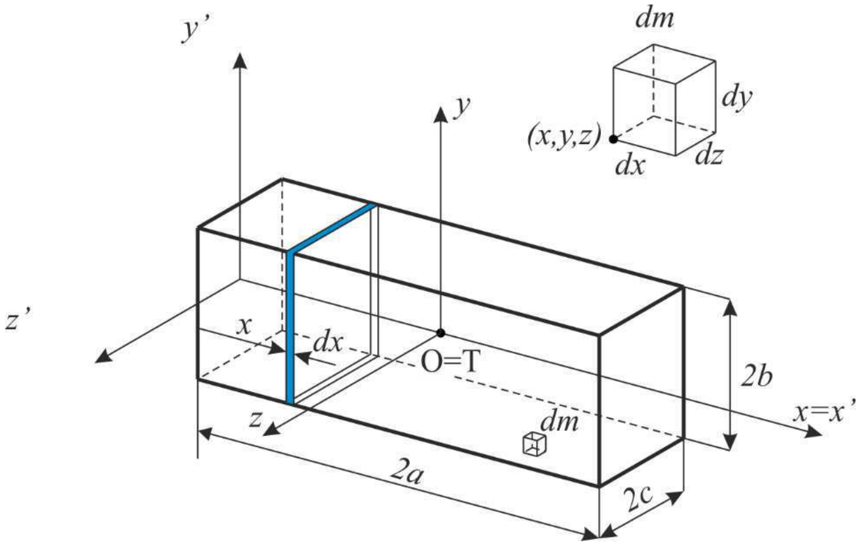
$$I_z = 2\pi\rho h \int_0^R r^3\,dr = \frac{1}{2}\pi\rho R^4 h$$

$$I_z = \frac{1}{2} m R^2$$

Príklad: Vypočítajte momenty zotrvačnosti homogénneho hranola hmotnosti m k počiatku 0 súradnicového systému, k rovine $y'z'$ a k osiam x, y, z prechádzajúcich ťažiskom.

D: $m[kg],\ a, b, c[m]$

H: $I_p, I_{yz}, I_x, I_y, I_z$



1) Momenty zotrvačnosti k osiam

$$I_x = \int_m (y^2 + z^2)\mathrm{d}m$$

$$dm = \rho dV = \rho dxdydz$$

$$\rho = \frac{m}{V} = \frac{m}{8abc}$$

$$I_x = \int_x\int_y\int_z \rho(y^2 + z^2)dxdydz$$

$$I_x = \int_x\int_y\int_z \rho(y^2 + z^2)dxdydz = \iiint_{x\,y\,z} \frac{m}{8abc}(y^2+z^2)dxdydz = \underbrace{\frac{m}{8abc}}_{=\rho}\int_{-a}^{a}\int_{-b}^{b}\int_{-c}^{c}(y^2+z^2)\,dx\,dy\,dz = \rho\int_{-b}^{b}\int_{-c}^{c}\left[(y^2+z^2)x\right]_{-a}^{a}dy\,dz =$$

$$= \rho\int_{-b}^{b}\int_{-c}^{c}2a(y^2+z^2)\,dy\,dz = 2a\rho\int_{-c}^{c}\left[\frac{y^3}{3}+z^2y\right]_{-b}^{b}dz = 2a\rho\int_{-c}^{c}\left[\frac{2b^3}{3}+2z^2b\right]dz = 4ab\rho\left[\frac{b^2}{3}z+\frac{z^3}{3}\right]_{-c}^{c} = 4ab\rho\left[\frac{2b^2}{3}c+\frac{2c^3}{3}\right] =$$

$$= \frac{8abc}{3}\rho(b^2+c^2) = \frac{8abc}{3}\frac{m}{8abc}(b^2+c^2) = \frac{m}{3}(b^2+c^2)$$

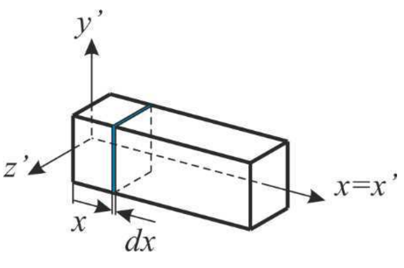
$I_x = \frac{m}{3}(b^2+c^2)$; analogicky $I_y = \frac{m}{3}(a^2+c^2)$; $I_z = \frac{m}{3}(a^2+b^2)$

