3

Conceptual Questions

1. Zero acceleration does not mean that there are no forces. It does mean that there is no net force. There could be canceling forces

2. A heavier rock experiences more force, but it also has more inertia, so it does not accelerate faster. *Their weight-to-mass ratios are the same.

Concise Answer

2kg rock ⇒ $w = mg = 2kg(9.8 m/s^2) = 19.6 N$ of weight

$\Sigma F = ma \Rightarrow 19.6N = 2kg(a)$

$a = 9.8 m/s^2$

1kg rock ⇒ $w = mg = 1kg(9.8 m/s^2) = 9.8 N$ of weight

$\Sigma F = ma \Rightarrow 9.8 N = 1kg(a)$

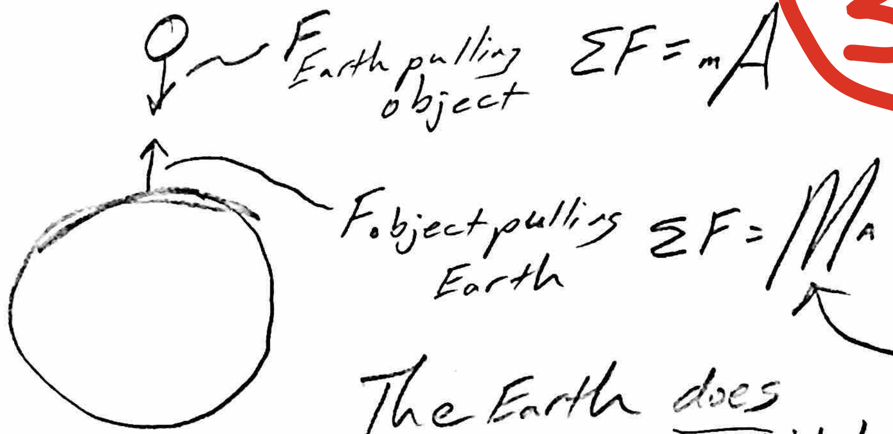
$a = 9.8 m/s^2$

More force, More mass (inertia), Same Acceleration.

less force, less mass (inertia), Same acceleration

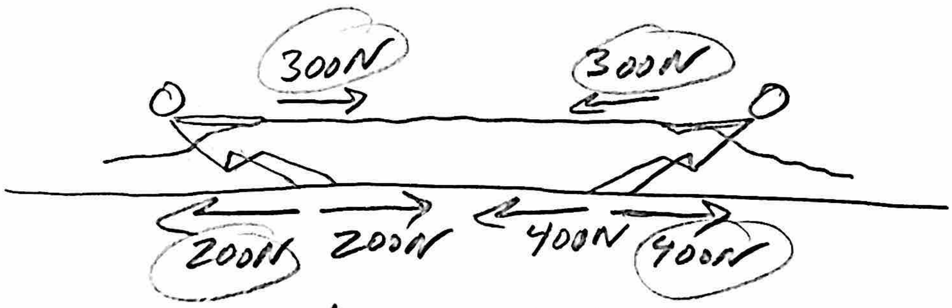
3-4

3.



The Earth does move, but it has so much mass that its acceleration is very small compared to the object's acceleration

4.



The circled forces are acting on the system of the people and rope.

The sum of those forces (Net force) is 200N to the right.

The team that pushes harder against the Earth will win.

Problems

1. $\Sigma F = ma$ $\quad \Sigma F = 60kg(1.25m/s^2)$

$\Sigma F = 75N$

---

2. $\Sigma F = ma$ $\quad 265N = m(2.3m/s^2)$

$m = 115kg$

---

3. a) $W = mg_{Earth} = 76kg(9.8m/s^2) = 745N$

b) $W = mg_{moon} = 76kg(1.7m/s^2) = 129N$

c) $W = mg_{mars} = 76kg(3.7m/s^2) = 281N$

d) $W = mg_{\text{outerspace with constant velocity}} = 76kg(0m/s^2) = 0N$

---

4. $\Sigma F = ma = 1100kg(a)$ — we need a

$\Delta t = 8s$

$V_0 = 95km/hr$ ← $\frac{95km}{hr}\left(\frac{1000m}{1km}\right)\left(\frac{1hr}{3600s}\right) = 26.4m/s$

