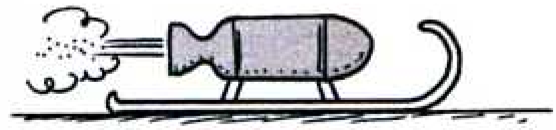
Show all calculations. Explain all assumptions. Answer in standard MKS units.
Explicitly substitute units into your symbolic equations to verify solution.
Express answers in 5 or fewer digits. Use scientific notation as appropriate.

Conceptual Questions: **Place the letter** corresponding to your answer **in the box.**

Limit your explanation to the space provided. Please write legibly.

1. A little sled weighs 2 Newtons. It is set in motion over a frictionless icy surface by a toy rocket motor with a weight of 1 Newton. After the fuel has been expended, the sled is coasting at a speed of 2 meters per second. How much force did the rocket exert on the sled?



$\boxed{E}$

a) 1 N
b) 4 N
c) 6 N
d) 12 N
e) There is no way to tell from the information given

Explain:

without either Δx or Δt, no way to calculate $\vec{a}$, and $\therefore$ $\vec{F}$ is unknown.

2. Since action and reaction are equal in magnitude and oppositely directed, can there ever be a net force that acts upon an object?

$\boxed{A}$

a) Yes, of course!
b) No, of course not!
c) More information is required.

Explain:

action + reaction act upon two different parts of the system, $\therefore$ each part o/t system experiences a net force.

Show all calculations. Explain all assumptions. Answer in standard MKS units.
Explicitly substitute units into your symbolic equations to verify solution.
Express answers in 5 or fewer digits. Use scientific notation as appropriate.

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3. The Levi Strauss trademark shows two horses trying to pull apart a pair of pants. Suppose Levi had only one horse and attached the other side of the pants to a fencepost. Using only one horse would__

$\boxed{B}$

a) Reduce the tension on the pants by one-half
b) Leave the tension unchanged
c) Double the tension on the pants
Explain:

if the pants are not moving $F_{net} = \emptyset$, whether it be b/c of forces provided by horses or fenceposts $\therefore$ T = same.

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4 A boulder is many times heavier than a pebble. That is - the gravitational force that acts upon the bolder is many times larger than the gravitational force that acts upon the pebble. Yet if you drop a boulder and a pebble at the same time they will fall with equal accelerations (neglecting air resistance). The principal reason that the much heavier boulder doesn't accelerate more than the lighter pebble has to do with

$\boxed{B}$

a) weight
b) inertia
c) surface area
d) none of the above
Explain:

$F_B = Mg \quad F_P = mg \quad a_B = \frac{F_B}{M} \quad a_P = \frac{F_P}{m}$

since acceleration $\propto$ mass and mass is measure of inertia, then inertia sets acceleration.

$\sum F(\hat{y}) = m\vec{a}_y$

$mg(-\hat{y}) + F_T(+\hat{y}) = m\vec{a}_y$

when $a = \emptyset$ then $F_T = mg = \boxed{7955\,N}$ = weight

$7955(-\hat{y}) + 6850(+\hat{y}) = m(\emptyset.15)(-\hat{y})$

$\boxed{m = 7367\ kg}$

g_{planet} … $(7367)(\vec{g}) + 7955(+\hat{y}) = \emptyset$

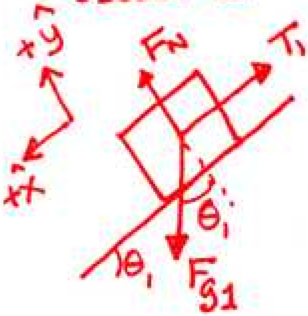
$\vec{g} = \frac{7955}{7367}(-\hat{y}) = \boxed{1.08\,m/s^2(-\hat{y})}$

$a_{net} \Rightarrow \Delta y = \frac{1}{2}at^2 \qquad \frac{2\Delta y}{t^2} = a_{net}(+\hat{y})$

