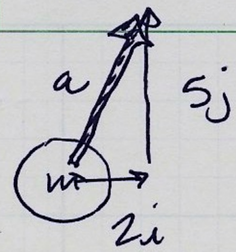
5.1 $m = 3.00\,kg$
$a = (2.00i + 5.00j)\ m/s^2$



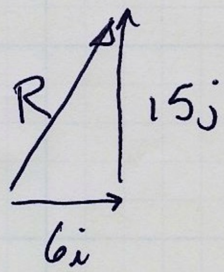
a. Resultant force acting on mass?

$F_{net} = ma$

$F = (3\,kg)(2i + 5j)\ m/s^2$

$F = \boxed{(6i + 15j)\ N}$

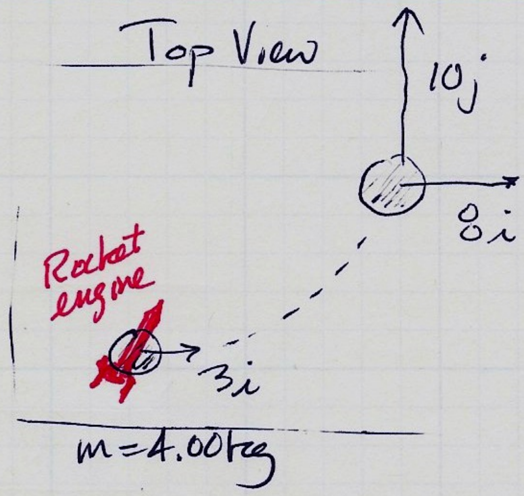
b. Magnitude of force = ?



$F = \sqrt{6^2 + 15^2}$

$= \boxed{16.2\,N}$

5.3



a. $F_{net} = ma$

$$= m \frac{v_f - v_i}{t}$$

$$= 4kg \frac{(8i + 10j) - (3i + 0j)}{8s}$$

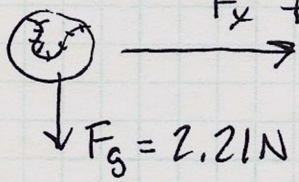
$$= \frac{4kg}{8s}(5i + 10j)$$

$$= (2.5i + 5j)\, kg\,m/s^2 = \boxed{(2.5i + 5.0j)\ N}$$

b. $F_{magnitude} = \sqrt{2.5^2 + 5.0^2}$

$$= \boxed{5.59N}$$

5.5



a) Distance ball moves horizontally during throw?

$v_i = 0$; $v_f = 18.0\,m/s$; $t = 170\,ms$
$= 170e{-3}s$
$= 0.170s$

$$a = \frac{v_f - v_i}{t} = \frac{18-0}{0.170} = \boxed{106\,m/s^2}$$

$$\Delta x = v_i t + \frac{1}{2}at^2$$
$$= 0t + \frac{1}{2}(106)(0.170s)^2 = \boxed{1.53m}$$

b) Magnitude & direction of Force exerted by pitcher?

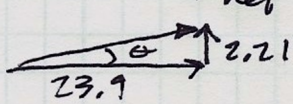
$F_{netx} = ma$, so we need to know the mass of the ball.

$$F_g = mg$$
$$2.21N = m(9.8)$$
$$m = \frac{2.21}{9.8} = \cancel{.226kg}\ 0.226\,kg$$

$$F_{netx} = (0.226\,kg)(106\,m/s^2)$$
$$= \boxed{23.9N}\ \boxed{\text{horizontally}}$$

What about the vertical force, though?
Pitcher needs to apply upward force, too, to pitch horizontally.

$$\vec{F}_{net} = \vec{F}_x + \vec{F}_y;\ \Rightarrow \sqrt{23.9^2 + 2.21^2} = \boxed{24.0N}$$



$$\theta = \tan^{-1}\left(\frac{2.21}{23.9}\right) = \boxed{5.28^\circ}$$

5.7

$m_e = 9.11e{-31}\,kg$
$V_i = 3.00e5\,m/s$
$V_f = 7.00e5\,m/s$
$\Delta x = 5\,cm = 0.0500\,m$

