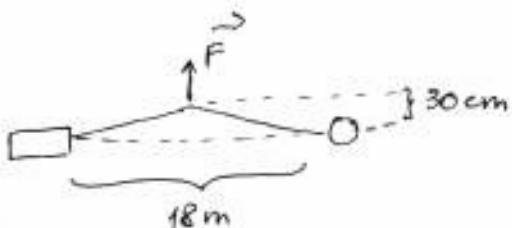


LISTA

①



$$|\vec{F}| = 560 \text{ N}$$

Força sobre o carro?

Parte da força \vec{F} puxa o carro e parte puxa o poste: Como o homem puxa no meio da corda: $F = F' \sin\theta + F' \cos\theta = 2F' \sin\theta$

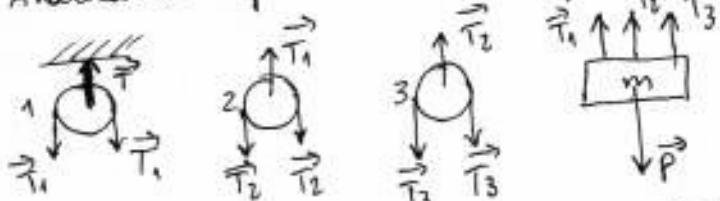
Analisando o triângulo retângulo hachurado, encontramos $\sin\theta$:

$$\sin\theta = \frac{\text{cat. adj}}{\text{hip}} = \frac{0,3}{\sqrt{0,3^2 + 9^2}} = 0,033$$

$$\text{Então } F' = \frac{F}{2 \sin\theta} = \frac{560}{0,066} = 8404,67 \text{ N} //$$

② Analisamos separadamente cada parte do sistema:

$$|\vec{T}| = ?$$



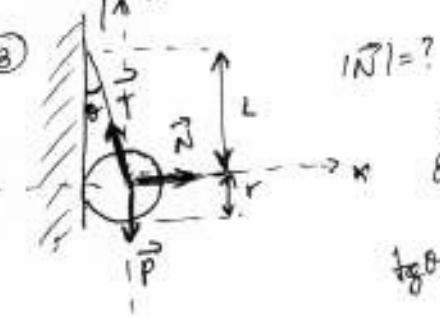
$$T = \frac{8}{3}mg$$

↓

$$T - 2T_1 = 0 \quad T_1 - 2T_2 = 0 \quad T_2 - 2T_3 = 0 \quad T_1 + T_2 + T_3 - P = 0$$

$$T_1 = \frac{T}{2} \Rightarrow T_2 = \frac{T_1}{2} = \frac{T}{4} \Rightarrow T_3 = \frac{T_2}{2} = \frac{T}{8} \Rightarrow \frac{T}{2} + \frac{T}{4} + \frac{T}{8} = P \quad \frac{4T + 2T + T}{8} = mg \quad \frac{7T}{8} = mg$$

③



$$|N| = ?$$

$$\text{Em X: } N - Tx = 0$$

$$N = T \sin\theta$$

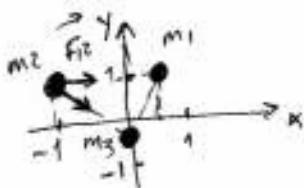
$$\text{Em Y: } Ty - P = 0$$

$$T \cos\theta = P \quad T = \frac{P}{\cos\theta}$$

$$N = \frac{P \sin\theta}{\cos\theta} = P \tan\theta$$

$$\tan\theta = \frac{\text{cat. op.}}{\text{cat. adj}} = \frac{r}{L} \Rightarrow N = \frac{r}{L} P$$

| $m(\text{kg})$ | $x(\text{m})$ | $y(\text{m})$ |
|----------------|---------------|---------------|
| 20 | 0,5 | 1 |
| 40 | -1 | 1 |
| 60 | 0 | -0,5 |



$$F = G \frac{mm}{r^2}$$

$$r_{12} = 1,5 \text{ m}$$

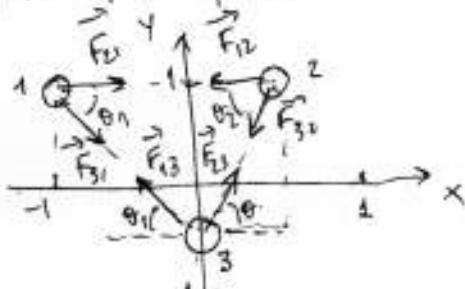
$$r_{13} = \sqrt{1,5^2 + 1^2} = 1,8 \text{ m}$$

$$r_{23} = \sqrt{0,5^2 + 1,5^2} = 1,58 \text{ m}$$

$$F_{21} = F_{12} = G \frac{m_1 m_2}{1,5^2} = 2,13 \cdot 10^8 \text{ N}$$

$$F_{31} = F_{13} = G \frac{m_1 m_3}{1,8^2} = 2,72 \cdot 10^8 \text{ N}$$

$$F_{23} = F_{32} = G \frac{m_2 m_3}{1,58^2} = 5,77 \cdot 10^8 \text{ N}$$



$$\left. \begin{array}{l} F_{R1x} = F_{21} + F_{31x} = F_{21} + F_{31} \cos \theta_1 = F_{21} + F_{31} \frac{1}{1,8} = 3,36 \cdot 10^8 \\ F_{R1y} = F_{31y} = F_{31} \sin \theta_1 = F_{31} \frac{1,5}{1,8} = 1,85 \cdot 10^8 \end{array} \right\} \quad \left. \begin{array}{l} F_{R1} = \sqrt{F_{R1x}^2 + F_{R1y}^2} \\ = 3,83 \cdot 10^8 N \end{array} \right.$$