$F_T(+\hat{y}) + 7955(-\hat{y}) = (7367)\left(\frac{2\Delta y}{t^2}\right)(+\hat{y})$

$\boxed{F_T \simeq \cancel{[illegible]}\,N(+\hat{y})}$
9914 N

OBJECT 1

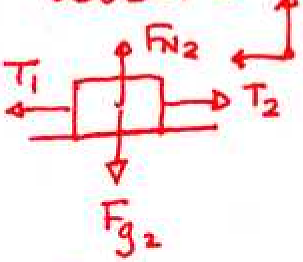


$\Sigma F_y = \emptyset$ b/c block rests on surface...

$\Sigma F_x = m_1 a_x \;\Rightarrow\; m_1 g \sin\theta_1 (+\hat{x}) + T_1(-\hat{x}) = m_1 a_x$

• $m_1 g \sin\theta_1 - T_1 = m_1 a$ • 1)

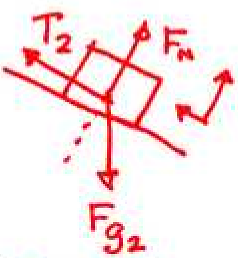
OBJECT 2



$\Sigma F_y = \emptyset$ b/c block rests on surface...

$\Sigma F_x = m_2 a_x \;\Rightarrow\; T_1(+\hat{x}) + T_2(-\hat{x}) = m_2 a_x$

• $T_1 - T_2 = m_2 a$ • 2)



$\Sigma F_y = \emptyset$ b/c block rests on surface...

$\Sigma F_x = m_3 a_x \;\Rightarrow\; T_2(+\hat{x}) + m_3 g \sin\theta_3 (-\hat{x}) = m_3 a_x$

OBJECT 3. • $T_2 - m_3 g \sin\theta_3 = m_3 a_x$ • 3)

substitute 3) and 1) into 2)...

$m_1 g \sin\theta_1 - m_1 a = T_1$; $T_2 = m_3 a + m_3 g \sin\theta_3$

$$a = \frac{m_1 g\sin\theta_1 - m_3 g \sin\theta_3}{m_1 + m_2 + m_3}$$ useful later..

solving slightly differently...

$$m_1(g\sin\theta_1 - a) - m_3(g\sin\theta_3 + a) = m_2 a$$

$$m_1 = \frac{m_2 a + m_3(g\sin\theta_3 + a)}{(g\sin\theta_1 - a)} \simeq \frac{45(1) + 15(9.8\sin 35 + 1)}{(9.8\sin 65 - 1)}$$

$$\boxed{m_1 \simeq 18.3\text{ kg}}$$

b) now $m_3 = 45\,kg$ and $\vec{a}$ changes

$$a = \frac{[(18.3)(9.8)\sin(65)] - [45(9.8)(\sin 35)]\,(N)}{108.3\ kg}$$

$a \simeq 8.35 \cdot 10^{-1}\ m/s^2\,(-\hat{x})$ so - with $V_f = V_0 + at$

and $V_0 = \emptyset$ then...

$$\boxed{V_f = 1.67\ m/s\,(-\hat{x}) \cdot \text{to the right}}$$

$T_1 = m_1(g\sin\theta_1 - a)$ $\quad$ $T_2 = m_3(g\sin\theta_3 + a)$

$T_1 = 18.3(9.8\sin 65 + .835)$ $\quad$ $T_2 = 45(9.8\sin 35 - .835)$

$\boxed{T_1 \simeq 178\,N}$ $\quad$ $\boxed{T_2 \simeq 215\,N}$

$$F_1 = \frac{3}{4}\frac{N}{s}t - \frac{35}{100}\frac{N}{s^2}t^2 \qquad \boxed{3/4\,N/s\,;\ \frac{35}{100}\,N/s^2}$$

$$F_2 = 9N - 1.25\frac{N}{s}t \qquad \boxed{9N;\ 1.25\frac{N}{s}}$$

motion in $\hat{y}$ stops when $V_y = \emptyset$; since $a_y = \frac{F_y}{m} = \frac{9}{10}N - \frac{1.25}{10}\frac{N}{s}t$

$$v_{fy} = v_{oy} + \int a\,dt \Rightarrow \quad V_{oy} + \frac{9}{10}t - \frac{1.25}{20}t^2 = \emptyset \quad \langle v_{fy} = \emptyset \rangle$$

$$\emptyset = 6 + .9t - 6.25 \cdot 10^{-2}t^2 \quad \langle \text{quadratic in } t \rangle$$