$V = 0m/s$

$V = V_0 + at \Rightarrow 0m/s = 26.4m/s + a(8s)$

$a = -3.3m/s^2$

$\Sigma F = 1100kg(-3.3m/s^2) = -3,630N$

4-5

5. $\boxed{\Sigma F = ma}$ $\Sigma F = 0.140\,kg\,(a)$

↑ we need a

$v_0 = 35\,m/s$

$v = 0\,m/s$

$\Delta x = 0.11\,m$

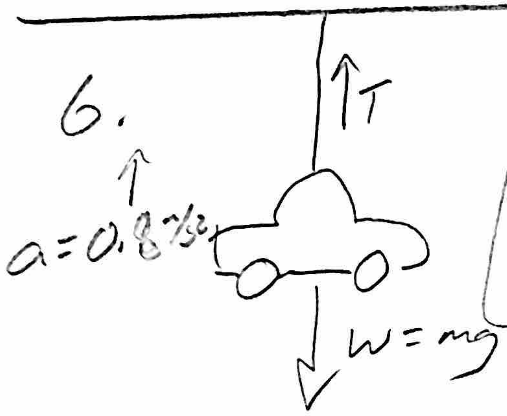
$$v^2 = v_0^2 + 2a\Delta x$$

$$0 = (35\,m/s)^2 + 2a(0.11\,m)$$

$$a = 5570\,m/s^2$$

$$\Sigma F = 0.140\,kg\,(5570\,m/s^2) = \boxed{780\,N}$$

6.



$$\boxed{\begin{aligned}\Sigma F &= ma\\ \Sigma F &= T - mg\end{aligned}}$$

$\Rightarrow ma = T - mg$

$ma + mg = T$

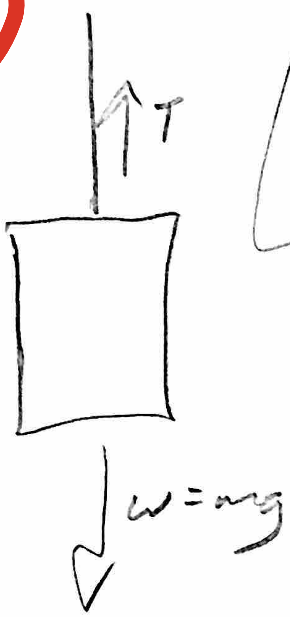
$m(a+g) = T$

$$1200\,kg\,(0.8\,m/s^2 + 9.8\,m/s^2) = T$$

$$\boxed{T = 12{,}720\,N}$$

7. The elevator can accelerate up or down

5



$\Sigma F = ma$

$\Sigma F = T - mg$

$0.068g = 0.068(9.8 m/s^2)$
$= 0.67 m/s^2$

$\Downarrow$

$ma = T - mg$

$ma + mg = T$

$m(a+g) = T$

When the elevator is going up...

$a = +0.67 m/s^2$...

$T = 4850kg(0.67 m/s^2 + 9.8 m/s^2)$

Max force → $T = 50,800N$

When the elevator is descending...

$a = -0.67 m/s^2$

$T = 4850kg(-0.67 m/s^2 + 9.8 m/s^2)$

Min force → $T = 44,280 N$

5

8.

$\Sigma F = ma$

$\Sigma F = T - mg$

$\Downarrow$

$T - mg = ma$

$T = mg + ma$

$T = m(g + a)$

(m: 75kg; g: 9.8m/s²)

max tension is 568N

"Supporting a mass of 58kg" means supporting a weight of:

$W = mg = 58kg(9.8m/s^2)$

$= 568N$

$\Downarrow$

$568N = 75kg(9.8m/s^2 + a)$

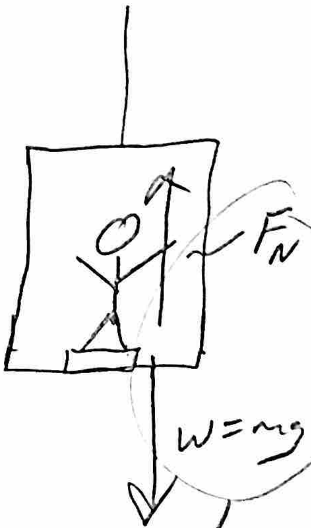
$a = -2.23m/s^2$

If the thief can manage to accelerate downward at a rate of $-2.23m/s^2$, then the force on the rope will only be 568N. One way to do this is to grip the rope lightly and slide down.

5

9.

$a = ?$



In this case the "normal force" is the force of the scale pushing the person up. This is also the scale reading.

These are the forces acting on the person.