$$a_1 = \frac{F_{R1}}{m_1} = 1,91 \cdot 10^7 m/s^2$$

$$\left. \begin{array}{l} F_{R2x} = F_{12} + F_{32} \cos \theta_2 = F_{12} + F_{32} \frac{0,5}{1,58} = 3,96 \cdot 10^8 \\ F_{R2y} = F_{32} \sin \theta_2 = F_{32} \frac{1,5}{1,58} = 5,48 \cdot 10^8 \end{array} \right\}$$

$$F_{R2} = \sqrt{F_{R2x}^2 + F_{R2y}^2} \\ = 6,76 \cdot 10^8 N$$

$$F_{R3y} = F_{23y} + F_{13y} = F_{23} \sin \theta_2 + F_{13} \sin \theta_1 = F_{23} \frac{1,5}{1,58} + F_{13} \frac{1,5}{1,8} = 7,33 \cdot 10^8$$

$$a_2 = \frac{F_{R2}}{m_2} = 1,69 \cdot 10^7 m/s^2$$

$$F_{R3x} = F_{23x} - F_{13x} = F_{23} \cos \theta_2 - F_{13} \cos \theta_1 = F_{23} \frac{0,5}{1,58} - F_{13} \frac{1}{1,8} = 0,63 \cdot 10^8$$

$$F_{R3y} = F_{23y} + F_{13y} = F_{23} \sin \theta_2 + F_{13} \sin \theta_1 = F_{23} \frac{1,5}{1,58} + F_{13} \frac{1,5}{1,8} = 7,33 \cdot 10^8$$

$$F_{R3} = \sqrt{F_{R3x}^2 + F_{R3y}^2} \\ = 7,35 \cdot 10^8 N$$

$$a_3 = \frac{F_{R3}}{m_3} = 1,22 \cdot 10^7 m/s^2$$

⑥ $m = 50 \text{ kg}$

$$6,67 \cdot 10^{11}$$

$$(a) F_{gT} = G \frac{M_T m}{R_T^2} = 6 \cdot 10^{11} \frac{6 \cdot 10^{24} \cdot 50}{(6 \cdot 10^6)^2} = 50 \cdot 10^{11} \frac{10^{-24}}{10^2} = 500 N$$

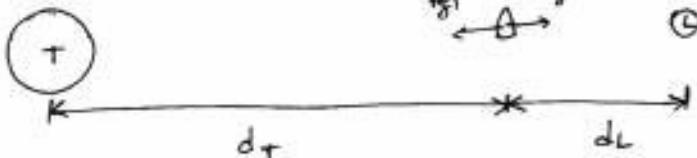
$$(b) F_{gL} = G \frac{M_L m}{(d_{TL} - R_T)^2} = \frac{6 \cdot 10^{11} \cdot 7 \cdot 10^{24} \cdot 50}{(3,82 \cdot 10^8 - 6,32 \cdot 10^6)^2} = \frac{2,1 \cdot 10^{44}}{(3,8 \cdot 10^8)^2} = 1,45 \cdot 10^{-3} N$$

$$(c) F_{gs} = G \frac{M_S m}{(d_{TS} - R_T)^2} = \frac{6 \cdot 10^{11} \cdot 2 \cdot 10^{30} \cdot 50}{(1,5 \cdot 10^8 - 6,4 \cdot 10^6)^2} = \frac{150 \cdot 10^{19}}{(1,5 \cdot 10^8)^2} = 0,07 N$$

$$(d) F_g = G \frac{M m}{r^2} = \frac{6 \cdot 10^{11} \cdot 50 \cdot 50}{1^2} = 6 \cdot 10^8 N$$

resultados
diferentes dos
da lista devendo
ser arredonda-
mentes

⑦



$$\text{onde } d_T + d_L = d_{TL} = 3,82 \cdot 10^8$$

$$F_{gT} = F_{gL} \Rightarrow \frac{G M_T m}{d_T^2} = \frac{G M_L m}{d_L^2} \Rightarrow \frac{M_T}{d_T^2} = \frac{M_L}{(d_{TL} - d_T)^2}$$

$$M_T (d_{TL} - d_T)^2 = M_L d_T^2$$

$$d_{TL}^2 - 2d_{TL} d_T + d_T^2 = \frac{M_L}{M_T} d_T^2$$

$$d_T^2 \left(1 - \frac{M_L}{M_T} \right) - 2d_{TL} d_T + d_{TL}^2 = 0$$

$$\left. \begin{array}{l} A = 1 - \frac{7,36 \cdot 10^{22}}{5,98 \cdot 10^{24}} = 0,99 \\ B = -2 \cdot 3,82 \cdot 10^8 = -7,64 \cdot 10^8 \\ C = (3,82 \cdot 10^8)^2 = 14,6 \cdot 10^{16} \end{array} \right\} \quad d_T = \frac{7,64 \cdot 10^8 \pm \sqrt{(7,64 \cdot 10^8)^2 - 4 \cdot 0,99 \cdot 14,6 \cdot 10^{16}}}{1,98}$$