a) $F_{net} = ?$

$$F_{net} = ma = m\,\frac{v_f^2 - v_i^2}{2x}$$

$$F_{net} = (9.11e{-31})\,\frac{(7e5)^2 - (3e5)^2}{2\,(0.05)}$$

$$= \boxed{3.64e{-18}\,N}$$

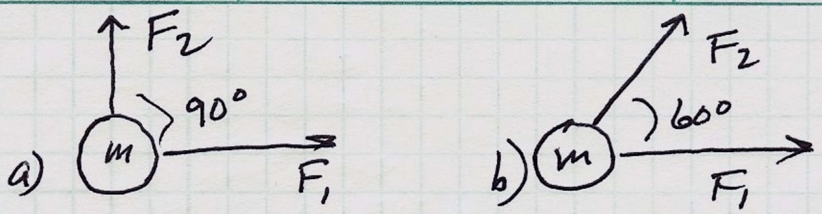
b) $F_g = mg$

$= (9.11e{-31}\,kg)(9.8)$

$= \underline{8.93e{-30}\,N}$

$\frac{3.64e{-18}\,N}{8.93e{-30}\,N} = 4.08e11$, so $F_{applied}$ is 400 billion times greater than $F_{gravity}$. It can be legitamately ignored.

5.13



$m = 5.00\,kg$, $F_1 = 20.0\,N$, $F_2 = 15.0\,N$. Find acceleration for each situation.

a) $F_{net} = ma$

$F_x = ma_x \qquad F_y = ma$

$20N = (5)a \qquad 15 = 5a$

$a_x = \underline{4\,m/s^2} \qquad a_y = \underline{3\,m/s^2}$

$a = \sqrt{4^2 + 3^2} = \boxed{5.00\,m/s^2}$

$\theta = \tan^{-1}\left(\frac{3}{4}\right) = \cancel{37.} \boxed{36.9°}$

b) $\Sigma F_x = ma_x$

$F_{1x} + F_{2x} = ma_x$

$\frac{20N + 15N\cos 60}{5} = a_x = 5.50\,m/s^2$

$\Sigma F_y = ma_y$

$F_{1y} + F_{2y} = ma_y$

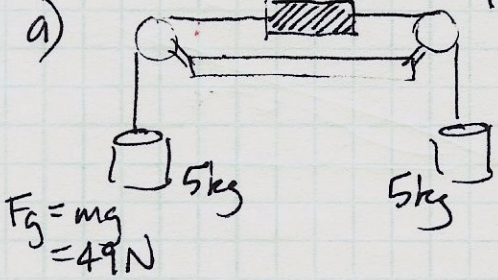
$\frac{0 + 15\sin 60}{5} = a_y = 2.60\,m/s^2$

$a = \sqrt{5.5^2 + 2.6^2} = \boxed{6.08\,m/s^2}$

$\theta = \tan^{-1}\left(\frac{2.6}{5.5}\right) = \boxed{25.3°}$

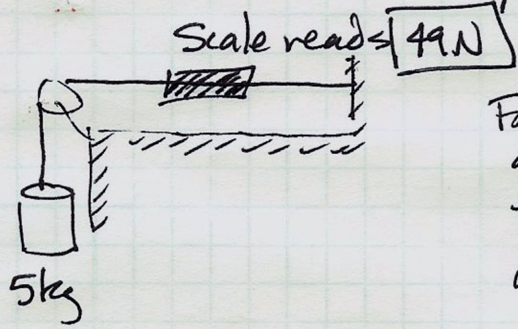
5.20

a) Scale reads $\boxed{49N}$ (~~not~~ 98N!)



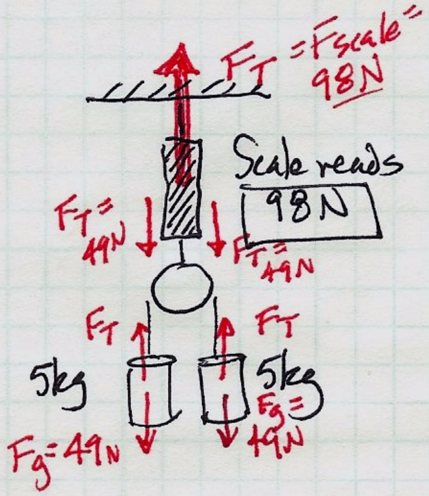
The scale measures the tension in the string, which is how force is transmitted to the masses. If the string transmitted more than 49N to either mass, that mass would be accelerating... but they're not. So $F_T = 49N$, & that's what the spring scale registers.

b)



For same reasons mentioned above, the scale registers the tension in the string, which has to match the 49N weight.

