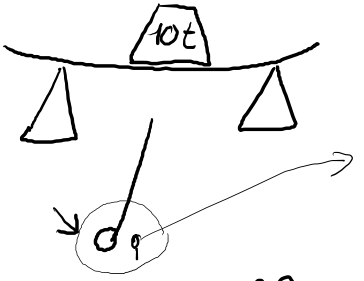
DINAMICA

FORZA

1. DEFORMAZIONE
2. MOVIMENTO



1. allungamento di una molla
2. misura l'accelerazione

FORZA IN NATURA

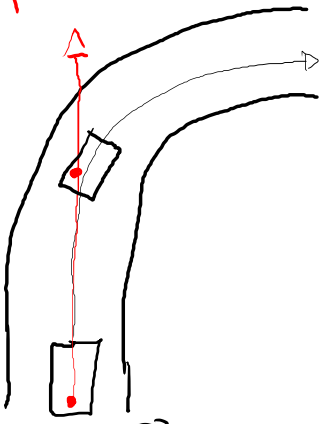
forza elettrica
forza magnetica
} 1865 Maxwell } forza e.m. } forza elettro debole } SUSY } GUT

forza nucleare debole

forza nucleare forte — QCD

forza gravitazionale

PRINCIPI DELLA DINAMICA



I) Legge d'inerzia

Sistemi di riferimento inerziali / non inerziali

II) In un sistema inerziale, $\Sigma \vec{F} = m\vec{a}$ $\quad (\vec{F} = m\vec{a})$

$$1\,N = 1\,kg \cdot 1\,\frac{m}{s^2} \qquad (SI)$$

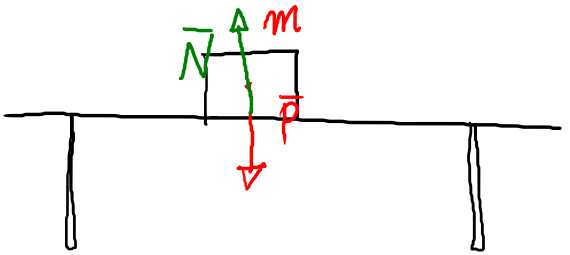
$$\downarrow$$

$$10^3\,g \cdot \frac{10^2\,cm}{s^2} = 10^5\,\frac{g\,cm}{s^2} = 10^5\,dyne \qquad (dyne)$$

III) Dati due corpi 1 e 2, se 1 esercita $\vec{F}_{12}$ su 2, allora 2 esercita $\vec{F}_{21}$ su 1, e $\vec{F}_{21} = -\vec{F}_{12}$.

e $\vec{F}_{21}$ e $\vec{F}_{12}$ hanno la stessa retta di applicazione

1)



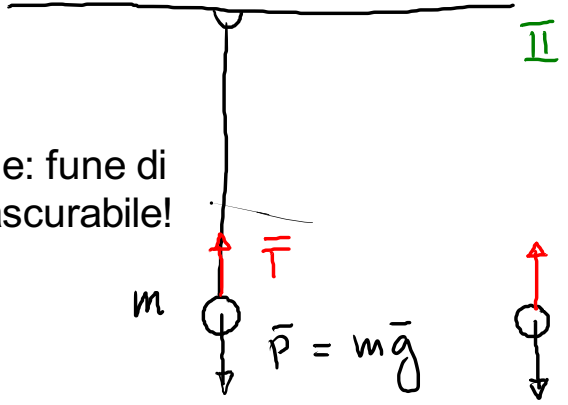
$\bar{P} = m\bar{g}$ $\quad |\bar{g}| = 9{,}8 \ \frac{m}{s^2}$

$|\bar{N}| = |\bar{P}|$ $\quad N = P$

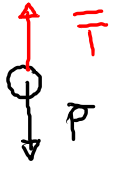
$\bar{P} + \bar{N} = 0$

$\Sigma \bar{F} = 0$ $\quad \bar{a} = 0$

2)