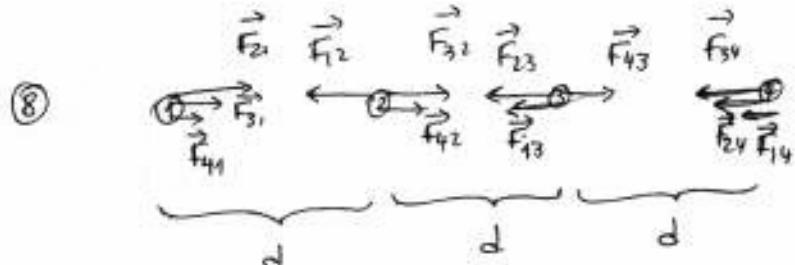
$$= \frac{7,64 \cdot 10^8 \pm \sqrt{58,37 \cdot 10^{16} - 57,82 \cdot 10^{16}}}{1,98} = \frac{7,64 \cdot 10^8 \pm \sqrt{0,55 \cdot 10^{16}}}{1,98}$$

\downarrow $4,2 \cdot 10^8 \text{ m}$ \downarrow $3,5 \cdot 10^8 \text{ m}$

⑦ (a) $mg_L = G \frac{M_L M}{R_L^2}$ $g_L = \frac{6,67 \cdot 10^{-11} \cdot 7,36 \cdot 10^{22}}{(1,74 \cdot 10^6)^2} = 16,2 \cdot 10^{-11} \cdot 10^{22} \cdot 10^{-12} = 16,2 \cdot 10^{-1} = 1,62 \text{ m/s}^2 (= g_T/6)$

(b) $F_L = mg_L = \frac{100}{9,8} \cdot 1,6 = 16,3 \text{ N}$

(c) Na Terra essa gravidade seria à altitude: $g_L = \frac{GM_T}{d^2}$ $d = \frac{GM_T}{g_L} = \frac{6,67 \cdot 10^{-11} \cdot 5,98 \cdot 10^{24}}{1,62}$
 $d^2 = 2,46 \cdot 10^{14} \Rightarrow d = 15,2 \cdot 10^6 \text{ m} (= 246 R_T)$



Força entre uma estrela e sua vizinha =
 $= G \frac{M M'}{d^2}$

$$F_{R1} = GM_1 \left(\frac{M_2}{d^2} + \frac{M_3}{(2d)^2} + \frac{M_4}{(3d)^2} \right) = \frac{GM_1}{d^2} \left(M_2 + \frac{M_3}{4} + \frac{M_4}{9} \right)$$

$$F_{R2} = GM_2 \left(\frac{M_3}{d^2} + \frac{M_4}{(2d)^2} - \frac{M_1}{d^2} \right) = \frac{GM_2}{d^2} \left(M_3 + \frac{M_4}{4} - M_1 \right)$$

$$F_{R3} = GM_3 \left(\frac{M_4}{d^2} - \frac{M_2}{(2d)^2} - \frac{M_1}{(3d)^2} \right) = \frac{GM_3}{d^2} \left(M_4 - M_2 - \frac{M_1}{4} \right)$$

$$F_{R4} = GM_4 \left(-\frac{M_3}{d^2} - \frac{M_2}{(2d)^2} - \frac{M_1}{(3d)^2} \right) = \frac{GM_4}{d^2} \left(-M_3 - \frac{M_2}{4} - \frac{M_1}{9} \right)$$

⑨



$$|\vec{v}_0| = 35 \text{ m/s}$$

$$\theta = 32^\circ$$

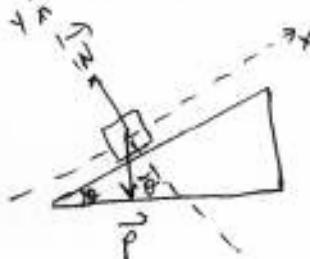
$$(a) \Delta x = ?$$

$$(b) v = v_0 = 35 \text{ m/s}$$

O mov. é retardado

$$\theta \stackrel{35^\circ}{X} = \theta_0 + 2\alpha \Delta X \quad \text{onde no ponto mais alto a veloc. é nula}$$

Para adarmos a aceleração, usamos a 2ª lei de Newton: $F_x = ma$



$$\text{Em } x: F_{x2} = -P_x = ma \quad -mg \sin \theta = ma$$

$$\text{Em } y: F_{y2} = 0$$

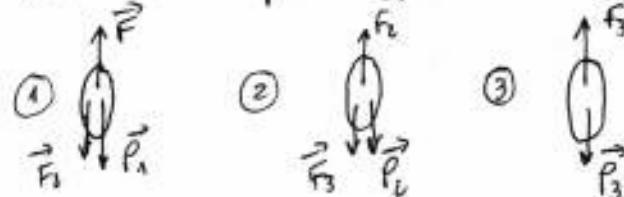
$$a = -g \sin \theta = -5,3 \text{ m/s}^2$$

$$\downarrow$$

$$\theta = 35^\circ - 2 \cdot 5,3 \Delta X$$

$$\Delta x = 115,57 \text{ m}$$

10) Analisando separadamente cada elo:



$$\vec{F} - \vec{F}_2 - \vec{P}_1 = 0$$

$$\vec{F} = \vec{F}_2 + \vec{P}_1$$

$$\vec{F} = 3N$$

$$\vec{F}_2 - \vec{F}_3 - \vec{P}_2 = 0$$

$$\vec{F}_2 = \vec{P}_2 - \vec{F}_3$$

$$\vec{F}_2 = 2N$$

$$\vec{F}_3 - \vec{P}_3 = 0$$

$$\vec{F}_3 = \vec{P}_3 = 1N$$

$$m = 0,1\text{ kg}$$

$$a = 2,5\text{ m/s}^2$$

$$(a) |\vec{F}_2| = ? \quad |\vec{F}_3| = ? \quad (b) |\vec{F}| = ?$$

$$(c) |\vec{F}_{R1}| = ? \quad |\vec{F}_{R2}| = ? \quad |\vec{F}_{R3}| = ?$$

↓

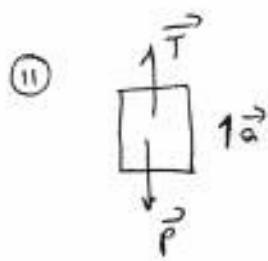
Todos com acel de $2,5\text{ m/s}^2$

↓

$$\vec{F}_{R1} = m_1 a = 2,5N \quad \vec{F}_{R2} = m_2 a = 2,5N$$

$$\vec{F}_{R3} = m_3 a = 2,5N$$

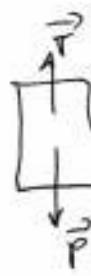
So F12 p/ TRÉS!



$$(a) \vec{T} - \vec{P} = m\vec{a}$$

$$\vec{T} = m(g + a)$$

↓
Peso aparente aumenta!

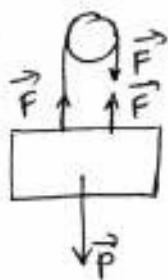


$$(b) \vec{T} - \vec{P} = m(-\vec{a})$$

$$\vec{T} = m(g - a)$$

↓
Peso aparente diminui!

12)



O topo/roldão e a corda (inextensível) transmitem a força \vec{F} que o homem faz.

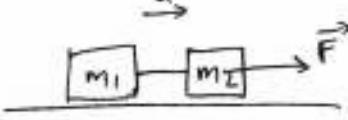
A força \vec{F} que o homem faz sobre a corda tem um par ação-reção que é a força que a corda faz sobre o homem. Como o homem é parte do sistema, desenhemos:

$$(a) Se sobe c/ veloc cte ($a=0$): $2\vec{F} - \vec{P} = 0 \quad \vec{F} = \frac{\vec{P}}{2} = \frac{Mg}{2}$$$

$$(b) Se sobe acelerado: $2\vec{F} - \vec{P} = Ma \quad \vec{F} = \frac{M(g+a)}{2}$$$

13)

\vec{a}



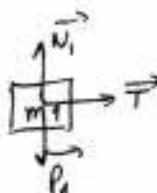
$$m_1 = 4,6\text{ kg}$$

$$m_2 = 3,8\text{ kg}$$

$$a_2 = 2,6\text{ m/s}^2$$

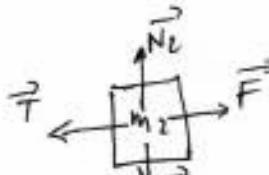
$$(a) |\vec{F}| = ?$$

$$(b) \vec{T} = ?$$



$$\vec{T} = m_1 a$$

$$\vec{T} = 4,6 \cdot 2,6 = 11,96N$$



$$\vec{F} - \vec{T} = m_2 a$$

$$\vec{F} = (m_1 + m_2)a$$

$$= 8,2 \cdot 2,6 = 21,32N$$

14)

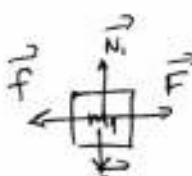


$$m_1 = 2,3\text{ kg}$$

$$m_2 = 1,2\text{ kg}$$

$$F = 3,6N$$

$$f_{\text{entre fato}} = ?$$



$$F - f = m_1 a$$

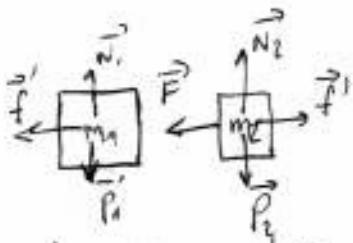
$$F = m_2 a$$

$$F = (m_1 + m_2)a$$

$$a = \frac{F}{m_1 + m_2}$$

$$f = F \frac{m_2}{m_1 + m_2}$$

$$= 1,1N$$



$$-f_1 = m_1(-a) \quad f_2 - f_1 = m_2(-a)$$

$$f_2 = m_2 a \rightarrow (m_1 + m_2)a = F$$

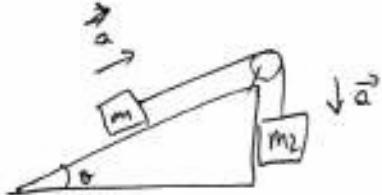
$$a = a$$

$$\frac{f_2}{m_1} = \frac{F}{m_1 + m_2}$$

$$f_2 = F \frac{m_1}{m_1 + m_2}$$

$$= 31 \text{ N}$$

⑤



$$m_1 = 3,7 \text{ kg} \quad (a) |T| = ?$$

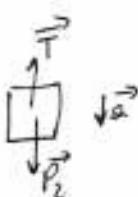
$$m_2 = 2,3 \text{ kg} \quad (b) |T| = ?$$

$$\theta = 30^\circ$$

$$T - P_1 = m_1 a$$

$$T = m_1 g \sin \theta + m_1 a$$

$$= m_1 (a + g \sin \theta)$$



$$T - P_2 = m_2 (-a)$$

$$T = m_2 (g - a)$$

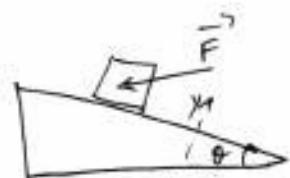
$$T = T$$

$$m_1 g \sin \theta + m_1 a = m_2 g - m_2 a$$

$$(m_1 + m_2) a = g (m_2 - m_1 \sin \theta)$$

$$a = g \left(\frac{m_2 - m_1 \sin \theta}{m_1 + m_2} \right) = 0,75 \text{ m/s}^2$$