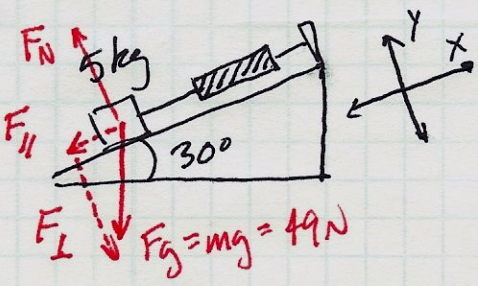
c)



Scale has to support the weight of the two masses which are in equilibrium.

Free-body diagram showing Tensions & Weights reveals 98N F_T in upper string.

d)



Scale is oriented along tilted x-axis.

$\Sigma F_x = 0$

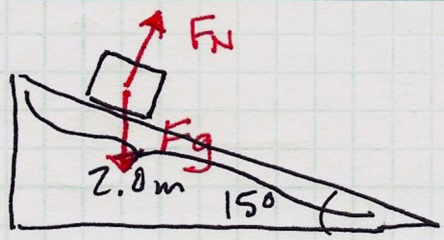
$F_{Tension} - F_{\parallel} = 0$

$F_T = F_{\parallel} = mg \sin\theta$

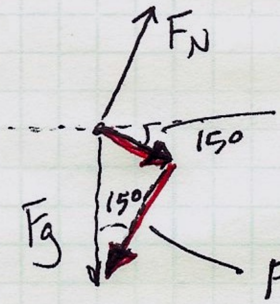
$F_T = 5 \cdot 9.8 \sin 30$

$= \cancel{4.9}\ \boxed{24.5N}$

5.21 a)



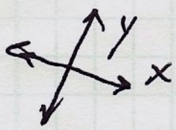
b) acceleration of block = ?



$F_{\parallel} = F_g \sin 15$

$F_{\perp} = F_g \cos 15$

$F_{net\,x} = ma_x$ Take "down the ramp" to be x.



$F_{g\parallel} = ma$

$F_g \sin 15 = ma$

$F_g = mg$, so

$\cancel{m}g \sin 15 = \cancel{m}a$

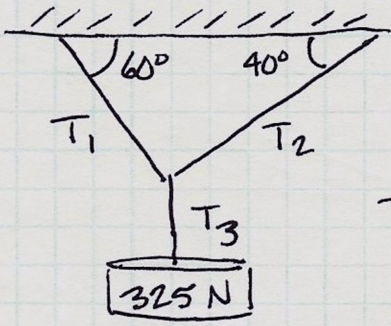
$a = g \sin 15 = \boxed{2.54\ m/s^2}$ down the ramp.

c) Speed at bottom?

$v_f^2 = v_i^2 + 2a\Delta x$

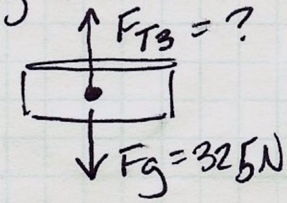
$v_f = \sqrt{0^2 + 2(2.54)(2)} = \boxed{3.19\ m/s}$

5.24



Find Tensions in wires.

T_3: The tension in T_3 is just the weight of the bag itself.

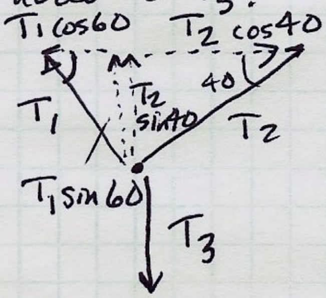


$$\Sigma F_y = ma_y = 0$$

$$F_{T3} - F_g = 0$$

$$F_{T3} = F_g = \boxed{325N}$$

For T_1 & T_2, the x- & y-components must total 0 when added to T_3.