Poznámka: pomocou Steinerovej vety:

$$I_{y'} = I_y + m.a^2 = \frac{m}{3}(a^2+c^2) + m.a^2 = \frac{m}{3}(4a^2+c^2)$$

$$I_{z'} = I_z + m a^2 = \frac{m}{3}(a^2+b^2) + m.a^2 = \frac{m}{3}(4a^2+b^2)$$

2) Momenty zotrvačnosti k rovinám



$I_{y'z'} = \int_{(m)} x'^2 dm$; $dm = \rho dV = \rho\, 4bc\, dx'$; $\rho = \frac{m}{8abc}$

$$I_{y'z'} = 4bc\rho\int_0^{2a} x'^2 dx' = 4bc\rho\frac{(2a)^3}{3} = 4bc\frac{m}{8abc}\cdot\frac{8a^3}{3}$$

$$I_{y'z'} = \frac{4}{3}ma^2$$

POZNÁMKA: pomocou Steiner. vety:

$$I_{y'z'} = I_{yz} + m.a^2$$

$$I_{yz} = I_{y'z'} - m.a^2 = \frac{4}{3}ma^2 - ma^2 = \frac{1}{3}ma^2$$

3) Polárny moment zotrvačnosti

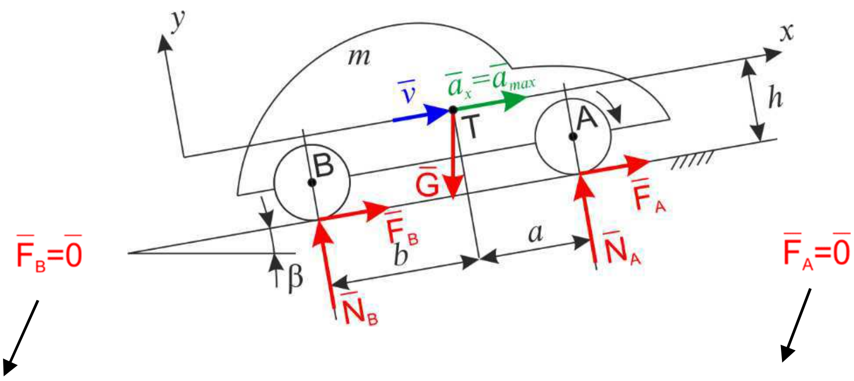
$$I_x = I_p - I_{yz} \rightarrow I_p = I_x + I_{yz} = \frac{m}{3}b^2 + c^2 + \frac{m}{3}a^2 = \frac{m}{3}(a^2 + b^2 + c^2)$$

4.2. Posuvný pohyb telesa

Príklad: Vozidlo hmotnosti m sa začne pohybovať z pokoja smerom nahor naklonenou rovinou. Vypočítajte maximálne možné zrýchlenie vozidla ak je poháňaná a) predná náprava, b) zadná náprava a c) sú poháňané obe nápravy.

D: $m = 1400\,kg$
$\beta = 10°$
$a = 1,2\,m$
$b = 1,3\,m$
$h = 0,4\,m$
$f = 0,8$

H: F_A, a_x



a) Hnaná predná náprava

$x: \quad ma_x = F_A - G\sin\beta \quad (1)$

$y: \quad 0 = N_A + N_B - G\cos\beta \quad (2) \quad \text{->} \; N_B$

$M_C: \quad 0 = F_A h + N_A a - N_B b \quad (3)$

$F_A = f\,N_A \quad (4)$

$$N_A = \frac{bmg\cos\beta}{a+b+fh} = \frac{1,3*1400*9,81*\cos 10°}{1,2+1,3+0,8*0,4} = 6235,1\,N$$

$$N_B = mg\cos\beta - N_A = 1400*9,81*\cos 10° - 6235,1 = 7290,3\,N$$

$$F_A = f\,N_A = 0,8*6235,1N = 4988,1\,N$$

$$a_x = \frac{F_A}{m} - g\sin\beta = \frac{4988,1}{1400} - 9,81\sin 10° = 1,86\,ms^{-2}$$

