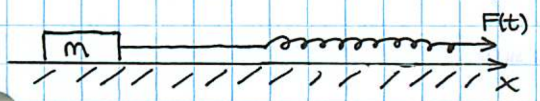
Poskus (eksperiment)

Klada (v tem primeru točkasto, majhno telo)



Newton: $F = G\frac{m_1 m_2}{r^2}$ ← razdalja med telesoma

↑ konstanta

$x(t) = ?$

pospešek je premosorazmeren s silo.

$\ddot{x}, \alpha, 1 \frac{F}{m}$

II. Newtnov zakon:

$\vec{F} = m \cdot \vec{a}$ ("fičko je mali avto.")

I. Newtnov zakon:

$\vec{F} = m \cdot \vec{a} = 0 \Rightarrow \vec{v} = $ konstanta

Einstein 1905

Newtonov zakon, $\vec{F} = m \cdot \vec{a}$, zadošča le, če telesa niso prehitra. Če so telesa hitra, uporabljamo Einsteinovo enačbo:

$$\vec{F} = m \cdot \gamma \vec{a} + m\gamma^3 \frac{\vec{v} \cdot \vec{a}}{c} \cdot \frac{\vec{v}}{c} + \text{nenavadno},$$ → $\vec{F} = \vec{F_n} + \vec{F_e}$

pri čem je $\gamma = \frac{1}{\sqrt{1-(\frac{v}{c})^2}}$; $1 \leq \gamma < \gamma \sim 1 + O(10^{-16}) = 1 + \alpha \cdot 10^{-16}$, $\alpha \approx 1$

↳ število med 0 in 1

$c = 3 \cdot 10^8$ m/s

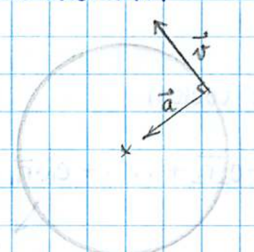
$v = |\vec{v}| = |\dot{\vec{r}}|$

$v(t) = \dot{\vec{r}}(t)$

$a(t) = \ddot{\vec{r}}(t)$

$\vec{a} \cdot \vec{v} = 0$

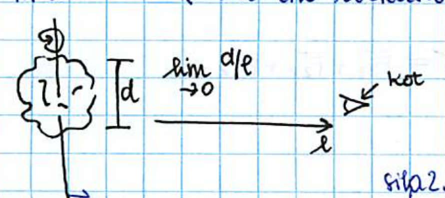
↳ kroženje po premici



NEWTONOVI ZAKONI: (=aksiomi)

I. $\vec{F} = 0 \Rightarrow \vec{v} = $ konstanta

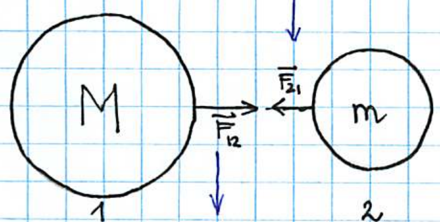
II. $\vec{F} = m \cdot \vec{a}$ (= za eno točkasto telo, ki ima koordinato $\vec{r} = (x, y, z)$ in maso m)



III. $\vec{F_{12}} = -\vec{F_{21}}$

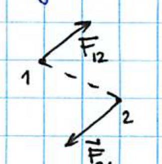
gravitacija

sila 2. zaradi 1. (vzrok, da sila je, je prvo telo)

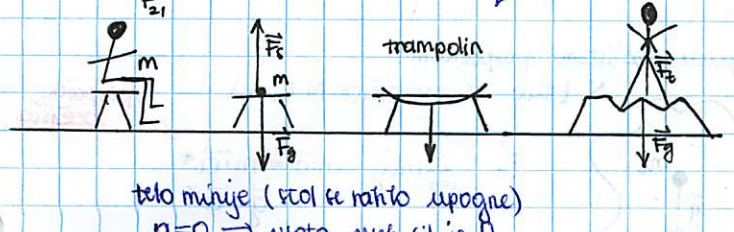


sila 1. zaradi 2.