X-analysis: $\Sigma F_x = 0$

$$+T_2 \cos 40 - T_1 \cos 60 = 0$$

$$T_2 = T_1 \frac{\cos 60}{\cos 40} = 0.653 T_1$$

y-analysis: $\Sigma F_y = 0$

$$+T_2 \sin 40 + T_1 \sin 60 - T_3 = 0$$

Sub in

$$(0.653 T_1) \sin 40 + T_1 \sin 60 - 325 = 0$$

$$0.412 T_1 + 0.866 T_1 = 325$$

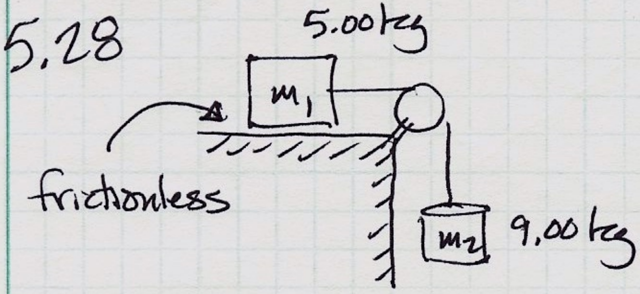
$$T_1 = \boxed{253N}$$

Sub back in to get T_2

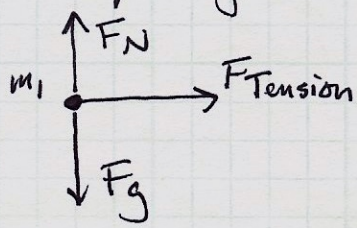
$$T_2 = 0.653 T_1 = (0.653)(253)$$

$$T_2 = \boxed{165N}$$

5.28



a) Free-body diagrams



b) Magnitude of acceleration of objects.

Take $\longrightarrow$ to be $+x$ for m_1.

To keep signs consistent, $\downarrow$ needs to be $+$ (positive) as well.

m_1: $\Sigma F_x = ma$

$F_T = ma = 5a$

m_2: $\Sigma F_y = ma$

$+F_g - F_T = ma = 9a$

$mg - F_T = 9a$

$9g - F_T = 9a$

Combine eqns to get

$9g - 5a = 9a$

$a = \frac{9}{14} g = \boxed{6.30\ m/s^2}$

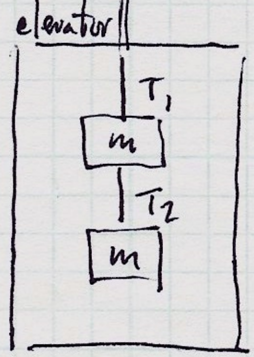
c) To get Tension in the string substitute back in.

$F_T = 5a$

$F_T = 5(6.3) = \boxed{31.5N}$

5.31

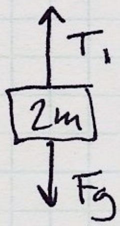
a) Find T_1 & T_2



$\uparrow a = 1.60\,m/s^2$

$m = 3.50\,kg$

For T_1, consider total mass supported to be $2m$.



$\Sigma F_y = ma_y$

$+F_T - F_g = ma_y$

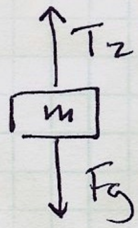
$F_T = F_g + ma_y$

$= (2m)g + (2m)(1.60)$

$= (2 \cdot 3.5)(9.8) + (2 \cdot 3.5)(1.6)$

$T_1 = \boxed{79.8\ N}$

For T_2, just focus on lower mass:



$\Sigma F_y = ma_y$

$F_T - F_g = ma$

$F_T = F_g + ma$

$= mg + ma$

$= (3.5)(9.8) + (3.5)(1.6)$

$= \boxed{39.9\ N}$

b) If $T_{max} = 85.0\,N$, what acceleration can the elevator have as its maximum?

Use T_1 equation from above:

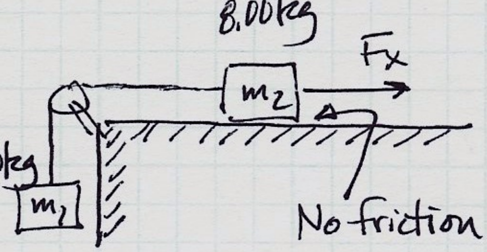
$F_T = F_g + ma_y$

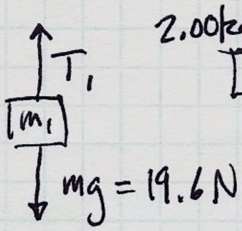
$85\,N = (7\,kg)(9.8) + (7\,kg)a$

Solve to get $a_{max} = \boxed{2.34\ m/s^2}\ \boxed{up}$

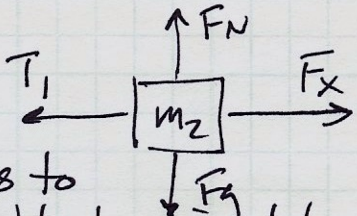
5.33

a) For what values of F_x does m_1 accelerate upwards?