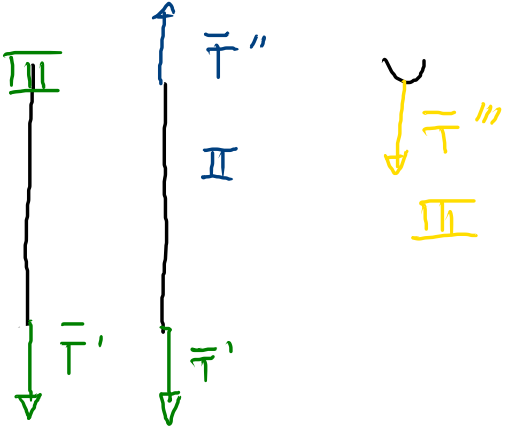
!attenzione: fune di massa trascurabile!



$\Sigma \bar{F} = \bar{P} + \bar{T} = 0$

$P - T = 0$

$|\bar{P}| - |\bar{T}| = 0$



$\bar{T} = -\bar{T}' = \bar{T}'' = -\bar{T}'''$

CONSERVAZIONE DELLA QUANTITÀ DI MOTO

$\bar{q} = m\bar{v}$

sistema N corpi

sistema isolato $\Sigma \bar{F}_{est} = 0$

$$\frac{d}{dt}\left(\sum_1^N i\ \bar{q}_i\right) = 0$$

$N = 2$

$$\bar{F}_{12} = m_2 \bar{a}_2 \qquad \bar{a}_2 = \frac{d}{dt}\bar{v}_2$$

$$\bar{F}_{21} = m_1 \bar{a}_1 \qquad \bar{a}_1 = \frac{d}{dt}\bar{v}_1$$

$$\bar{F}_{12} + \bar{F}_{21} = 0$$

$$m_2\bar{a}_2 + m_1\bar{a}_1 = 0$$

$$m_2 \frac{d\bar{v}_2}{dt} + m_1 \frac{d\bar{v}_1}{dt} = 0$$

$$\frac{d}{dt}(m_2\bar{v}_2) + \frac{d}{dt}(m_1\bar{v}_1) = 0$$

$$\frac{d}{dt}(m_2\bar{v}_2 + m_1\bar{v}_1) = 0 \qquad \frac{d}{dt}(\bar{q}_2 + \bar{q}_1) = 0$$

II Principio (reloaded)

$$\bar{F} = m\bar{a}$$

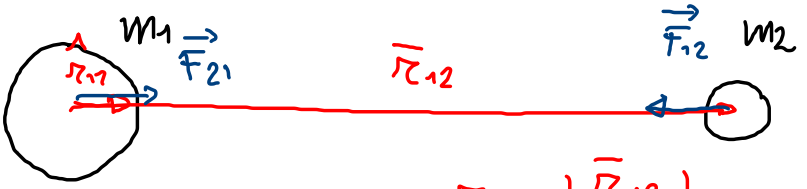
$$\bar{F} = m\frac{d\bar{v}}{dt} = \frac{d(m\bar{v})}{dt} = \frac{d\bar{q}}{dt}$$

$$\boxed{\bar{F} = \frac{d\bar{q}}{dt}}$$

LA FORZA DI GRAVITA'

$\vec{P} = m\vec{g}$

m_1, m_2



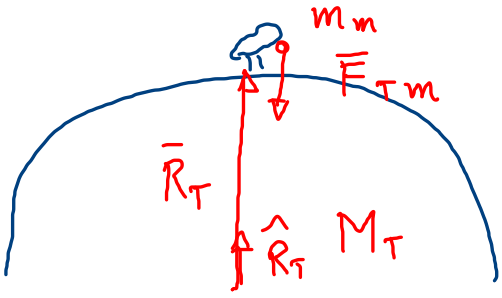
$$\vec{F}_{12} = -G\frac{m_1 m_2}{r^2}\hat{r}_{12}$$