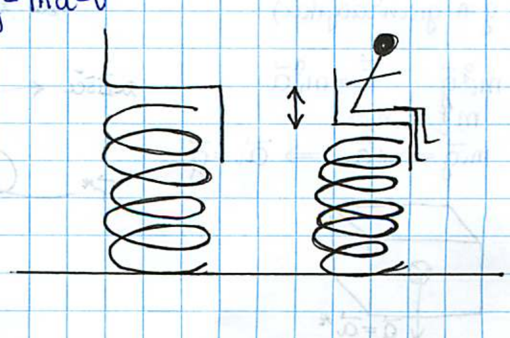
npr. magneti (= zveznica ni centralna sila)



se upogne zaradi teže



$\vec{F_t} + \vec{F_g} = m\vec{a} = 0$



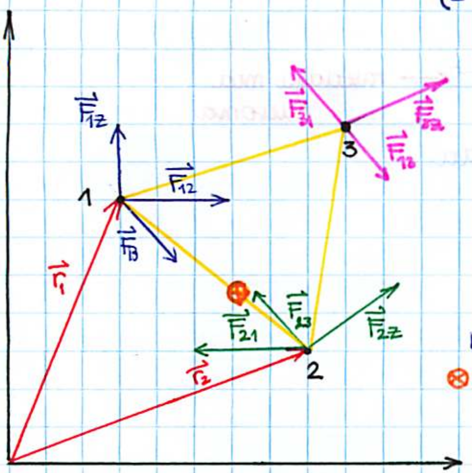
telo miruje (stol se rahlo upogne)

$a = 0 \Rightarrow$ vsota vseh sil je 0

$\vec{F_s} = -\vec{F_g}$ ← pogoj ravnovesja

IZREK O GIBALNEM TEŽIŠČU:

(= v prostoru)



$m_1 < m_2$

⊗ težišče

$N=2$

$\vec{F}_{1z}$ ~ zunanja sila

$m_1\vec{a}_1 = \vec{F}_{1z} + \vec{F}_{12}$

vektorsko seštejemo

$m_2\vec{a}_2 = \vec{F}_{2z} + \vec{F}_{21}$

$m_1\vec{a}_1 + m_2\vec{a}_2 = \underbrace{\vec{F}_{1z} + \vec{F}_{2z}}_{\text{skupna zunanja sila}} + \underbrace{\vec{F}_{21} + \vec{F}_{12}}_{=0} \rightarrow$ 3. Newtonov zakon

$\vec{F}_z = \sum_{i=1}^{n} \vec{F}_{iz}$

$\vec{F}_z = \sum_{i=1}^{n} \vec{F}_{iz}$

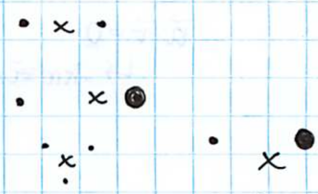
$m\vec{a} \overset{def.}{=} m_1\vec{a}_1 + m_2\vec{a}_2$

$m = m_1 + m_2$

$$\boxed{a^* = \frac{m_1\vec{a}_1 + m_2\vec{a}_2}{m_1+m_2}}$$ pospešek težišča

$$\boxed{m \cdot \vec{a}^* = \vec{F}_z}$$

izrek o gibanju težišča



Def.: težišče (= ni nujno telo, lahko le točka)

$\vec{r}^* = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1+m_2} = c_1\vec{r}_1 + c_2\vec{r}_2 + \dots + c_n\vec{r}_n$

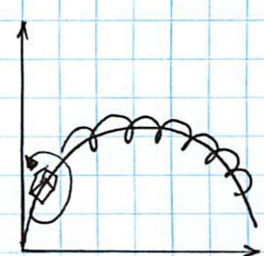
$\searrow \vec{r}^* = \frac{\sum_{i=1}^{n} m_i\vec{r}_i}{\sum_{i=1}^{n} m_i}$