b) Hnaná zadná náprava

$x: \quad ma_x = F_B - G\sin\beta \quad (1)$

$y: \quad 0 = N_A + N_B - G\cos\beta \quad (2)$

$M_C: \quad 0 = F_B h + N_A a - N_B b \quad (3)$

$F_B = f\,N_B \quad (4)$

$$N_B = \frac{amg\cos\beta}{a+b-fh} = \ldots = 7445,1\,N$$

$$N_A = mg\cos\beta - N_B = \ldots = 6080\,N$$

$$F_B = f\,N_B = \ldots = 5956,1\,N$$

$$a_x = \frac{F_B}{m} - g\sin\beta = \ldots = 2,55\,ms^{-2}$$

c) Hnané obe nápravy

$x: \quad ma_x = F_A + F_B - G\sin\beta \quad (1)$

$y: \quad 0 = N_A + N_B - G\cos\beta \quad (2)$

$M_C: \quad 0 = F_A h + F_B h + N_A a - N_B b \quad (3)$

$F_A = f\,N_A \quad (4)$

$F_B = f\,N_B \quad (5)$

$$N_A = \frac{mg\cos\beta(b - fh)}{a+b} = \ldots = 5301,9\,N$$

$$N_B = mg\cos\beta - N_A = \ldots = 8223,5\,N$$

$$F_A = f\,N_A = \ldots = 4241,5\,N$$

$$F_B = f\,N_B = \ldots = 6578,8\,N$$

$$a_x = \frac{F_A + F_B}{m} - g\sin\beta = \ldots = 6,025\,ms^{-2}$$

Pozn.: $\bar{F}_A$ a $\bar{F}_B$ sú tangenciálne reakcie = trakčné sily. Maximálne zrýchlenie je dané trakciou telies = schopnosť kolies odvaľovať sa po povrchu vozovky bez šmýkania.

Príklad: Tyč AB hmotnosti m je dvíhaná z pokoja pomocou rovnobežných prútov zanedbateľnej hmotnosti. Spodný prút sa otáča okolo bodu E vplyvom momentu M. Určte uhlové zrýchlenie α ako funkciu uhla pootočenia φ a silu v prúte BD v okamihu kedy $\varphi = 30°$

D: $m = 150\,kg$

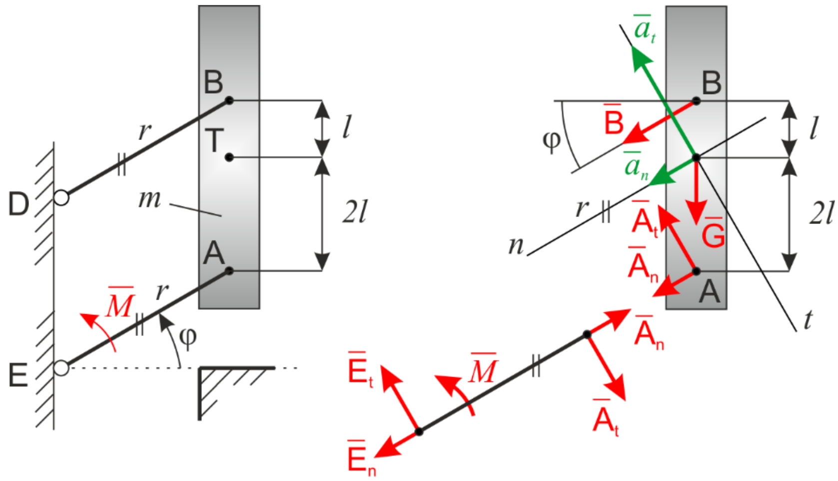
$r = 1{,}5\,m \quad l = 0{,}6\,m$

$M = 5\,kNm$

$\varphi_1 = 30°$

ZP: $t_0 = 0: \omega_0 = 0; \varphi_0 = 0$

H: $\alpha(\varphi)\,;\ B$



$t: \quad ma_t = A_t - G\cos\varphi; \qquad a_t = r\alpha \qquad (1)$

$n: \quad ma_n = A_n + G\sin\varphi + B; \qquad a_n = r\omega^2 \qquad (2)$

$M_C: \quad 0 = B\cos\varphi l - A_n\cos\varphi 2l - A_t\sin\varphi 2l \qquad (3)$

