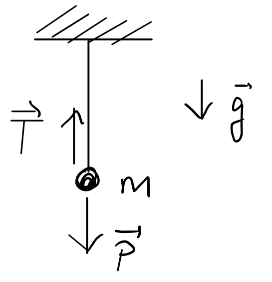
3. Tensione

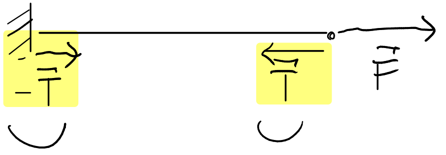
Fili, funi, ...

Analogia con il caso della molla:
costante elastica elevata → allungamento trascurabile
vale soltanto in allungamento ...

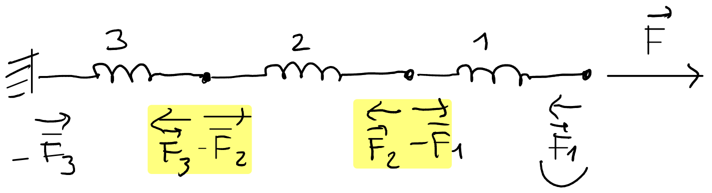


Equilibrio statico $\Rightarrow \vec{a} = 0 \Rightarrow \sum \vec{F} = 0$

$\vec{T} + m\vec{g} = \vec{0} \Rightarrow \vec{T} = -m\vec{g}$



III Newton:



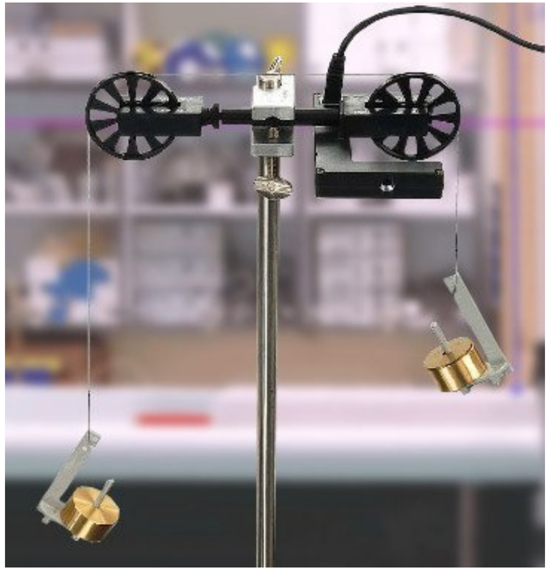
$-\vec{F}_1 + \vec{F}_2 = \vec{0} \Rightarrow \vec{F}_1 = \vec{F}_2$

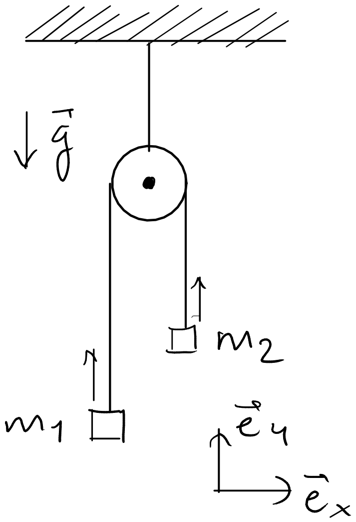
$-\vec{F}_2 + \vec{F}_3 = \vec{0} \Rightarrow \vec{F}_2 = \vec{F}_3$

$\Rightarrow \vec{F}_3 = \vec{F}_1 \Rightarrow -\vec{F}_3 = -\vec{F}_1$

Modello di filo ideale:
senza massa, inestensibile,
tensione uniforme in ogni punto

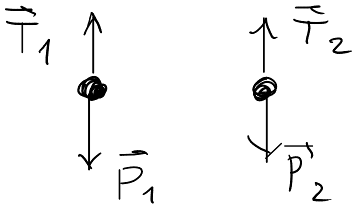
Esempio: macchina di Atwood





Filo ideale che scorrere senza attrito sulla carrucola

Filo inestensibile: $\vec{a}_1 = -\vec{a}_2 = \vec{a}$ $\quad \Sigma \vec{F} = m\vec{a}$



$$\begin{cases} \vec{T}_1 + m_1 \vec{g} = m_1 \vec{a} \\ \vec{T}_2 + m_2 \vec{g} = -m_2 \vec{a} \end{cases}$$

$|\vec{T}_1| = |\vec{T}_2| = |\vec{T}|$ $\quad$ filo ideale

$\vec{T}_1 = \vec{T}_2 = \vec{T}$

$\vec{a} = a\,\vec{e}_y$

$$\begin{cases} |\vec{T}| - m_1 g = m_1 a \\ |\vec{T}| - m_2 g = -m_2 a \end{cases}$$