$c_i = \frac{m_i}{m}$

$\vec{v}^* = \dot{\vec{r}}^*$

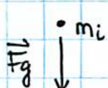
$\vec{a}^* = \dot{\vec{v}}^* = \ddot{\vec{r}}^* = \sum_{i=1}^{n} c_i\vec{a}_i$

$m_3\vec{a}_3 + m_2\vec{a}_2 + m_1\vec{a}_1 = \vec{F}_{3z} + \cancel{\vec{F}_{31}} + \cancel{\vec{F}_{32}} + \vec{F}_{2z} + \cancel{\vec{F}_{23}} + \cancel{\vec{F}_{21}} + \vec{F}_{1z} + \cancel{\vec{F}_{13}} + \cancel{\vec{F}_{12}} = \vec{F}_{3z} + \vec{F}_{2z} + \vec{F}_{1z}$



togo telo (zato lahko uporabimo te izreke)

TEŽA (= točkasto telo) ali SILA TEŽE:



telo pada, ker vleče proti Zemlji sila teže (gravitacijski pospešek). To silo preverimo z vzmetjo.

$\vec{F}_g = m_i^g g$

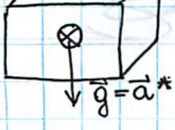
m_i^g (m gravitacijska)

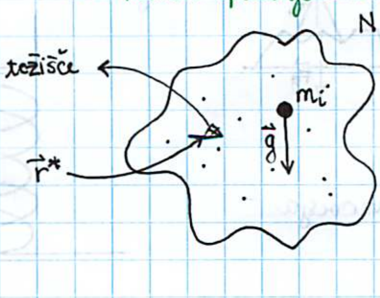
$\vec{F}_g = m_i^g\vec{g}$; $\vec{F} = m_i^a\vec{a}$

$m_i^g = m_i^a$

$m_i\vec{g} = m_i\vec{a}_i \implies \vec{a}_i = \vec{g}$

Vsa telesa padajo z istim pospeškom.





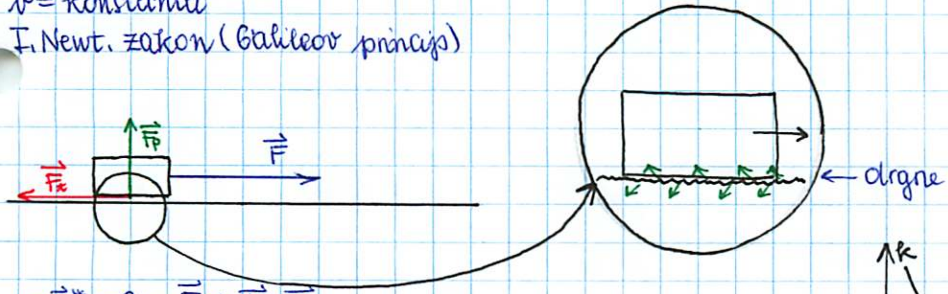
N (telo iz množice N točk)

$\vec{F}_z = \sum_{i=1}^{n} m_i\vec{g} = m\cdot\vec{g} = m\cdot\vec{a}^*$ ← pospešek težišča

$\vec{g} = \vec{a}^*$

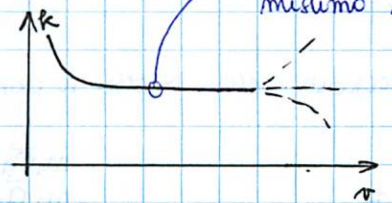
TRENJE:

(= klada – togo telo)
v = konstanta
I. Newt. zakon (Galileov princip)



$m\vec{a}^* = 0 = \vec{F_g} + \vec{F} + \vec{F_t}$

$m\vec{a}^* = 0 = \underbrace{\vec{F_g} + \vec{F_p}}_{0} + \underbrace{\vec{F} + \vec{F_t}}_{0}$ ⟶ če je hitrost konstantna, sta te dve sili enaki

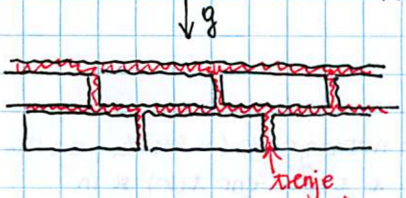


Ko govorimo o trenju, mislimo na to konstanto.