⑥



$$m_1 = 10,0 \text{ kg}$$

$$\theta = 30^\circ$$

$$(a) |F| = ? \quad \vec{v} \text{ ctk}$$

$$P_x - F_x = 0$$

$$N - F_y - P_y = 0$$

$$P_{30^\circ} - F_{30^\circ} = 0$$

$$N = F \sin \theta + P \cos \theta = 573,75 \cdot 0,5 + 1000 \cdot 0,87$$

$$\approx 1158,67 \text{ N} = 1,16 \text{ kN}$$

$$m_1 = 5 \text{ kg}$$

$$m_2 = 1,3 \text{ kg}$$

$$\mu_e = 0,6$$

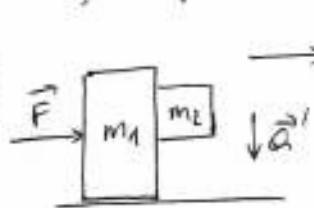
$$\mu_c = 0,4$$

$$(a) |\vec{F}_{\min}| = ?$$

$$(b) F = \frac{3}{4} F_{\min} \Rightarrow |\vec{a}_1| = ?$$

$$(c) F \text{ de superf. sobre } m_1? \quad (b)$$

⑦



$$m_1 = 5 \text{ kg}$$

$$m_2 = 1,3 \text{ kg}$$

$$\mu_e = 0,6$$

$$\mu_c = 0,4$$

(a)

$$a = a$$

$$\frac{F - N_2}{m_1} = \frac{N_2}{m_2}$$

$$\frac{F}{m_1} = N_2 \left(\frac{1}{m_2} + \frac{1}{m_1} \right)$$

$$F = \frac{P_2}{\mu_e} m_1 \left(\frac{1}{m_2} + \frac{1}{m_1} \right)$$

$$F = \frac{m_1 m_2 g}{\mu_e} \left(\frac{1}{m_2} + \frac{1}{m_1} \right) = 105,1 \text{ N} //$$

$$\text{Ex: } F - N_2 = m_1 a$$

$$N_1 - F_a - P_1 = 0$$

$$N_2 = m_2 a$$

$$F_a - P_2 = 0$$

$$\mu_e N_2 - P_2 = 0$$

$$\downarrow N_2 = \frac{P_2}{\mu_e}$$

$$(b) \text{ Se } F = 78,8 \text{ N} \Rightarrow F_a - P_2 = m_2 (-\alpha')$$

$$\mu_e N_2 - P_2 = -m_2 \alpha'$$

$$N_2 = N_2$$

$$F - m_1 a = m_2 a$$

$$F = (m_1 + m_2) a$$

$$a = \frac{F}{m_1 + m_2} = \frac{78,8}{6,3} = 12,5 \text{ m/s}^2 //$$

m_1 se move com acel. \vec{a} : $12,5 \text{ m/s}^2$

m_2 se move com duas acelerações: \vec{a} e \vec{a}' $a' = \frac{P_2 - \mu_e N_2}{m_2}$ onde $N_2 = m_2 a$

$$\begin{aligned} a_{\text{enmm}} &= \sqrt{a^2 + a'^2} \\ &= \sqrt{12,5^2 + 5^2} \end{aligned}$$

$$= 13,5 \text{ m/s}^2 //$$

$$a' = \frac{m_2 g - \mu_e m_2 a}{m_2}$$

$$a' = 10 - 0,4 \cdot 12,5 = 5 \text{ m/s}^2$$

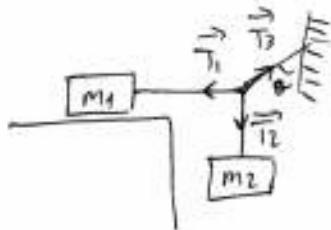
(c) A força de interação entre a superfície horizontal e m_1 é \vec{N}_1 .

$$N_1 = P_1 + F_a = P_1 + \mu_e N_2 \quad \begin{array}{l} \mu_e \text{ no caso (a)} \\ \mu_e \text{ no caso (b)} \end{array} \quad \text{onde } N_2 = \frac{P_2}{\mu_e} \text{ no caso (a)}$$

$$\text{Caso (a): } N_1 = m_1 g + \mu_e \frac{m_2 g}{\mu_e} = (m_1 + m_2) g = 63 \text{ N} //$$

$$\text{Caso (b): } N_1 = m_1 g + \mu_e (m_2 g - m_2 a') = (m_1 + m_2) g - m_2 a' = 56,5 \text{ N} //$$