Any $T_1 > 19.6\text{N}$ will cause m_1 to begin to accelerate upwards. This T_1 is also applied to m_2, so F_x has to be equal to 19.6N to hold blocks in static equilibrium. $\boxed{F_x > 19.6\text{N}}$ will cause upwards acceleration then.

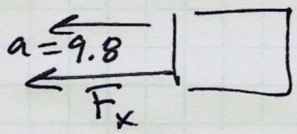


b) For T in cord to be 0, m_1 has to be in free-fall, accelerating at $9.8\ m/s^2$. For m_2 then:

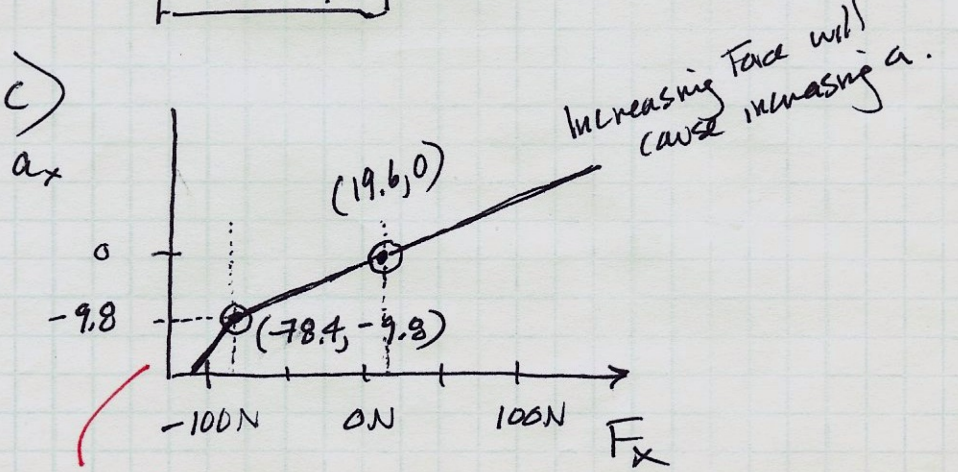
$F_{net} = ma$

$F_x = (8\text{kg})(-9.8)$

$= \boxed{-78.4\text{N}}$



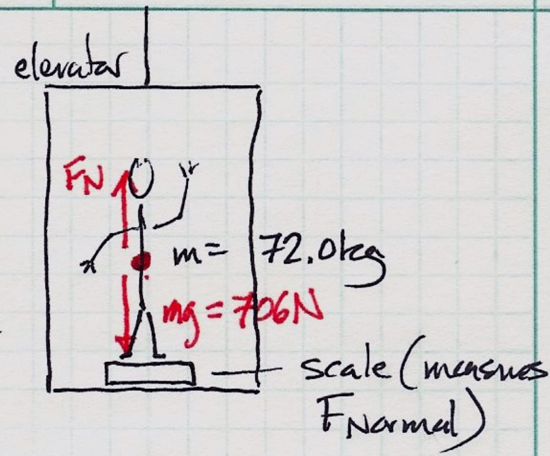
c)



Note change in slope. Once m_1 is in freefall, F_x doesn't act on it anymore – there's slack in the rope. F_x only accelerates m_2 now, so greater ΔF produces a greater Δa.

5.35

Elevator varies its acceleration as it moves.

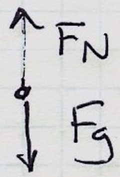


At first, its $a = \frac{\Delta V}{t} = \frac{1.2-0}{0.8}$
$= +1.5 m/s^2$

Then, at constant speed, $a = 0$.

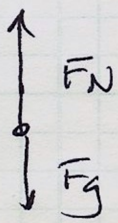
Then, when slowing down, $a = \frac{v_f - v_i}{t}$
$= \frac{0-(1.2m/s)}{1.5s} = -0.800 m/s^2$

a) What does spring scale read before elevator starts to move?