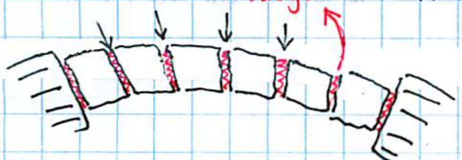
Sila trenja je sorazmerna z navpično silo (s silo podlage oz. teže).

$\boxed{F_t = k_t \cdot F_p}$

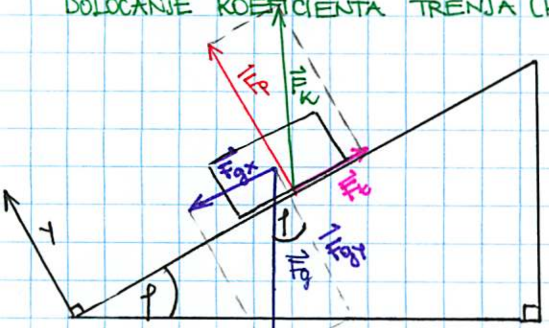
↑ odvisno od obeh podlag

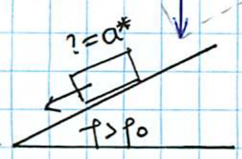


Koeficient trenja je zelo visok, zato hiša sploh stoji.
Malta kot povzročitelj trenja



DOLOČANJE KOEFICIENTA TRENJA (k_t):





m

v = konstanta ⟹ zato je $\sum \vec{F_{iz}} = m\vec{g} + \vec{F_t} + \vec{F_p} = 0$

$\vec{F_t} = k_t \cdot \vec{F_p}$

Kaj je k_t = ?

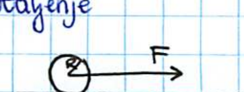
x: $m \cdot g \cdot \sin\varphi = \vec{F_t} = k_t \cdot \vec{F_p}$

y: $m \cdot g \cdot \cos\varphi = \vec{F_g}$

$\varphi \neq \frac{\pi}{2}$, če pa je, je to potem prosti pad in hitrost ni kostantna

$\frac{\sin\varphi}{\cos\varphi} = \tan\varphi_0 = k_t$

Kotaljenje



$F_t \propto \frac{F_p}{R}$

IZREK O GIBALNI KOLIČINI:

A)

$\vec{F}(r)$, $F(\vec{x})$ — poznamo $\vec{F}$ v odvisnosti od lege (ENERGIJA)

$\vec{F}(t)$ — poznamo $\vec{F}$ v odvisnosti od časa (GIBALNA KOLIČINA)

(x parameter, x „os" je površje klanca)

Predpostavimo, da poznamo $F(t) = m \cdot a$

$$m\int_{t_1}^{t_2} a(t)\,dt = \int_{t_1}^{t_2} F(t)\,dt$$

Prej smo se spraševali, kako do pospeška. Vidimo, da iz sile.

$v_2 = v(t_2)$

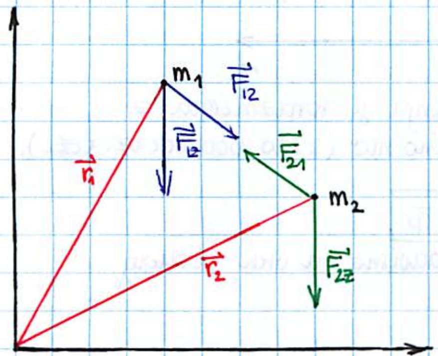
$$mv_2 - mv_1 = \int_{t_1}^{t_2} F(t)\,dt \leftarrow \text{sunek sile}$$