18)



$$m_1 = 10 \text{ kg}$$

$$m_2 = 5 \text{ kg}$$

$$\theta = 30^\circ$$

$$(a) \mu_e = ?$$

$$(b) |T_1| = ? \quad |T_2| = ?$$

$$|T_3| = ?$$

$$(a) F_e = T_1 \Rightarrow \mu_e N_1 = T_3 \sin \theta$$

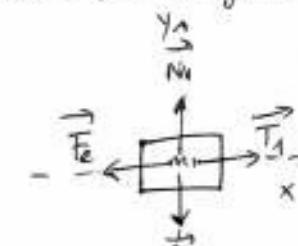
$$\mu_e m_1 g = T_3 \sin \theta$$

$$\left. \begin{array}{l} T_2 = P_2 \\ T_2 = T_3 \cos \theta \end{array} \right\} T_3 = \frac{P_2}{\cos \theta}$$

$$\left. \begin{array}{l} T_2 = P_2 \\ T_2 = T_3 \cos \theta \end{array} \right\} T_3 = \frac{P_2}{\cos \theta}$$

$$\mu_e m_2 g = m_2 g \frac{\sin \theta}{\cos \theta}$$

$$\mu_e = \frac{m_2 g \tan \theta}{m_1} = 0,29$$



$$T_1 - F_e = 0$$

$$N_1 - P_1 = 0$$

$$T_2 - P_2 = 0$$

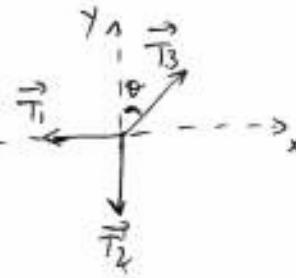
$$T_3 \sin \theta - T_1 = 0$$

$$T_3 \cos \theta - T_2 = 0$$

$$(b) T_2 = P_2 = 50 \text{ N}$$

$$T_3 = \frac{T_2}{\cos \theta} = 57,7 \text{ N}$$

$$T_1 = T_3 \sin \theta = 28,9 \text{ N}$$



(19)



$$|\vec{F}| = ?$$

$$m = 5 \text{ kg}$$

$$\theta = 36,8^\circ$$

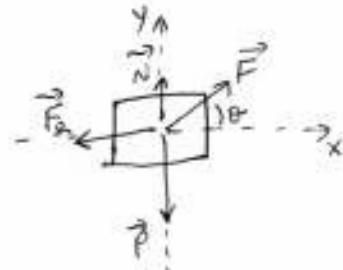
$$\mu_e = 0,9$$

$$\mu_c = 0,75$$

$$(a) |\vec{a}| = 0$$

$$(b) |\vec{a}| = 1,2 \text{ m/s}$$

$$(c) |\vec{a}| = 0,5 \text{ m/s}^2$$



$$(a) \left\{ \begin{array}{l} F \cos \theta - F_a = 0 \\ N + F \sin \theta - P = 0 \end{array} \right. \rightarrow N = P - F \sin \theta$$

$$F \cos \theta = \mu_e \cdot m g - \mu_c F \sin \theta$$

$$F (\cos \theta + \mu_e \sin \theta) = \mu_e m g$$

$$F = \frac{\mu_e m g}{(\cos \theta + \mu_e \sin \theta)} = \frac{0,9 \cdot 50}{0,8 + 0,9 \cdot 0,6} = 33,6 \text{ N} //$$

$$(b) F = \frac{\mu_c m g}{\cos \theta + \mu_c \sin \theta} = \frac{0,75 \cdot 50}{0,8 + 0,75 \cdot 0,6} = 30 \text{ N} //$$

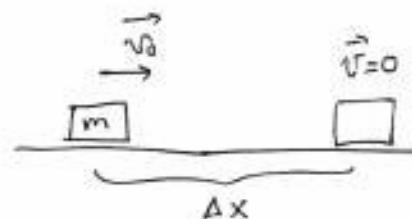
$$(c) \left\{ \begin{array}{l} F \cos \theta - F_a = m a \\ N + F \sin \theta - P = 0 \end{array} \right. \rightarrow N = P - F \sin \theta$$

$$F \cos \theta - \mu_c (m g - F \sin \theta) = m a$$

$$F (\cos \theta + \mu_c \sin \theta) = m (a + \mu_c g)$$

$$F = \frac{m (a + \mu_c g)}{(\cos \theta + \mu_c \sin \theta)} = \frac{5 (0,5 + 7,5)}{0,8 + 0,75 \cdot 0,6} = 32$$

(20)



$$m = 110 \text{ g} = 0,11 \text{ kg}$$

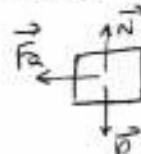
$$\Delta x = 1,5 \text{ m}$$

$$|\vec{v}_0| = 6 \text{ m/s}$$

↓

$$0 = v_0^2 + 2 a \Delta x$$

$$a = - \frac{36}{2 \cdot 1,5} = - 1,2 \text{ m/s}^2$$



$$\left\{ \begin{array}{l} -F_a = m(-a) \rightarrow F_a = 0,13 \\ N - P = 0 \quad N = P \end{array} \right.$$