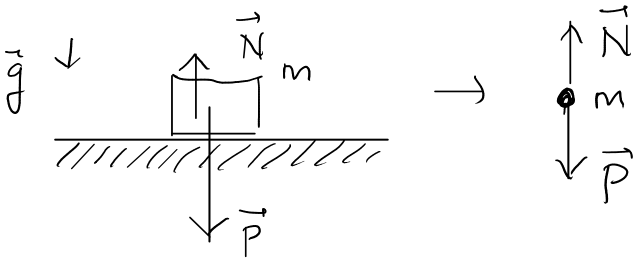
$$(m_2 - m_1) g = (m_1 + m_2) a$$

$$a = \frac{m_2 - m_1}{m_1 + m_2} g \quad \rightarrow \quad g = \frac{m_1 + m_2}{m_1 - m_2} a$$

- $m_2 > m_1$: $a > 0$ ☑
- $m_1 = m_2$: $a = 0$
- $m_2 \gg m_1$: $a \approx \frac{m_2}{m_2} g = g$
- misurare g è più facile ma attenzione a $\frac{\Delta m}{m}$!

4. Reazione normale

Corto raggio, contatto tra corpi solidi

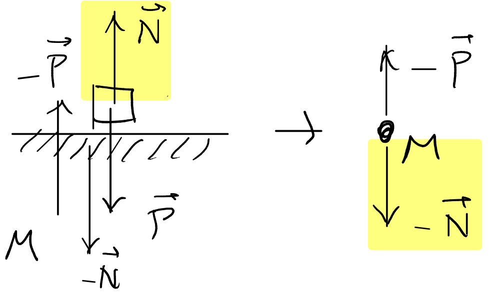


Equilibrio statico $\Rightarrow \vec a = 0 \Rightarrow \sum \vec F = \vec 0$

$\vec N + m\vec g = \vec 0 \Rightarrow \vec N = -m\vec g \qquad |\vec N| = mg$

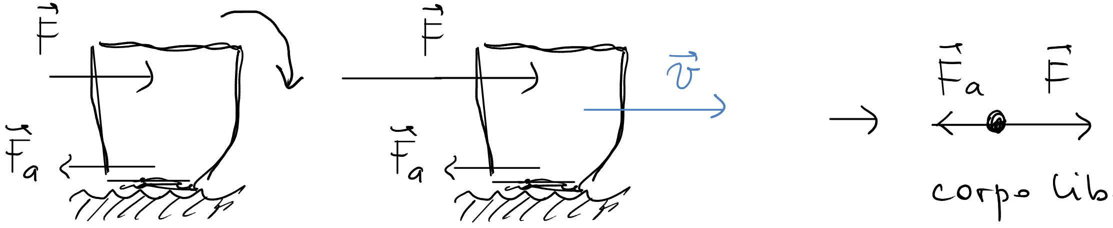
~ forza elastica "estrema"

III Newton:



5. Attrito radente

Corto raggio, contatto tra corpi solidi



statico

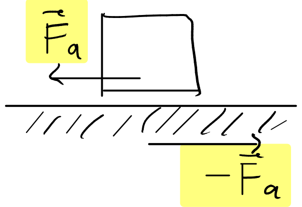
dinamico

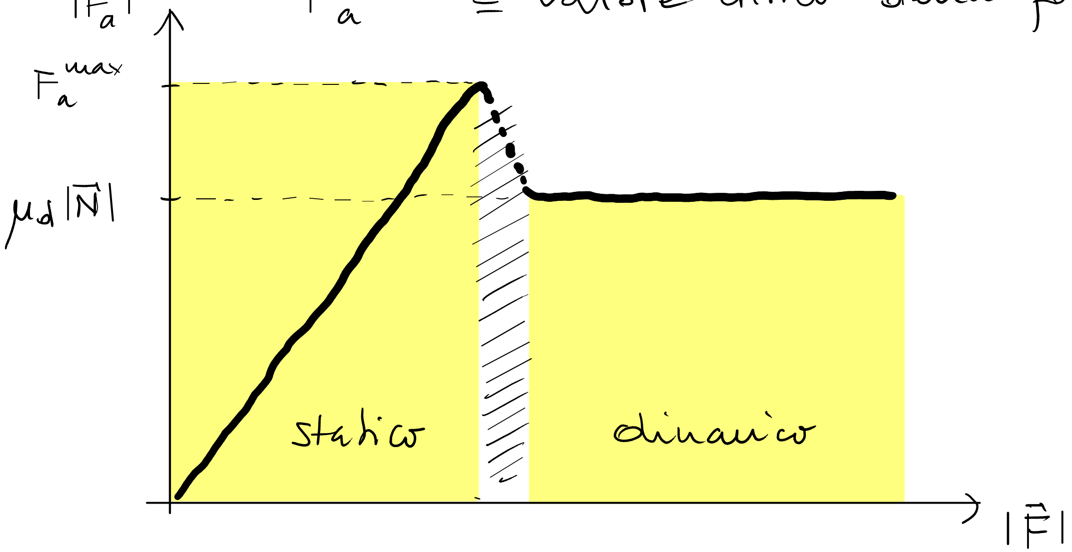
corpo libero

↓

Solo forze

III Newton:





F_a^{max} = valore critico della forza attrita in regime statico, dipende da:

- coppia di materiali
- $|\vec{N}|$ esercitata dalla superficie su cui striscia il corpo

$$F_a^{max} \sim |\vec{N}| \Rightarrow \boxed{F_a^{max} = \mu_s |\vec{N}|}$$

$$|\vec{F}_a| \leq \mu_s |\vec{N}|$$

coefficiente di attrito statico

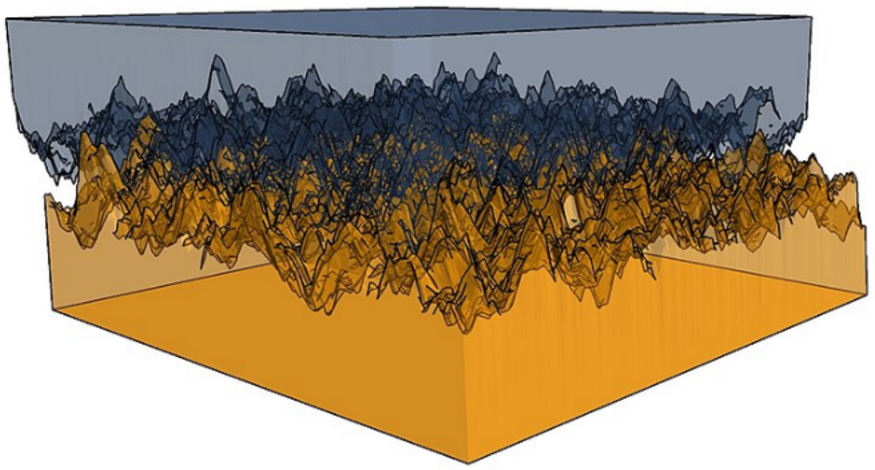
In regime dinamico

$$\boxed{|\vec{F}_a| = \mu_d |\vec{N}|} \Rightarrow \mu_s < \mu_d$$

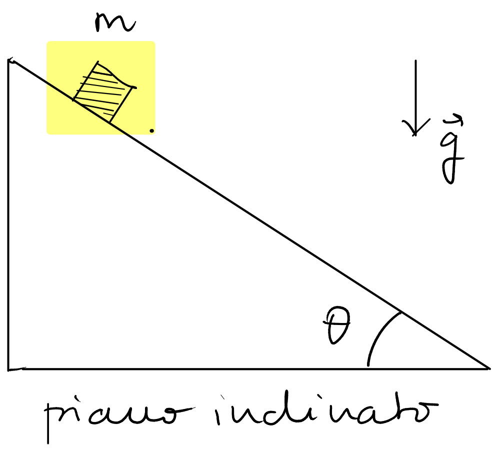
coefficiente attrito dinamico

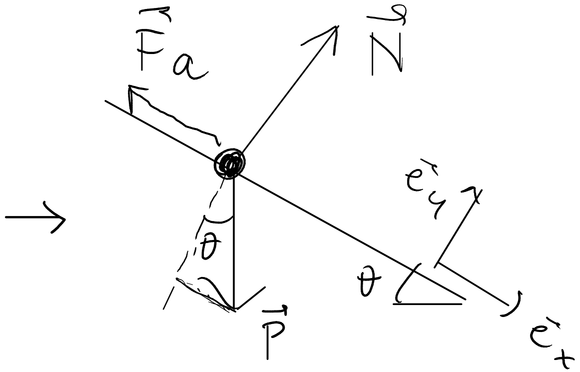
$$[\mu_s] = [\mu_d] = 1 \qquad \mu_d = A \mu_s \qquad \underline{A < 1}$$

- Direzione di $\vec{F}_a$ // superficie
- Verso opposto al moto effettivo (se dinamico) o a quello imminente (statico)



