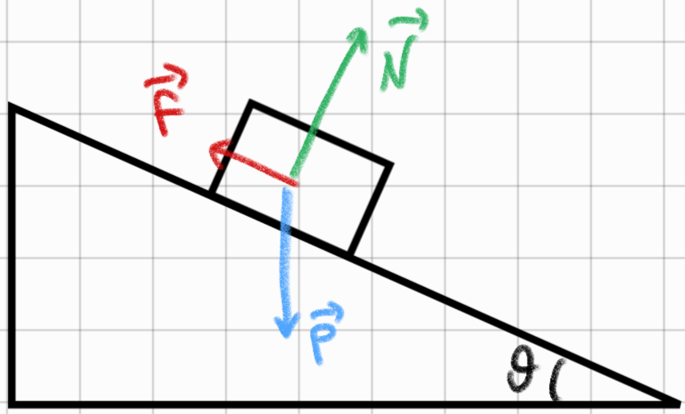
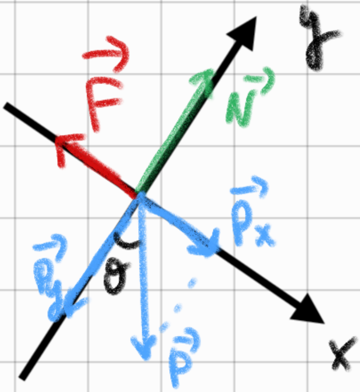
7.1



(a) velocità costante: $\sum \vec F = 0 \Rightarrow \vec F + \vec N + \vec P = \vec 0$

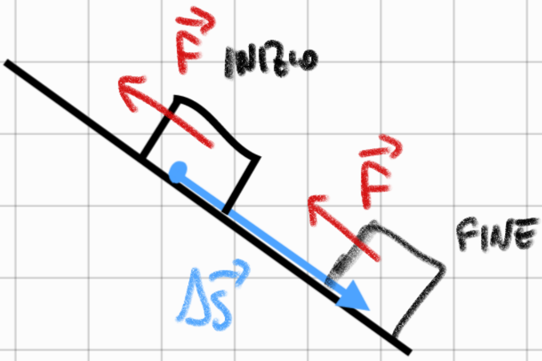


$$\Rightarrow \begin{cases} -F + P_x = 0 \\ -P_y + N = 0 \end{cases}$$

$$\Rightarrow F = P_x = |\vec P| \sin\vartheta$$

$$\Rightarrow \boxed{F = Mg\sin\vartheta} = 1170\ N$$

(b)



- $\vec F$ costante durante lo spostamento; il lavoro è:

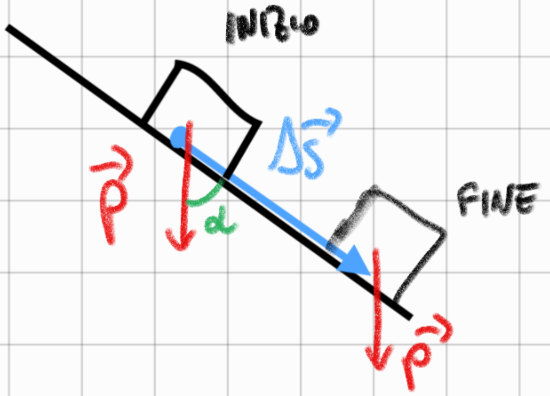
$L_u = |\vec F||\Delta\vec s|\cos\alpha$ → angolo tra $\vec F$ e $\Delta\vec s$ = 180°!

