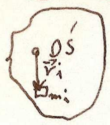
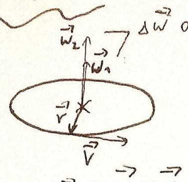
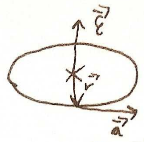
BRYŁA SZTYWNA

$\Delta\vec{w}$ daje $\vec{\varepsilon}$: $\vec{w_2}$, $\vec{w_1}$ $\uparrow\vec{\varepsilon}$





$\vec{v} = \vec{w} \times \vec{r}$



$\angle(r,\varepsilon) = const.$

$\vec{a} = \vec{\varepsilon} \times \vec{r}$

$\vec{a} = \vec{\varepsilon} \times \vec{r} \quad / \cdot m\vec{r}\times$

$m\vec{r} \underset{\perp}{\times} \vec{a} = m\vec{r} \underset{\perp}{\times} \vec{\varepsilon} \underset{\perp}{\times} \vec{r}$

$\vec{r} \times \vec{F} = m r^2 \vec{\varepsilon} \quad / \sum_{r_i}$ da $\vec{M}, \vec{\varepsilon}$ wypadkowe i $I = \sum_i m_i r_i^2$

$\underline{\vec{M} = I \cdot \vec{\varepsilon}}$

$\vec{L} = \vec{r} \times \vec{p} = m\vec{r} \times \underset{\vec{w}\times\vec{r}}{\vec{v}} \quad / \frac{d}{dt}$

$\frac{d\vec{L}}{dt} = m\vec{r} \times \vec{\varepsilon} \times \vec{r} \Rightarrow \boxed{} = \frac{d\vec{L}}{dt}$

Ogólnie dla bryły sztywnej:

$m \to I = \sum m r^2$

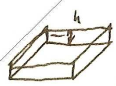
$s \to \varphi \qquad s = \boxed{} + \boxed{}t + \frac{at^2}{2}, \quad \varphi = \boxed{} + \boxed{}t + \frac{\varepsilon t^2}{2}$

$\vec{v} \to \vec{w} \qquad v = v_0 + a\boxed{}, \quad w = w_0 + \varepsilon\boxed{}$

$\left.\begin{array}{l} \vec{a} \to \vec{\varepsilon} \\ \vec{F} \to \vec{M} \\ \vec{p} \to \vec{L} \end{array}\right\} \begin{cases} \vec{F} = m\vec{a}, & \vec{M} = \boxed{} \\ \vec{F} = \frac{d\vec{p}}{dt}, & \vec{M} = \boxed{} \end{cases}$

$E_k = \frac{mv^2}{2} \to E_k = \frac{Iw^2}{2}$

$I = \sum m r^2 = \iint \rho_s(x,y)\,(x^2+y^2)\,dx\,dy$



$S = x\ [m^2]$
$M = y\ [kg]$

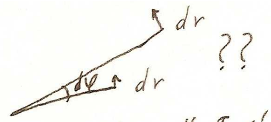
$\rho_s = \frac{y}{x} \left[\boxed{}\right]$

h nieważne

I walca: $I = \iint \rho_S r^2 dS$

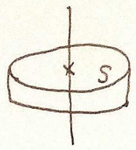
$dS = dx\,dy$ lub

$dS = \underset{?}{dr} \cdot r\,d\varphi$ [m·m·1]



$d\varphi$ to jaka odległość?

$r \cdot d\varphi$ to poprawna odległość

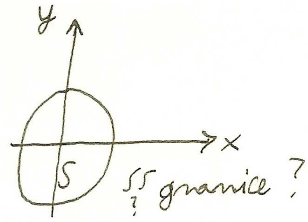


$$\rho_S = \frac{M}{S} = \frac{\rho_S \cdot \pi R^2}{\pi R^2}$$

1) $I = \int\limits_{r=0}^{R}\int\limits_{\varphi=0}^{2\pi} \rho_S r^2\, dr \cdot r\,d\varphi$