$$\mu_e g = \mu_c a$$

$$\mu = 0,12$$

$$(21) \mu_e = 0,04 \\ \theta_{\min} = ?$$

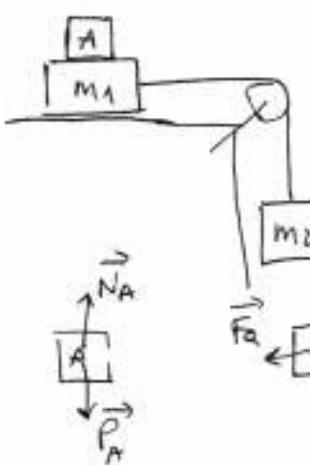


$$P_x - F_a \cos \theta = 0 \quad \mu_f \sin \theta = \mu_e m g \cos \theta \\ N - P_y = 0 \rightarrow N = P \cos \theta \quad \downarrow$$

$$\tan \theta = \mu_e \\ = 0,04$$

$$\theta = 2,3^\circ$$

(22)



$$\mu_e = 0,2$$

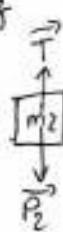
$$\mu_c = 0,15$$

$$m_1 = 4,4 \text{ kg}$$

$$m_2 = 42 \text{ kg}$$

$$(a) m_A \text{ minimo} = ?$$

$$(b) \sin \alpha \Rightarrow |\vec{a}| = ?$$



$$\left\{ \begin{array}{l} F_a = T \quad \mu_e N_1 = m_2 g \quad N_1 = \frac{m_2 g}{\mu_e} \\ N_A = N_1 - P_1 \quad N_A = \frac{m_2 g}{\mu_e} - m_1 g \end{array} \right.$$

$$m_A = \frac{N_A}{g} = \frac{m_2}{\mu_e} - m_1$$

$$m_A = 6,6 \text{ kg}$$

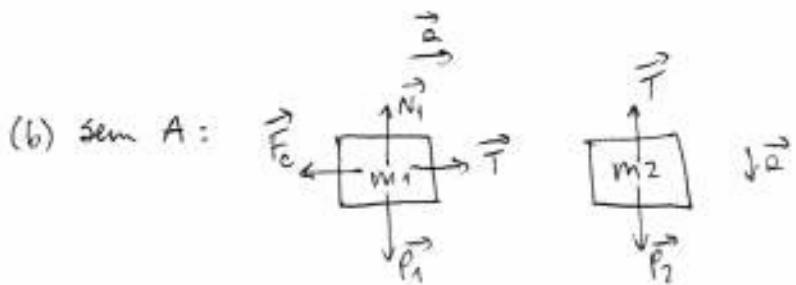
$$P_A = 66 \text{ N}$$

$$N_A - P_A = 0$$

$$N_A = m_1 g$$

$$\left\{ \begin{array}{l} T - F_a = 0 \\ N_1 - N_A - P_1 = 0 \end{array} \right.$$

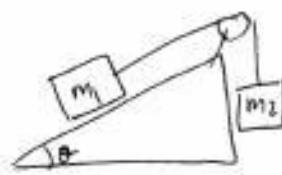
$$\left\{ \begin{array}{l} T - P_2 = 0 \\ T = m_2 g \end{array} \right.$$



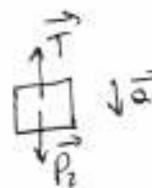
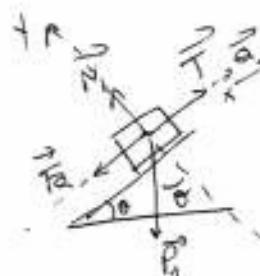
$$\begin{cases} T - \mu_c N_1 = m_1 a \\ N_1 - P_1 = 0 \end{cases} \quad T - P_2 = m_2 (-a)$$

$$\begin{aligned} T &= T \\ m_1 a + \mu_c m_1 g &= m_2 g - m_2 a \\ a(m_1 + m_2) &= g(m_2 - \mu_c m_1) \\ a &= g \frac{(m_2 - \mu_c m_1)}{(m_1 + m_2)} = 2,3 \text{ m/s}^2 \end{aligned}$$

(23)



- (a) $|\vec{a}| = ?$
 (b) $|T| = ?$
 (c) $|F_{R2}| = ?$
 (d) \vec{F}_2 sobre plano?



$$T - P_2 = m_2 (-a)$$

(a) $T = T$

$$\begin{aligned} m_1 a + m_1 g \sin \theta + \mu_c m_1 g \cos \theta &= m_2 g - m_2 a \\ a(m_1 + m_2) &= g(m_2 + m_1 \sin \theta + m_1 \mu_c \cos \theta) \\ a &= g \left[\frac{m_2 + m_1 (\sin \theta + \mu_c \cos \theta)}{m_1 + m_2} \right] \end{aligned}$$

(d) No planes:

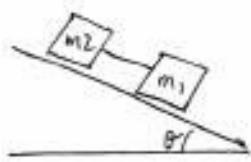


$$\begin{aligned} F_R &= \sqrt{F_p^2 + N^2} \\ &= \sqrt{(\mu_c m_1 g \cos \theta)^2 + (m_1 g \sin \theta)^2} \\ &= m_1 g \sqrt{\cos^2 \theta + \sin^2 \theta} = m_1 g \end{aligned}$$