$\Rightarrow \cos 180° = 1$; $\quad |\Delta \vec{s}| = d$; $\quad |\vec{F}| = Mg\,d\sin\vartheta$

$$\Rightarrow L_u = -F\Delta s$$

$$\Rightarrow \boxed{L_u = -Mg\,d\sin\vartheta} = -3290\ \text{J}$$

(c)



$\vec{P}$ costante durante lo spostamento:

$$\Rightarrow L_g = |\vec{P}|\cdot|\Delta\vec{s}|\cdot\cos\alpha$$

con $\alpha = 90° - \vartheta$ angolo alla base del piano inclinato

$$\hookrightarrow L_g = Mg\cdot d\cdot\cos(90° - \theta) =$$
$$= Mg\,d\sin\vartheta$$

$$\Rightarrow \boxed{L_g = Mg\,d\sin\vartheta} \quad - \quad 3290\ \text{J}$$

lavoro di $\vec{F}$ $\qquad$ lavoro di $\vec{N}$

(d) $L_{TOT} = L_u + L_g + L_N$

lavoro di $\vec{P}$

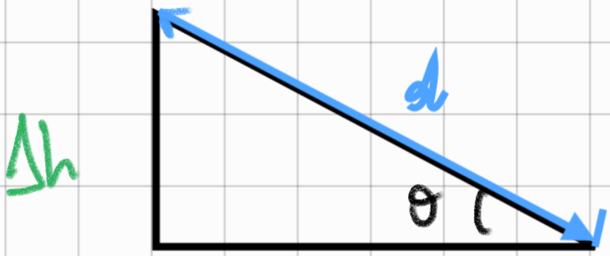
ma $L_N = 0\ J$ $(\vec{N} \perp \Delta\vec{s})$

$$\Rightarrow \boxed{L_{TOT} = L_N + L_g = 0}$$

(anche perché $L_{TOT} = \Delta K = 0$)
$\downarrow$
v cost.

NB: nel punto (b) potevamo dire che il lavoro compiuto dalla forza-peso è:

$$L_g = -\Delta U_g = -Mg(h_f - h_i) = -Mg\Delta h$$

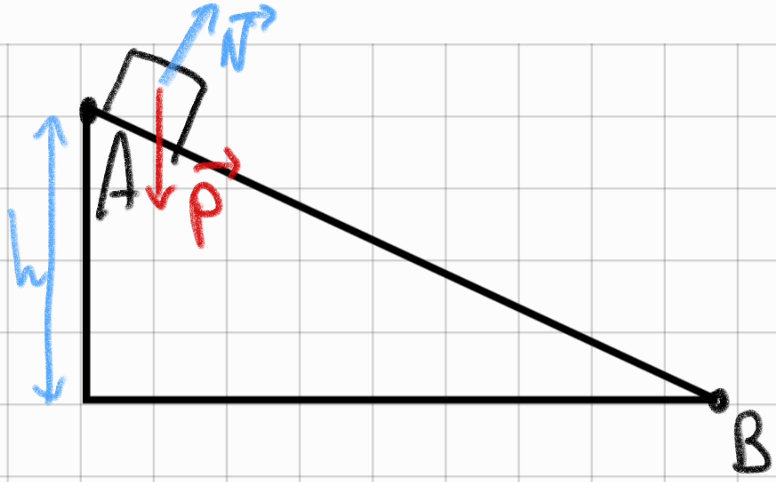


$\Rightarrow \Delta h = d \sin\theta$

$\Rightarrow L_g = -Mgd\sin\theta$

7.2

(a)



Tra A e B non ci sono forze dissipative:

$$\Delta E_{AB} = 0 \Rightarrow \Delta K_{AB} + \Delta U_{AB} = 0$$

con $U = U^g$ (presente solo la forza-peso che compie lavoro)

$$\Rightarrow \Delta K_{AB} = -\Delta U^g_{AB}$$

$$\Rightarrow \frac{1}{2}\cancel{M}\left(v_B^2 - \cancel{v_A^2}\right) = -\cancel{M}g\left(\cancel{h_B} - \underset{h}{h_A}\right)$$