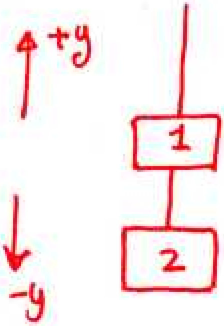
$$\emptyset = 96 + 14.4t - t^2 \Rightarrow \qquad t = \frac{-14.4 \pm 24.3}{-2} = \boxed{19.4s}$$

$$v_{fy} = v_{oy} + \frac{9}{10}t - \frac{1.25}{20}t^2 \ @\ t = 10 \qquad v_{fy} = 8.75\,m/s\,(+\hat{y})$$

$$v_{fx} = V_{ox} + \frac{3}{80}t^2 - \frac{35}{3000}t^3 \quad @\ t = 10 \quad v_{fx} = 7.08\,m/s\,(+\hat{x})$$

$$v_f = \sqrt{V_{fx}^2 + V_{fy}^2} = 11.3\,m/s \ @\ \theta = \tan^{-1}\left(\frac{8.75}{7.08}\right)$$

$$\boxed{v_f = 11.3\,m/s\ @\ \theta = 51^\circ \text{ wrt}(+\hat{x})}$$



$$\Sigma F_{x_2} = F_{g_2}(-\hat{y}) + T_2(+\hat{y}) = m_2 a_2$$

$$\Sigma F_{x_1} = F_{g_1}(-\hat{y}) + T_2(-\hat{y}) + T_1(+\hat{y}) = m_1 a_1$$

$$\Sigma F_{x_2} \Rightarrow \quad m_2 g(-\hat{y}) + T_2(+\hat{y}) = m_2 a$$

$$\Sigma F_{x_1} \Rightarrow \quad m_1 g(-\hat{y}) + T_2(-\hat{y}) + T_1(+\hat{y}) = m_1 a$$

a) if blocks are @ rest $a = \varnothing$

$$\boxed{\begin{aligned} T_2 &= m_2 g &&= 19.6\,N \\ T_1 &= (m_1 + m_2) g &&= 29.4\,N \end{aligned}}$$

b) if V = constant; then $a = \varnothing$ and

$$\boxed{\begin{aligned} T_2 &= 19.6\,N \\ T_1 &= 29.4\,N \end{aligned}}$$

c) if $a = 2\,m/s^2\,(+\hat{y})$ then ...

$$T_2 - m_2 g = m_2(2) \qquad T_2 = m_2(g+2) \simeq \boxed{23.6\,N}$$

$$T_1 = m_1(g+a) + m_2(g+a) = (3)(g+2) \simeq \boxed{35.4\,N}$$

if blocks accelerate in $(-\hat{y})$ direction then

$$T_2 - m_2 g = -m_2 a \quad \therefore \; T_2 = m_2(g-a)$$

$$T_1 = (m_1+m_2)(g-a)$$

$$\boxed{\begin{array}{l} T_2 = 15.6\,N \\ T_1 = 23.4\,N \end{array}}$$

e) If $T_{max} = 75\,N$ then what is a_{max}

- related question - which rope snaps first?

→ the one bearing the heavier load, T_1

$\therefore$ if $T_1 = 75\,N$ then

$$75 = (m_1+m_2)(g+a)$$

$$25 = g + a \;;\; 25 - g = a$$

$$\boxed{a_{max} = 15.2\ m/s^2\ (+\hat{x})}$$