$\sum M_{iE} = 0: \ M - A_t r = 0$

$$A_t = \frac{M}{r} = \frac{5000}{1{,}5} = 3333{,}\overline{3}\,N$$

Z (2): $A_n = mr\omega^2 - B - mg\sin\varphi$

Z (3): $B = 2A_n + 2A_t\dfrac{\sin\varphi}{\cos\varphi} = 2\left(A_n + A_t\tan\varphi\right)$

Z (1): $mr\alpha = A_t - mg\cos\varphi$

$$\alpha = \frac{A_t}{mr} - \frac{g}{r}\cos\varphi = \frac{3333{,}3}{150*1{,}5} - \frac{9{,}81}{1{,}5}\cos\varphi = 14{,}81 - 6{,}54\cos\varphi$$

$$\alpha = \frac{\omega d\omega}{d\varphi} \rightarrow \int_{\omega_0=0}^{\omega} \omega d\omega = \int_0^{\varphi}(14{,}81 - 6{,}54\cos\varphi)d\varphi$$

$$\omega^2 = 29{,}62\varphi - 13{,}08\sin\varphi$$

$$B = 2mr\omega^2 - 2B - 2mg\sin\varphi + 2A_t\tan\varphi$$

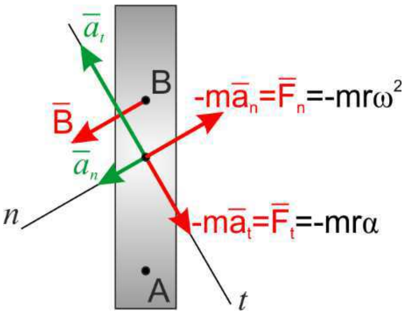
$$B = \frac{2}{3}\left(mr\omega^2 - mg\sin\varphi + A_t\tan\varphi\right)$$

$\varphi_1 = 30° = 0{,}5236\,rad:$

$\omega_1^2 = 29{,}62*0{,}5236 - 13{,}08\sin 30° = 8{,}969\left(rads^{-1}\right)^2 \qquad B = \dfrac{2}{3}\left(mr\omega^2 - mg\sin\varphi_1 + A_t\tan\varphi_1\right) = 2137{,}8\,N$

$\alpha_1 = 14{,}81 - 6{,}54\cos 30° = 9{,}146\,rad/s^2$

Alternatívne riešenie: pomocou zotrvačných síl



$$\sum M_{iA}=0:\; B\cos\varphi(2l+l)-ma_n\cos\varphi 2l-ma_t\sin\varphi 2l=0$$

$$3Bl\cos\varphi-2mrl\left(\omega^2\cos\varphi-\alpha\sin\varphi\right)=0$$

$$B=\frac{2}{3}mr\left(\omega^2+\alpha\tan\varphi\right)$$

$$B=\frac{2}{3}*150*1,5*\left(8,969+9,146*\tan 30°\right)=2137,4\,N$$

Pozn.: $\tan x=\dfrac{\sin x}{\cos x}=\dfrac{1}{\cot x}$

Príklad: The bar rigidly attached to the massless shaft rotates in the fluid with a constant speed. The shaft is driven by an electric motor. Determine the angular velocity of the shaft after one revolution from the instatnt when the motor turns off. Resistance of fluid is expressed by the moment M_r.