(b) $a = a$

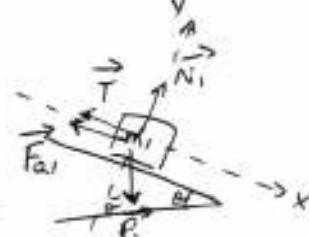
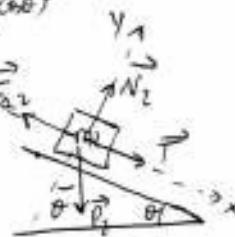
$$\begin{aligned} T - \mu_c m_1 g \cos \theta - m_1 g \sin \theta &= \frac{m_2 g - T}{m_2} \\ T \left(\frac{1}{m_1} + \frac{1}{m_2} \right) &= g [m_2 + m_1 (\sin \theta + \mu_c \cos \theta)] \\ T &= \frac{m_1 m_2 g}{m_1 + m_2} \left[\dots \right] \end{aligned}$$

(24)



$$\theta = 30^\circ$$

$$\begin{aligned} m_1 &= 3,6 \text{ kg} \\ \mu_1 &= 0,1 \\ m_2 &= 7,2 \text{ N} \\ \mu_2 &= 0,2 \end{aligned}$$

(a) $|\vec{a}| = ?$ (b) $|T| = ?$ (a) $T = T$

$$\begin{aligned} m_2 a + m_2 g \sin \theta + \mu_2 m_2 g \cos \theta &= m_2 g \sin \theta - \mu_1 m_1 g \cos \theta - m_1 a \\ a(m_1 + m_2) &= g [m_1 (\sin \theta - \mu_1 \cos \theta) + m_2 (\sin \theta + \mu_2 \cos \theta)] \end{aligned}$$

$$a = \frac{10}{10,8} \left[3,6 (0,5 - 0,1 \cdot 0,87) + 7,2 (0,5 + 0,2 \cdot 0,87) \right] = 3,5 \text{ m/s}^2$$

$$\begin{cases} T + P_2 x - F_{2z} = m_2 a \\ N_2 - P_2 y = 0 \end{cases}$$

$$\begin{cases} P_2 x - T - F_{2z} = m_1 a \\ N_1 - P_1 y = 0 \end{cases}$$

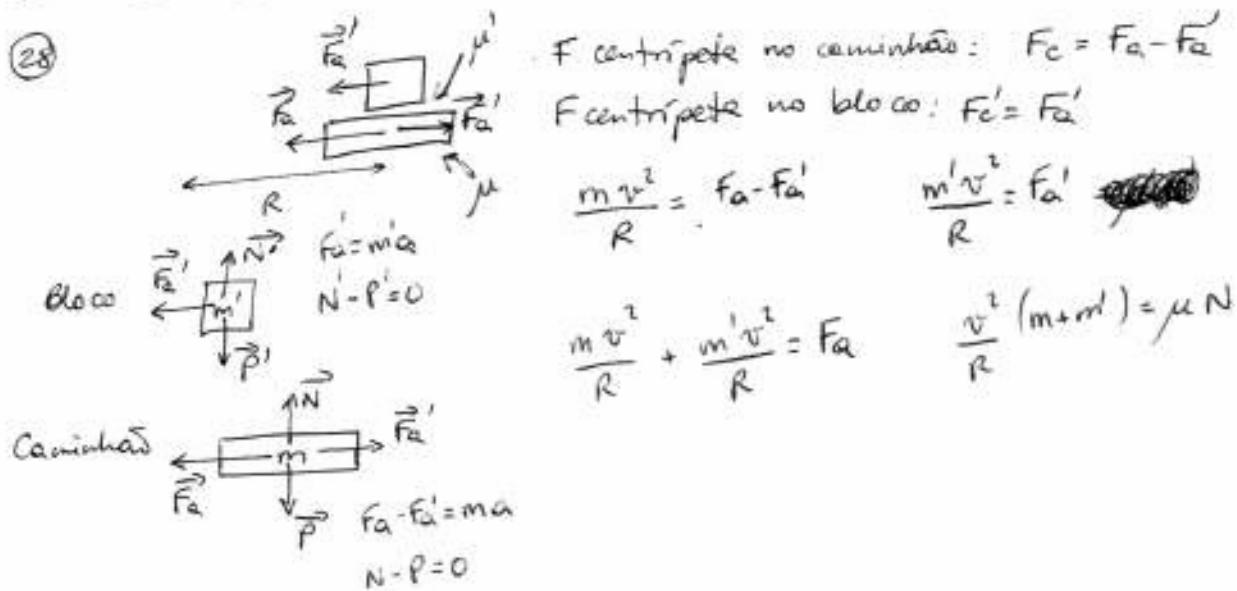
(b) $a = a$

$$\frac{T + P_2 \sin \theta - \mu_2 P_2 \cos \theta}{m_2} = \frac{P_1 \sin \theta - T - \mu_1 P_1 \cos \theta}{m_1} \quad T \left(\frac{1}{m_2} + \frac{1}{m_1} \right) = \frac{\mu_1 g (\sin \theta - \mu_1 \cos \theta)}{m_1}$$

$$T \left(\frac{1}{m_2} + \frac{1}{m_1} \right) = g \cos \theta (\mu_2 - \mu_1) \quad T = \frac{10 \cdot 9,87 \cdot 0,1}{0,42} = 91 \text{ N} \quad - \frac{\mu_1 g (\sin \theta - \mu_1 \cos \theta)}{m_1}$$

(25) (26) (27) Em avião

(28)



$$(b) R = 60\text{m}$$

$$\mu = 0,4$$

$$N_{\text{net}} = ?$$