$$r = |\vec{r}_{12}|$$

$$\hat{r}_{12} = \frac{\vec{r}_{12}}{|\vec{r}_{12}|} = \frac{\vec{r}_{12}}{r}$$

$$G = 6.67 \cdot 10^{-11}\ \frac{N m^2}{kg^2}$$

Per il III principio, $\vec{F}_{21} = -\vec{F}_{12}$



$$\bar{F}_{Tm} = -G\,\frac{M_T\,m_m}{|\bar{R}_T|^2}\,\hat{R}_T \qquad R_T = |\bar{R}_T|$$

$$|\bar{F}_{Tm}| = \frac{G\,M_T\,m_m}{R_T^2}$$

$$a_m = \frac{|\bar{F}_{Tm}|}{m_m} = \frac{G\,M_T}{R_T^2}$$

$$R_T = 6{,}37 \cdot 10^6\ m \qquad M_T = 5{,}97 \cdot 10^{24}\ kg$$

$$= \frac{6.67 \cdot 10^{-11}\ \frac{Nm^2}{kg^2} \cdot 5.97 \cdot 10^{24}\ \cancel{kg}}{(6{,}37 \cdot 10^6\ m)^2}$$

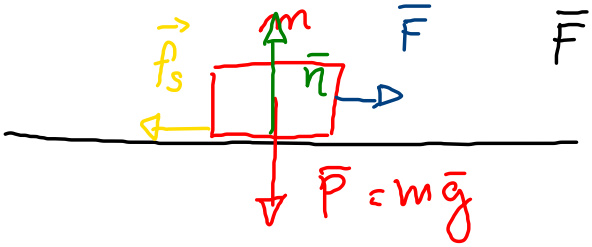
$$= \frac{6.67 \cdot 5.97}{6{,}37^2} \cdot 10 \cdot \frac{N}{kg} \simeq 10\,\frac{N}{kg} = 10\,\frac{m}{s^2}$$

$\frac{6.67 \cdot 5.97}{6{,}37^2} \sim 1$

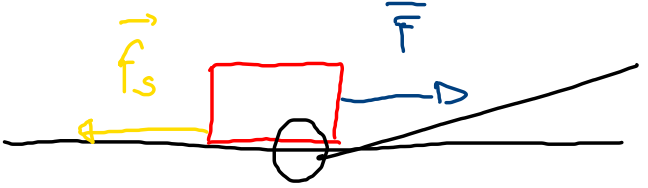
FORZE D'ATTRITO

$$\bar{n} + \bar{P} = 0$$

STATICO

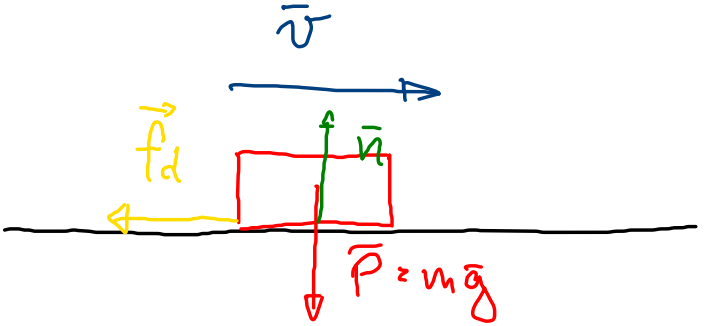


$$\bar{F} + \vec{f_s} = 0$$



$$f_s \leq f_{s,max} = \mu_s n \qquad \mu_s \leq 1$$

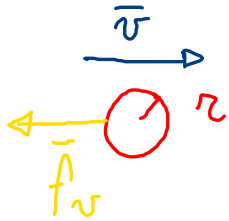
DINAMICO



$$f_d = \mu_d \cdot n \qquad \mu_d \leq \mu_s$$

In generale attenzione: $n \neq mg$!