2) $I = \iint\limits_{S} \rho_S (x^2+y^2)\,dx\,dy$

$S = ?$

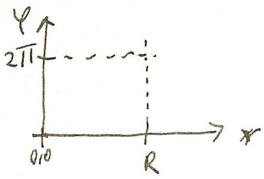


Zamiana zmiennych:

$$I = \iint\limits_{S} \rho_S \left(x(r,\varphi)^2 + y(r,\varphi)^2\right) J\, dr\,d\varphi =$$

Jacobian $\begin{vmatrix} \frac{\partial x}{\partial r} & \frac{\partial x}{\partial \varphi} \\ \frac{\partial y}{\partial r} & \frac{\partial y}{\partial \varphi} \end{vmatrix} = r$

$$= \iint\limits_{S} \rho_S\, r^2 \cdot r \cdot dr\,d\varphi$$



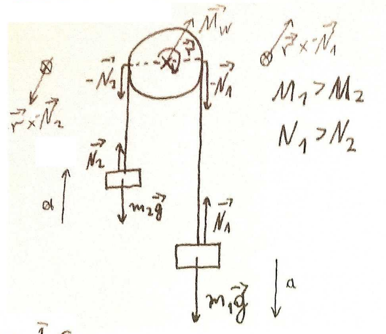
granice proste

$$I = \int\limits_0^R\int\limits_0^{2\pi} \rho_S\, r^3\, dr\,d\varphi =$$

$$= \rho_S \int\limits_0^{2\pi} \underbrace{\left[\frac{r^4}{4}\right]_0^R}_{\text{const}(\varphi)} d\varphi = \rho_S \cdot \frac{R^4}{4} \cdot 2\pi = \rho_S \cdot \frac{\pi R^2}{2} R^2 = \frac{M R^2}{2}$$

BLOCZEK

$\vec{M} = \vec{r} \times \vec{F} \neq 0$, bo bloczek $\square$, $m \neq 0$, $I = \frac{m r^2}{2} \neq 0$



$M_1 > M_2$

$N_1 > N_2$

$M = I \varepsilon$

$$\begin{cases} a = \dfrac{m_1 g - N_1}{m_1} \\[2ex] a = \dfrac{N_2 - \square}{\square} \\[2ex] a = \varepsilon r = \square\, r = \dfrac{r(N_1 - N_2)}{\frac{m r^2}{2}} \cdot r \end{cases}$$

niezname N_1, N_2, a

$$\begin{cases} m_1 a + N_1 = m_1 g \\ m_2 a - N_2 = -m_2 g \\ m a - 2N_1 + 2N_2 = 0 \end{cases} \Rightarrow \begin{pmatrix} m_1 & 1 & 0 \\ m_2 & 0 & -1 \\ m & 2 & -2 \end{pmatrix} \begin{pmatrix} a \\ N_1 \\ N_2 \end{pmatrix} = \begin{pmatrix} m_1 g \\ -m_2 g \\ 0 \end{pmatrix}$$

$W = -2\left(\frac{m}{2} + m_1 + m_2\right)$

$W_a = 2(m_2 - m_1) g$

$W_{N_1} = -2\left(2 m_1 m_2 + \frac{m}{2} m_1\right) g$

$W_{N_2} = -2\left(2 m_1 m_2 + \frac{m}{2} m_2\right) g$

$a = g \cdot \dfrac{m_1 - m_2}{\frac{m}{2} + m_1 + m_2}$

$N_1 = m_1 g \cdot \dfrac{2 m_2 + \frac{m}{2}}{m_1 + m_2 + \frac{m}{2}}$

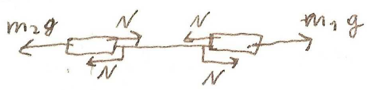
$N_2 = m_2 g \cdot \dfrac{2 m_1 + \frac{m}{2}}{m_1 + m_2 + \frac{m}{2}}$

Dla $m \to \infty$:

$a \to \square$, $N_1 \to \square$, $N_2 \to \square$ - dobrze

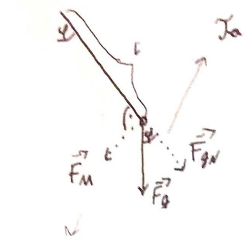
Dla $m \to 0$:

$$\left.\begin{aligned} a &= g \frac{m_1 - m_2}{m_1 + m_2} \\ N_1 &= \square = \frac{2 m_1 m_2}{m_1 + m_2} \cdot g \end{aligned}\right\}$$ jak dla:



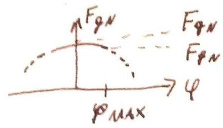
WAHADŁO

φ duże tylko dla ~~pozy~~ telnych rysunków.