$\Downarrow$

Scale reading is $0.75(mg) = F_N$

$$\sum F = ma$$
$$\sum F = F_N - mg$$

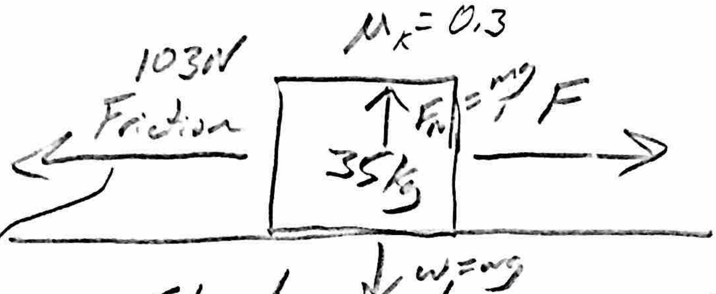
$$ma = F_N - mg$$
$$ma = 0.75mg - mg$$
$$ma = -0.25mg$$
$$a = -0.25\,g \Rightarrow a = -0.25(9.8\,m/s^2)$$
$$a = -2.45\,m/s^2$$

Elevator is moving downward.

5

10.

a)



Steady speed means $a = 0$

$\sum F = ma$

If $a = 0$, then $\sum F = 0$,

So forces are balanced, and

$F = F_{Friction}$

$F_{Fr} = \mu_k F_N$

$= \mu_k mg$

$= 0.3(35kg)(9.8 m/s^2)$

$= 103N$

We know $F_N = mg$ because box is not moving in Y dimension

$$\sum F = ma$$
$$\sum F = F - F_{Fr}$$

$ma = F - F_{Fr}$

$35kg(0 m/s^2) = F - 103N$

$F = 103N$

---

b) If $\mu = 0$, then $F_{Fr} = 0$

$\sum F = ma$

$\sum F = F - F_{Fr}$

$ma = F - F_{Fr}$

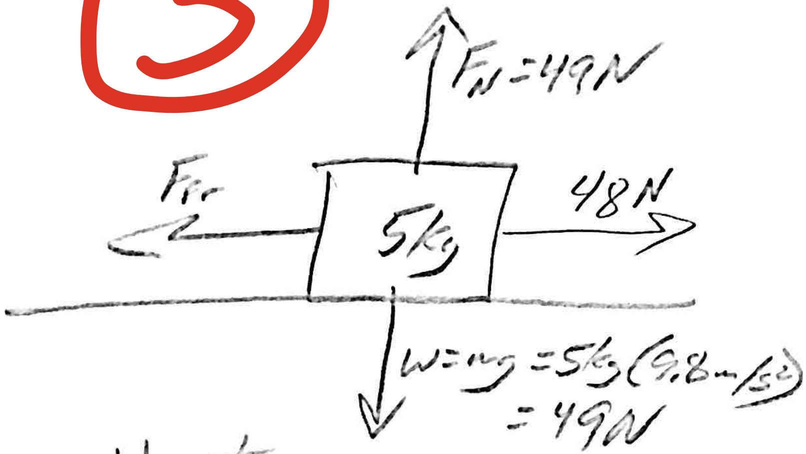
$35kg(0 m/s^2) = F - 0$

$F = 0$

5

11.

a)



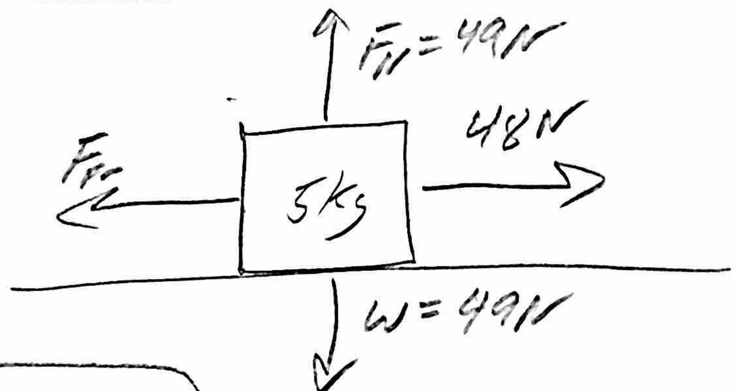
If at least 48N is needed to start moving the box, then F_{Fr} must = 48N

$$F_{Fr} = \mu_s F_N = 48N$$

$$\mu_s (49N) = 48N$$

$$\boxed{\mu_s = 0.98}$$

b)



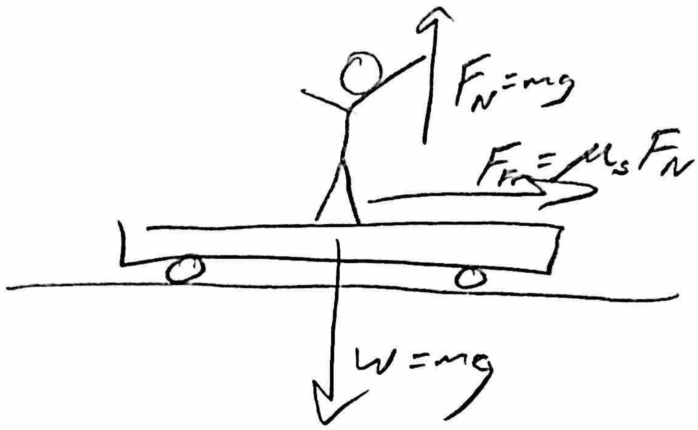
$$\sum F = ma$$
$$\sum F = 48N - F_{Fr}$$