Esempio: misura di μ_s (e μ_d)





II Newton: $\sum \vec{F} = m\vec{a}$

Equilibrio statico $\rightarrow \vec{a} = \vec{0} \rightarrow \sum \vec{F} = 0$

$$m\vec{g} + \vec{N} + \vec{F}_a = \vec{0}$$

Base cartesiana $(\vec{e}_x, \vec{e}_y)$

$$\begin{cases} \vec{P} = mg\sin\theta\, \vec{e}_x - mg\cos\theta\, \vec{e}_y = m\vec{g} \\ \vec{N} = |\vec{N}|\, \vec{e}_y \\ \vec{F}_a = -|\vec{F}_a|\, \vec{e}_x \end{cases}$$

$$mg\sin\theta\, \vec{e}_x - mg\cos\theta\, \vec{e}_y + |\vec{N}|\, \vec{e}_y - |\vec{F}_a|\, \vec{e}_x = \vec{0}$$

$$\begin{cases} mg\sin\theta - |\vec{F}_a| = 0 & \Rightarrow \ |\vec{F}_a| = mg\sin\theta \\ -mg\cos\theta + |\vec{N}| = 0 & \Rightarrow \ |\vec{N}| = mg\cos\theta \end{cases}$$

Valore critico: $mg\sin\theta = \mu_s |\vec{N}|$

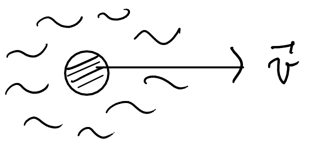
$$mg\sin\theta = \mu_s\, mg\cos\theta$$

$$\Rightarrow \mu_s = \tan\theta.$$

$$\theta = 20^\circ \Rightarrow \mu_s = 0.364$$

6. Attrito viscoso

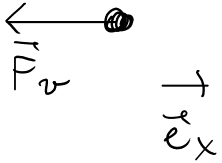
Corpo in moto in un fluido (gas, liquido)



"bassa" $\vec v$ → $\boxed{\vec F_v = -\xi \vec v}$. ; "alta" $\vec v$ → $|\vec F_v| \sim |\vec v|^2$

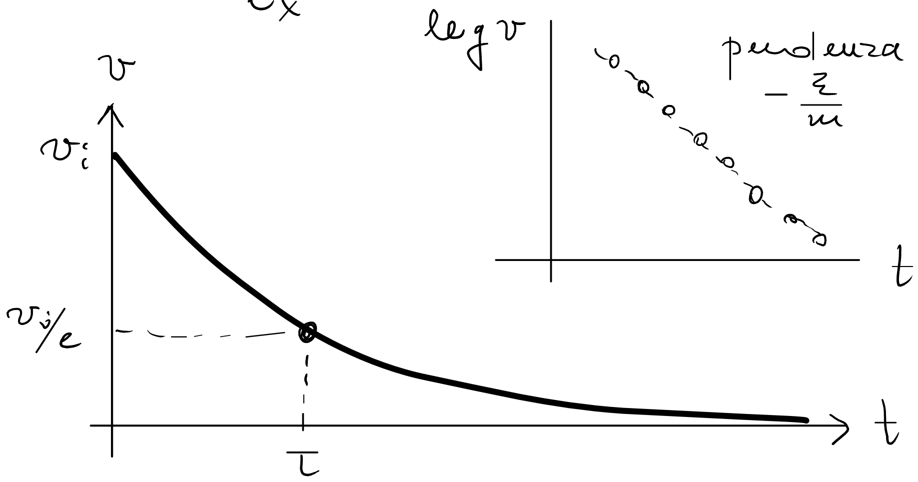
↑ coeff. attrito viscoso

Trascuro $\vec g$. II Newton: $\Sigma \vec F = m \vec a$



$$-\xi \vec v = m \frac{d\vec v}{dt} \quad \rightarrow \quad m \frac{dv}{dt} = -\xi v \quad \rightarrow \quad \boxed{\frac{dv}{dt} = -\frac{\xi}{m} v}.$$

equazione differenziale



Soluzione: $v = A \exp(-\xi/m\, t)$

Condizione iniziale: $t_i = 0 \rightarrow v = v_i$

$$\Rightarrow \quad v = v_i \exp(-\xi/m\, t)$$

$\tau \equiv \frac{m}{\xi}$ tempo di rilassamento

$$\log v = \log v_i + \underbrace{\log\left[\exp\left(-\frac{\xi}{m} t\right)\right]}_{-\frac{\xi}{m} t}$$