VISCOSO



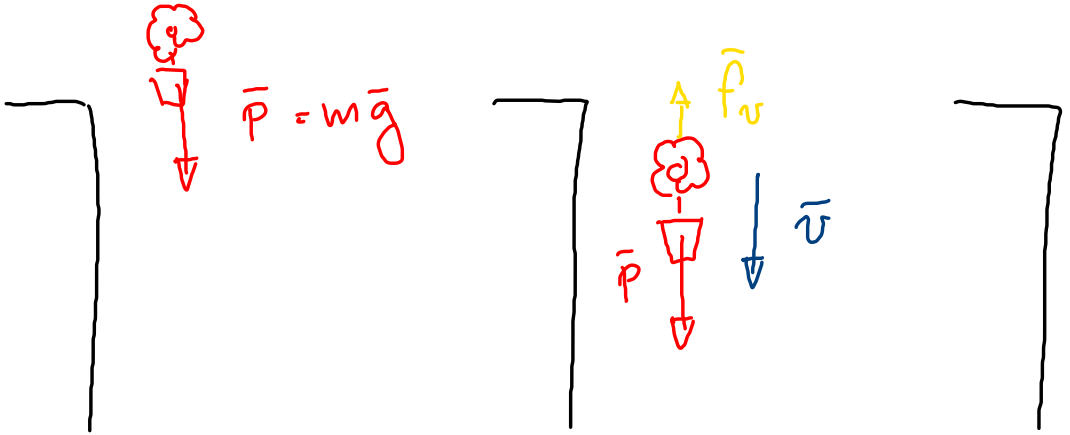
$$\bar{f}_v = -6\pi\eta r\,\bar{v}$$

legge di Stokes

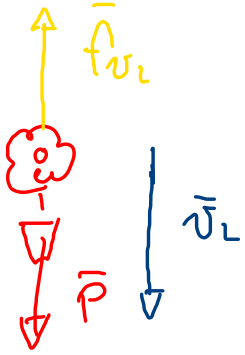
$$[\eta] = \frac{[f_v]}{[r][v]} = \frac{[M][L][t^{-2}]}{[L][L][t^{-1}]} = \frac{[M]}{[L][t]}$$

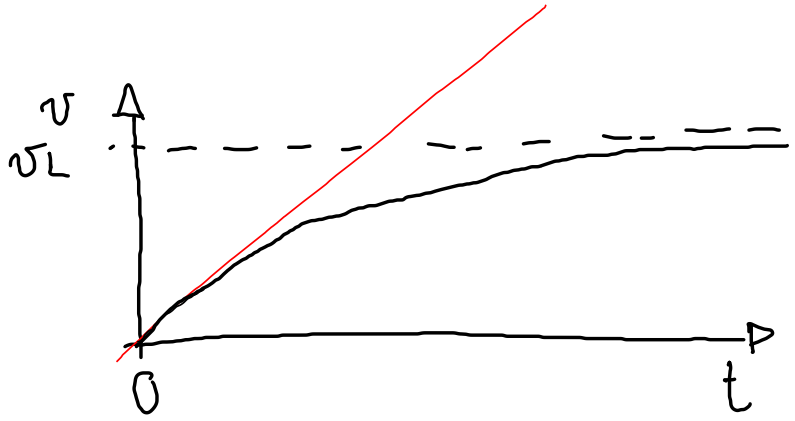
$$SI: \frac{kg}{m\,s} = \frac{10^3\ g}{10^2\ cm\cdot s} = 10\ Poise : 1\ decaPoise$$

$$cgs: \frac{g}{cm\cdot s} = Poise$$



$\bar{f}_{v_L} + \bar{P} = 0$





v_L

moto rettilineo uniforme

SEDIMENTAZIONE

$\rho = \frac{m}{V}$ densità dell'oggetto

ρ' densità del fluido

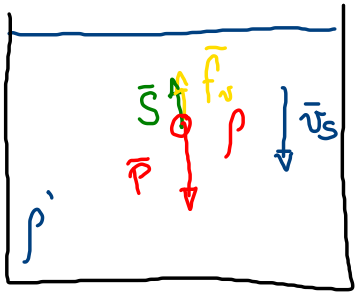
$\rho > \rho'$

$P > S$

$\bar{P} + \bar{S} + \bar{f}_v = 0$

$P = mg = \rho V g$

$S = \rho' V g$



$$\text{o } V = \frac{4}{3}\pi r^3$$

$$\bar{P} + \bar{S} + \bar{f}_v = 0$$

$$P = S + f_v$$

$$|\bar{P}| = P, \quad |\bar{S}| = S, \quad |\bar{f}_v| = f_v$$

$$\rho V g = \rho' V g + 6\pi r \eta v_s$$

$$v_s = \frac{\rho V g - \rho' V g}{6\pi r \eta} = \frac{(\rho - \rho') V g}{6\pi r \eta} = \frac{(\rho - \rho')\frac{4}{3}\pi r^3 g}{6\pi r \eta}$$