$\Rightarrow$ $ma = 48N - F_{Fr}$ ← $\mu_k(F_N)$

$$5kg\,(0.7\,m/s^2) = 48N - \mu_k(49N)$$

$$\boxed{\mu_k = 0.91}$$

12.



The only unbalanced force acting on you is Friction!

$$\sum F = ma$$
$$\sum F = F_{Fr} = \mu_s F_N = \mu_s mg$$

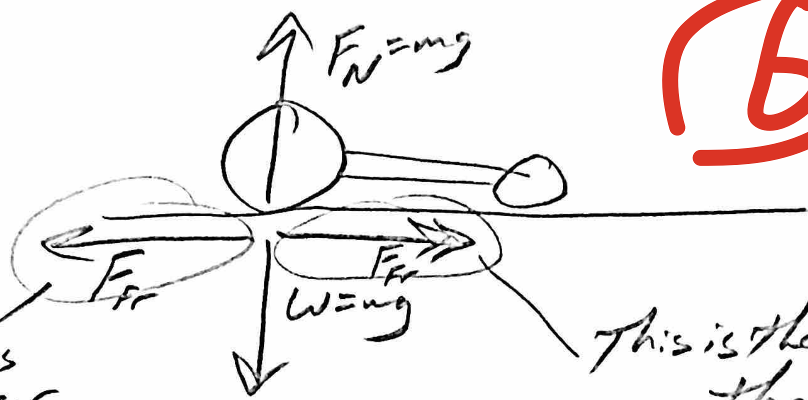
$\Downarrow$

$$ma = \mu_s mg$$
$$\frac{a}{g} = \mu_s$$
$$\frac{0.2g}{g} = \mu_s$$
$$\boxed{0.2 = \mu_s}$$

⑥

13.

(6)



This is the car pushing the road, using Friction.

This is the road pushing the car, using friction

$$\sum F_{car} = ma$$

$$\sum F_{car} = F_{Fr} = \mu_s F_N = \mu_s mg$$

$$ma = \mu_s mg$$

$$\mu_s = \frac{a}{g}$$ ← we need a...

Using kinematics...

$\Delta x = 1{,}000\ m$

$V_{0x} = 0\ m/s$

$\Delta t = 12\ s$

$$\Delta x = V_0 t + \tfrac{1}{2} a t^2$$

$$1{,}000\ m = 0\ m/s\,(12\ s) + \tfrac{1}{2}\, a\,(12\ s)^2$$

$$a = 13.9\ m/s^2$$

$$\mu_s = \frac{13.9\ m/s^2}{9.8\ m/s^2} = \boxed{1.42}$$

6

14. Kinematics to find Δx

$\Delta x = ?$

$V_0 = 4\,m/s$

$V = 0\,m/s$

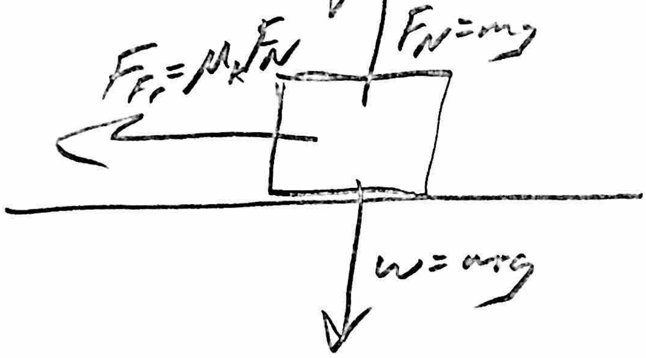
$a =$

$t =$

we need a

$$V^2 = V_0^2 + 2a\Delta x$$

During the slide



$$\sum F = ma$$

$$\sum F = -F_{Fr} = -\mu_k F_N = -\mu_k mg$$

$$ma = -\mu_k mg$$

$$a = -(0.2)(9.8\,m/s^2) = -1.96\,m/s^2 = a$$

$$(0\,m/s)^2 = (4\,m/s)^2 + 2(-1.96\,m/s^2)\Delta x$$

$$\boxed{\Delta x = 4.08\,m}$$