$\vec{G} = m\vec{v}$

$$\vec{G}(t_2) - \vec{G}(t_1) = \int_{t_1}^{t_2} \vec{F}(t)\,dt$$

$$\vec{F} = 0 \Rightarrow \Delta\vec{G} = 0$$

B) N teles (= 2 točkasti telesi. N teles se obnaša podobno. Potem posplošimo.)



$$\left.\begin{aligned} m_1\vec{a}_1 &= \vec{F}_{1z} + \vec{F}_{12} + \vec{F}_{13} \\ m_2\vec{a}_2 &= \vec{F}_{2z} + \vec{F}_{21} + \vec{F}_{23} \\ m_3\vec{a}_3 &= \vec{F}_{3z} + \vec{F}_{31} + \vec{F}_{32} \end{aligned}\right] +$$

$$m_1\vec{a}_1 + m_2\vec{a}_2 = \vec{F}_{1z} + \vec{F}_{2z} + \underbrace{\vec{F}_{12} + \vec{F}_{21}}_{=0}$$

$$m_1\int_{t_1}^{t_2} a_1\,dt + m_2\int_{t_1}^{t_2} a_2\,dt = \int_{t_1}^{t_2} \vec{F}_z(t)\,dt$$

← notranje sile (v smislu, da sta ti točki eno telo) se

$$\vec{G} = \sum_{i=1}^{N} \vec{G}_i$$

$\vec{G}_i$ → gibalna količina i-tega telesa

gibalna količina sistema N teles

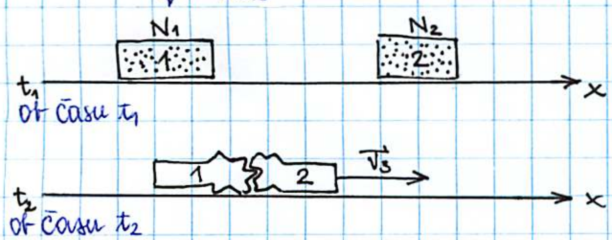
$$\vec{G}(t_2) - \vec{G}(t_1) = \int_{t_1}^{t_2} \vec{F}_z(t)\,dt$$

$$\vec{G} = \sum_{i=1}^{N} m_i\vec{v}_i = m\,\frac{\sum_{i=1}^{N} m_i\vec{v}_i}{\sum_{i=1}^{N} m_i} = m\vec{v}^*$$

m ← skupna masa

Primer: $\vec{F}_z = 0 \Rightarrow \Delta\vec{G} = 0$

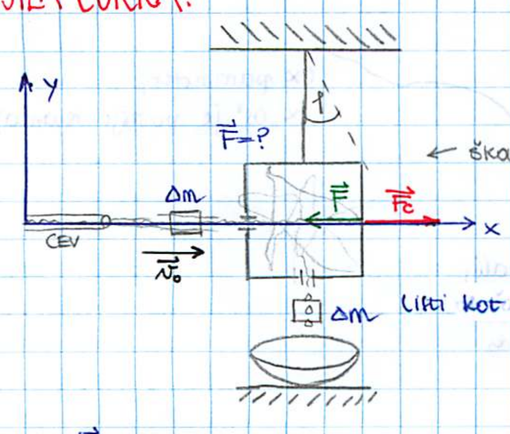
Poskus: N točkastih teles



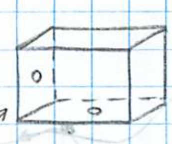
$\vec{v}_1 = (v_1, 0, 0)$ torej ima samo komponento v smeri osi x

$\vec{v}_3 = ?$ Recimo $\vec{F}_z = 0 \Rightarrow m_1v_1 + m_2v_2 = (m_1+m_2)v^*$

SILA CURKA:



← škatla



(= dve luknji, ena spodaj, druga na levi ploskvi)

(isti kot ob času t_1) $\vec{v}_0 = (v_0, 0, 0)$

x: $\vec{G}(t_1) = \Delta m(v_0, 0, 0)$

y: $\vec{G}(t_2) = \Delta m(0, v_y, 0)$