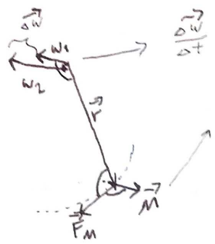


Ta siła równoważona jest przez $\boxed{}$.

$$F_{gN} = \cos\varphi \cdot F_g :$$



Ta siła (zawsze styczna) przeciwna nić:



$\frac{\vec{\Delta w}}{\Delta t} \to \frac{\vec{dw}}{dt} = \vec{\varepsilon}$ - w tył , $\varepsilon = \frac{d^2\varphi}{dt^2}$

$\vec{M} = \vec{r} \times \vec{F}_M$ - w przód

$\vec{M} = \boxed{}\,\vec{\varepsilon}$

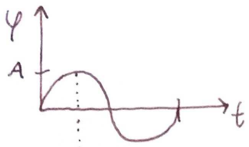
$r F_M = -mr^2 \cdot \varepsilon$, $r = l$

$mg \sin\varphi = -ml\ddot{\varphi}$, dla φ małego $\sin\varphi \approx \varphi$:

$\varphi = -\frac{l}{g}\ddot{\varphi}$, r. różniczkowe II-ego rzędu. $\varphi = ?$

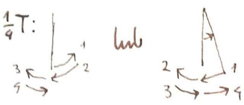
$\underline{\varphi = A \sin\left(\sqrt{\frac{g}{l}}\, t + \varphi_0\right)}$, - warto sprawdzić. Dla $\varphi_0 = -\frac{\pi}{2}$ mamy kosinus.

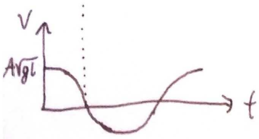
Dla $\varphi_0 = \boxed{}$:



$T: \omega = \frac{2\pi}{T} = \boxed{}$, $T = 2\pi \boxed{}$

Po $\frac{1}{4}T$:

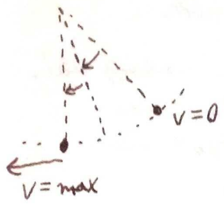




$V = \boxed{}\, r = \dot{\varphi} \cdot l = A \cdot \sqrt{gl} \cos(\omega t)$

$\varphi = 0$, $V = max$, $E_k = max$, $E_p = min$

$\varphi = max$, $V = 0$, $E_k = 0$, $E_p = max$



(np. = 0)
$E_p = max$
$\updownarrow \Delta h$
$E_p = min$
(np. = 0)

$a = \boxed{} = \ddot{\varphi} \cdot l = -A \cdot g \cdot \sin(\omega t)$

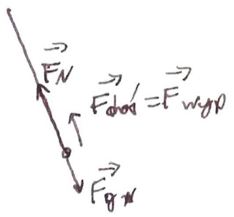
$\varphi = 0,\ a = 0$

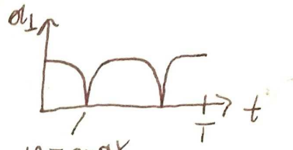
$\begin{cases} \varphi = max,\ a = max \\ \text{ale } v = 0,\ F_{doś} = \frac{mv^2}{\boxed{}} = 0 \end{cases}$

To jest a styczne ($a_{\parallel}$ do ruchu)

$a_{\perp}$ normalne do ruchu:

$a = \frac{\boxed{}}{r} = \frac{(\dot{\varphi} \cdot l)^2}{l} = \dot{\varphi}^2 l = A^2 g \cos^2(\omega t)$





$\varphi = max$
$v = 0$
$a_{doś} = 0,\ a_{styczne} = max$

$F_{doś} = F_N - F_{gN}$ $\quad a = \frac{v^2}{r} \quad$ od $\vec{F}_g$

$F_N = F_{doś} + F_{gN} = m\left(A^2 g \cos^2(\omega t) + g\cos(\underset{A\sin(\omega t)}{\underset{\parallel}{\varphi}})\right)$