$$v_s = \frac{2}{9}\frac{(\rho - \rho') r^2 g}{\eta}$$

v.e.s. ~ 7 mm/h

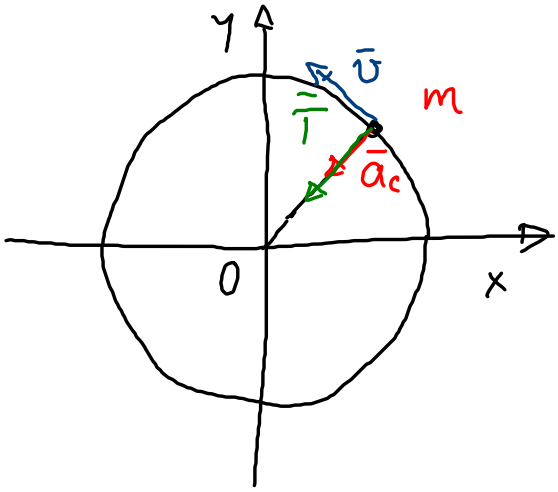
15-20 mm/h

centrifuga $g \to \omega^2 R$

$10^4 - 10^6\ g$

FORZA CENTRIPETA E CENTRIFUGA

inerziale

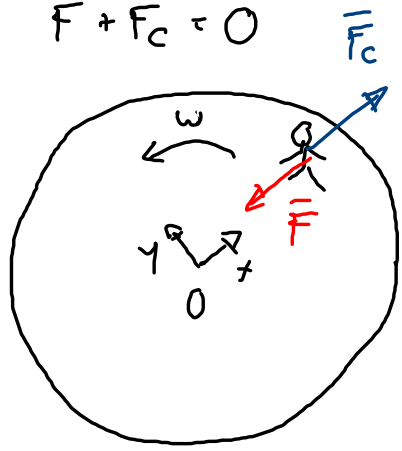


$$\vec{T} = m\vec{a}_c$$

$$a_c = \frac{v^2}{R} = \omega^2 R$$

non-inerziale

$$\bar{F} + \bar{F}_c = 0$$

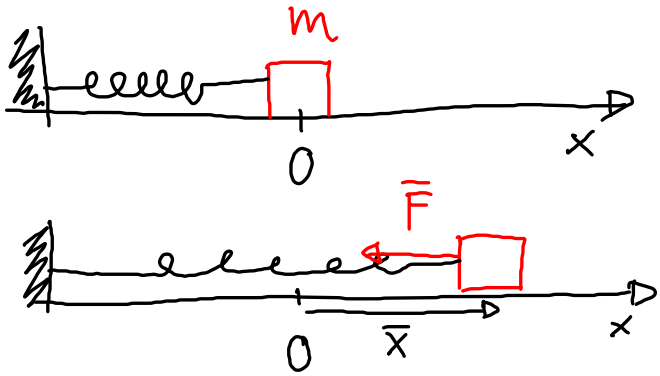


$\bar{F}_c$ forza centrifuga

FORZA APPARENTE

$$F = m a_c = m\omega^2 R$$

FORZA ELASTICA



molla a riposo

$\bar{F} = -k\bar{x}$ legge di Hooke

k costante elastica della molla

$k \sim 10^3 \frac{N}{m}$

$$\left.\begin{aligned} F &= -kx \\ F &= ma \end{aligned}\right\} \quad a = -\frac{k}{m}x$$

$a = -\omega^2 x$ moto armonico con $\omega^2 = \frac{k}{m}$

$\omega = \sqrt{\frac{k}{m}}$

$$\nu = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$x(t) = A\cos(\omega t)$