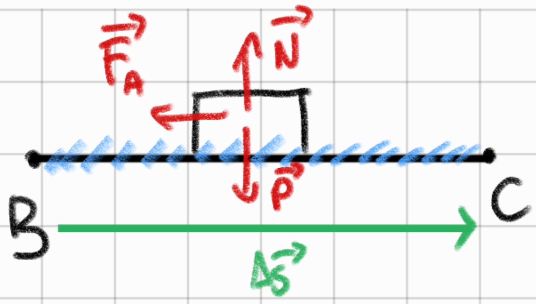
blocco fermo in A

$h_B \to 0$ se mettiamo lo 0 delle altezze al suolo ($\Rightarrow U_g = 0$ al suolo)

$$\Rightarrow \frac{1}{2}v_B^2 = gh$$

$$\Rightarrow \boxed{v_B = \sqrt{2gh}} = 4{,}08 \text{ m/s}$$

(b)



Tra B e C presente forza d'attrito opposta al moto:

→ forza dissipativa!

$$\Rightarrow \Delta E_{BC} = L^{(nc)}$$ → lavoro svolto dalle forze NON conservative!

$$\Rightarrow \Delta K_{BC} + \cancel{\Delta U^{g}_{BC}} = L_{\vec{F}_A}$$ → lavoro della forza d'attrito

forza peso non compie lavoro: $\vec{P} \perp \Delta\vec{s}$

tra $\vec{F}_A$ e $\Delta\vec{s}$ → 180°

dall'equilibrio lungo la verticale $|\vec{N}| = |\vec{P}|$

$$L_{\vec{F}_A} = |\vec{F}_A| \cdot |\Delta\vec{s}| \cdot \underbrace{\cos\alpha}_{-1} = -|\vec{F}_A| L = -|\vec{N}|\mu L = -Mg\mu L$$

$$\frac{1}{2}\cancel{M}(v_C^2 - v_B^2) = -\cancel{M}g\mu L \Rightarrow v_C^2 - v_B^2 = -2g\mu L$$

$$v_C = v_B - \frac{30}{100} v_B = v_B\left(1 - \frac{3}{10}\right) = \frac{7}{10} v_B$$

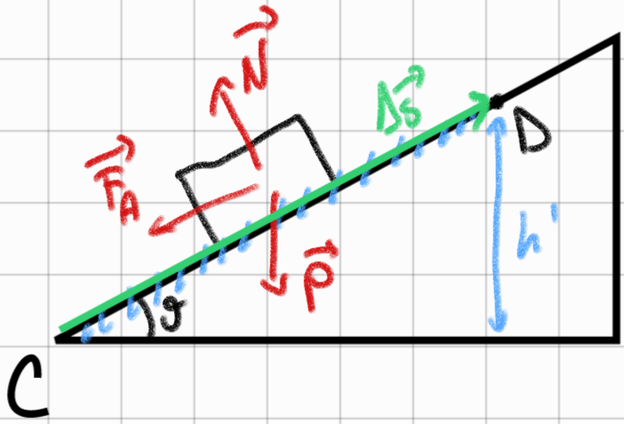
$$\Rightarrow \quad \frac{49}{100} v_B^2 - v_B^2 = -2g\mu L$$

$$\Rightarrow \cancel{-}\frac{51}{100} v_B^2 = \cancel{-}2g\mu L$$

$$\Rightarrow \quad L = \frac{51\, v_B^2}{200\, g\mu} = \frac{51\, \cancel{2g}h}{\underset{100}{\cancel{200}}\, \cancel{g}\mu} =$$

$$\Rightarrow \boxed{L = \frac{51}{100}\frac{h}{\mu}} = 1{,}73\ \text{M}$$

(c)