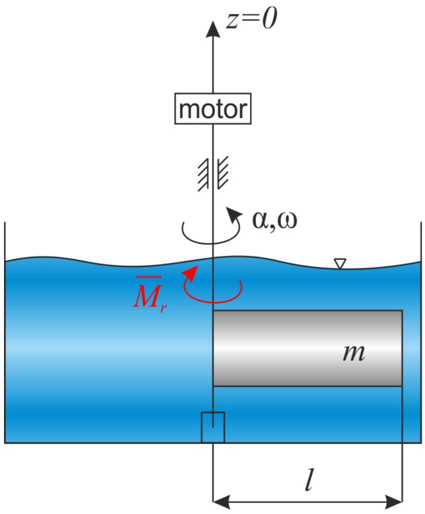
D: $n_0 = 90\, ot.\mathrm{min}^{-1}$

$l = 0{,}75\, m$

$m = 4\, kg$

$M_r = \dfrac{3}{40}\omega^2$

H: ω_1



$$I_z \alpha = \sum M_{iz}$$

$$\frac{1}{3} m l^2 \alpha = -M_r$$

$$\alpha = -\frac{M_r}{\frac{1}{3} m l^2} = -\frac{9\omega^2}{40 m l^2} = \frac{-9}{40*4*0{,}75^2}\omega^2 = -0{,}1\omega^2$$

$$\alpha = \frac{\omega d\omega}{d\varphi} = -0{,}1\omega^2 \rightarrow -0{,}1\omega^2 d\varphi = \omega d\omega$$

$$-0{,}1\int_0^{2\pi} d\varphi = \int_{\omega_0}^{\omega_1} \frac{1}{\omega} d\omega; \qquad \omega_0 = \frac{2\pi n_0}{60} = \frac{2\pi * 90}{60} = 3\pi\, rad/s$$

$$-0{,}2\pi = \ln\frac{\omega_1}{\omega_0}$$

$$\omega_1 = \omega_0 e^{-0{,}2\pi} = 3\pi e^{-0{,}2\pi} = 1{,}6\pi\ \mathrm{rad/s}$$

Príklad: Kyvadlo hmotnosti m s polomerom zotrvačnosti r_g sa otáča okolo kĺbu O. Určte výslednú reakciu v mieste uchytenia kyvadla keď $\varphi = 60°$. Trenie v ložisku zanedbajte.

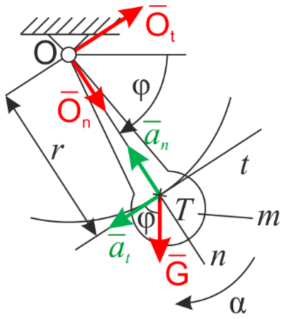
D: $m = 7{,}5\,\mathrm{kg}$

$r = 250\,\mathrm{mm}$

$r_g = 295\,\mathrm{mm}$

$\varphi_1 = 60°$

$\mathrm{ZP}: t_0 = 0; \omega_0 = 0; \varphi_0 = 0$



H: O

RIEŠENIE:

$$I_O = mr_g^2 = 7{,}5*0{,}295^2 = 0{,}6527\mathrm{kgm}^2$$

$$t: ma_t = -O_t + G\cos\varphi; \qquad a_t = r\alpha \;\rightarrow\; O_t = G\cos\varphi - mr\alpha$$

$$n: ma_n = -O_n - G\sin\varphi; \qquad a_n = r\omega^2 \;\rightarrow\; O_n = -G\sin\varphi - mr\omega^2$$

$$\underline{M_O: \;\; I_O\alpha = G\cos\varphi r}$$

$$\alpha = \frac{mgr\cos\varphi}{I_O} = \frac{7{,}5*9{,}81*0{,}25}{0{,}6527}\cos\varphi = 28{,}18\cos\varphi\left[rad/s^2\right]$$

$$\alpha = \frac{\omega d\omega}{d\varphi} = 28{,}18\cos\varphi \;\rightarrow\; \int_0^\omega \omega d\omega = 28{,}18\int_0^\varphi \cos\varphi d\varphi$$

$$\omega^2 = 56{,}36\sin\varphi$$

$\varphi = \varphi_1 = 60°$:

$$\alpha_1 = 28{,}18\cos\varphi_1 = 28{,}18\cos 60° = 14{,}09\,rad/s^2$$

$$\omega_1^2 = 56{,}36\cos\varphi_1 = 56{,}36\cos 60° = 48{,}81\,rad/s$$

$$O_t = mg\cos\varphi_1 - mr\alpha_1 = \ldots = 10{,}37\,N$$

$$O_n = -mg\sin\varphi_1 - mr\omega_1^2 = \ldots = -155{,}24\,N$$

$$O = \sqrt{O_t^2 + O_n^2} = \ldots = 115{,}6\,N$$