Anche qui $\Delta E_{CD} = L^{(NC)}$

$$\Delta K_{CD} + \Delta U_{CD} = L_{\vec{F_A}}$$

stavolta $\vec P$ compie lavoro

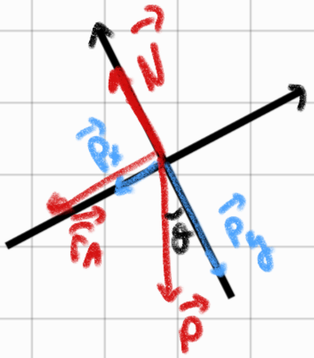
$\Rightarrow \Delta U g$

fermo in D

tra $\vec{\Delta s}$ e $\vec{F_A}$ $= 180°$

$$\Rightarrow \frac{1}{2}M(\cancel{v_D^2} - v_C^2) + Mg(\overset{h'}{h_D} - \underset{\to 0}{\cancel{h_C}}) = |\vec{F_A}|\cdot|\Delta\vec s|\cdot\underbrace{\cos\alpha}_{=-1}$$

NB: $|\vec{F}_A| = |\vec{N}|\mu$

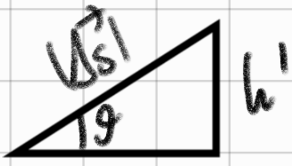


dall'analisi delle forze

$|\vec{N}| = |\vec{P}_y| = Mg\cos\theta$

$\Rightarrow \cdot\ |\vec{F}_A| = Mg\mu\cos\theta$

$\cdot\ |\vec{\Delta s}| = \dfrac{h'}{\sin\theta}$



$\cdot\ v_C^2 = \dfrac{49}{100} v_B^2 = \dfrac{49}{100} 2gh = \dfrac{49}{50} gh$

visto prima!

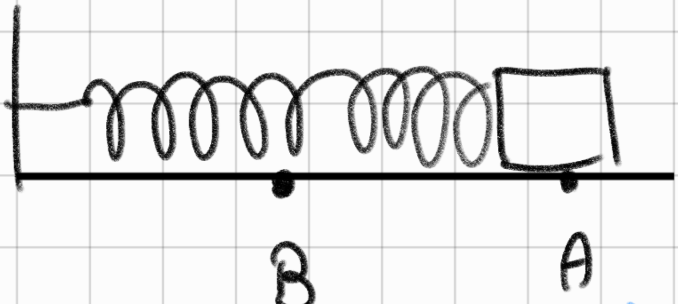
$$\Rightarrow \frac{1}{2} \cancel{M} \frac{49}{50} \cancel{g} h + \cancel{M}\cancel{g} h' = -\cancel{M}\cancel{g}\mu \cos\theta \frac{h'}{\sin\theta}$$

$$\frac{49}{100} h + h' = -h' \frac{\mu}{\tan\theta}$$

$$\Rightarrow h'\left(1 + \frac{\mu}{\tan\theta}\right) = -\frac{49}{100} h$$

$$\Rightarrow \boxed{h' = \frac{49\,h}{100\left(1 + \frac{\mu}{\tan\theta}\right)}} \simeq 0{,}29\ m$$

7.3



(a)

B: posizione finale, $x_B = 0$

A: posizione iniziale, $x_A = x_i$

Non ci sono forze dissipative

$$\Rightarrow \Delta E_{AB} = 0$$

$$\Rightarrow \Delta K_{AB} + \Delta U_{AB} = 0$$

$\Delta U_{AB} = \Delta U^{el}_{AB}$ unica forza conservativa che compie lavoro e forza elastica ($\vec{P} \perp \Delta\vec{s}$)

$$\Rightarrow \Delta K_{AB} = -\Delta U^{el}_{AB}$$

$$\Rightarrow \cancel{\frac{1}{2}} m(\underbrace{v_B^2}_{v} - \underbrace{\cancel{v_A^2}}_{=0 \text{ fermo in } A}) = -\cancel{\frac{1}{2}} k(\underbrace{\cancel{x_B^2}}_{=0} - \underbrace{x_A^2}_{x_i})$$

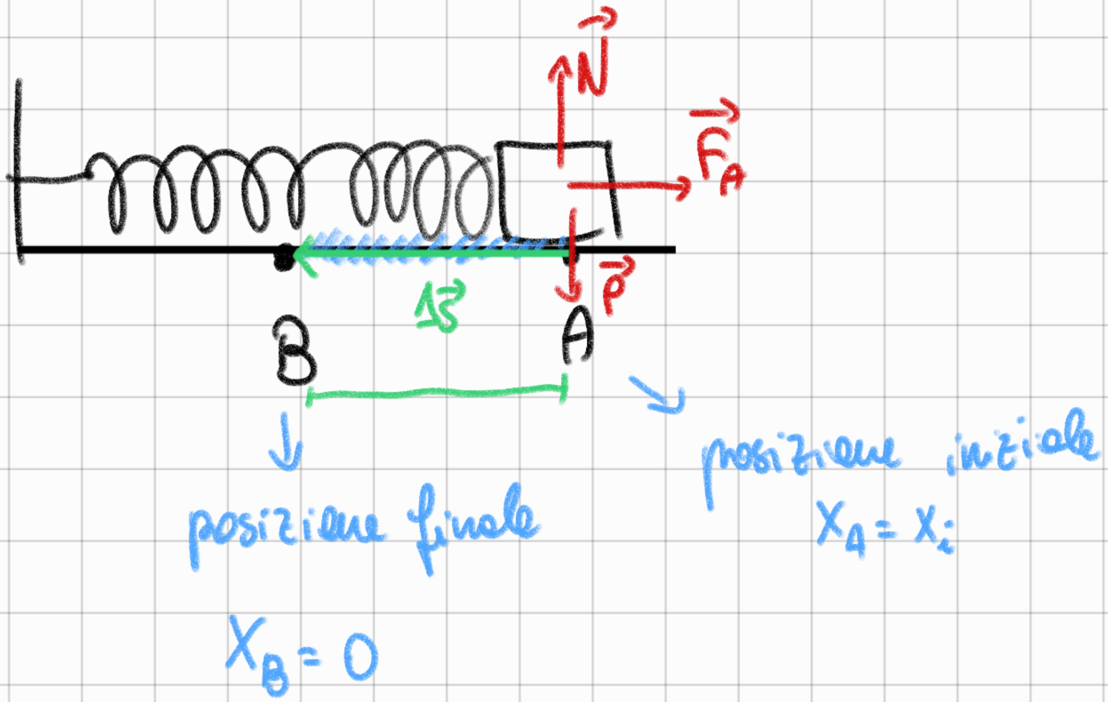
$$\Rightarrow \quad m v^2 = k x_i^2 \Rightarrow \quad v = \sqrt{\frac{k}{m}}\, x_i$$

So che quando $x = x_i$, la forza elastica ha modulo $|\vec{F}_{x_i}| = k x_i \Rightarrow k = \frac{|\vec{F}_{x_i}|}{x_i}$

$$\Rightarrow v_i = \sqrt{\frac{|\vec{F}_{x_i}|}{x_i m}}\, x_i$$

$$\Rightarrow \boxed{v_i = \sqrt{\frac{F_{x_i} \cdot x_i}{m}}} \simeq 0{,}97 \text{ m/s}.$$

(b)



Adesso ho attriti: $\Delta E_{AB} = L^{(NC)}$

$$\frac{1}{2}m(\underbrace{v_B^2}_{v} - \cancel{v_A^2}) + \frac{1}{2}k(\cancel{x_B^2} - \underbrace{x_A^2}_{x_i}) = |\vec{F}_A|\underbrace{|\Delta\vec{s}|}_{|x_B - x_A| = |0 - x_A| = x_i}\underbrace{\cos\alpha}_{=-1}$$

equilibrio forze ⊥ piano

NB: $|\vec{F}_A| = |\vec{N}|\mu \overset{\uparrow}{=} |\vec{P}|\mu = mg\mu$

$$\rightarrow \frac{1}{2}mv^2 - \frac{1}{2}kx_i^2 = -mg\mu x_i$$

$$\Rightarrow \boxed{v = \sqrt{\frac{k}{m}x_i^2 - 2g\mu x_i}} = 0{,}87\ m/s$$