Man is in static equilibrium:
$F_N = F_g = \boxed{706N}$

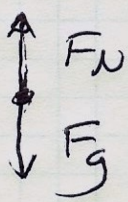
b) During acceleration upwards:



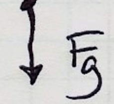
F_N must be greater than F_g to accelerate man upwards.

$\Sigma F = ma$
$F_N - F_g = ma$
$F_N = ma + mg = (72)(1.5) + (72)(9.8)$
$= \boxed{814N}$

c) While at constant speed, man is in dynamic equilibrium, & forces are again balanced.



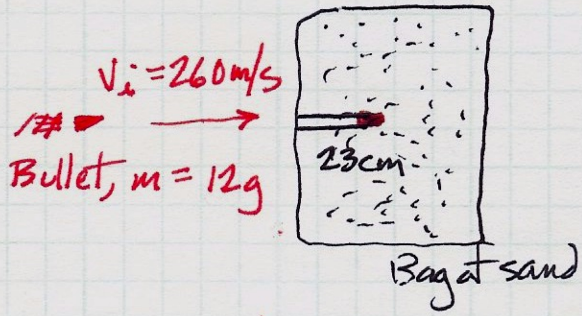
d) During slowdown, net force has to be down, so F_N is less than F_g



$\Sigma F = ma$
$F_N - F_g = ma$
$F_N = \cancel{72}(-0.8) + (72)(9.8) = \boxed{648N}$

5.37

Friction force between bullet & sand during its slow down?



$$F_{net} = ma$$

$$F_F = ma$$

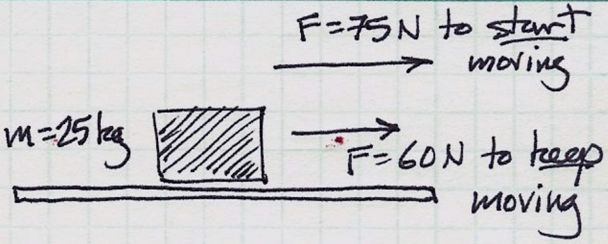
$$a = \frac{v_f^2 - v_i^2}{2x} = \frac{0^2 - 260^2}{2(0.23m)}$$

$$= 1.47e5 \text{ m/s}^2$$

$$F_f = (0.012kg)(1.47e5)$$

$$= \boxed{1.76e3N}$$ in the opposite direction of the bullet's motion

5.39



a. Coefficient of static friction is calculated based on maximum static friction force, which is infinitely close to 75.0N.

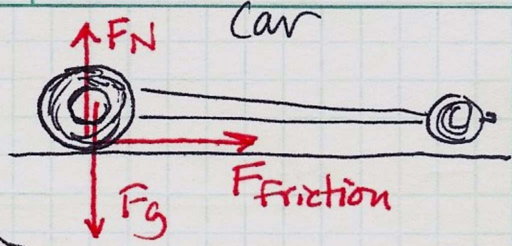
$$\mu = \frac{F_F}{F_N} = \frac{75.0N}{mg} = \frac{75.0N}{(25\,kg)(9.8)} = \boxed{0.306}$$

b. Coefficient of kinetic friction is based on force of friction while block is moving.

$$\mu = \frac{F_F}{F_N} = \frac{60}{(25)(9.8)} = \boxed{0.245}$$

Note that there are no units for coefficients, & that $\mu_k < \mu_s$.

5.42 As the car tire spins, a force of friction between the tire & the road pushes the car forwards, causing it to accelerate in that direction.



(The same force of friction between the wheel & the ground causes gravel on the road to be accelerated in the opposite direction via Newton's 3rd Law)

a) acceleration = ? $\Delta x = v_i t + \frac{1}{2}at^2$

$$a = \frac{2\Delta x}{\cancel{2}t^2} = \frac{2 \cdot 1609\,m/4}{\cancel{2}(4.43)^2}$$

$$= \cancel{10.25}\ m/s^2 \quad 40.99$$

$$\Sigma F_x = ma$$

$$F_f = m(\cancel{10.25}) \quad 40.99$$

$$\mu_s = \frac{F_F}{F_N}$$

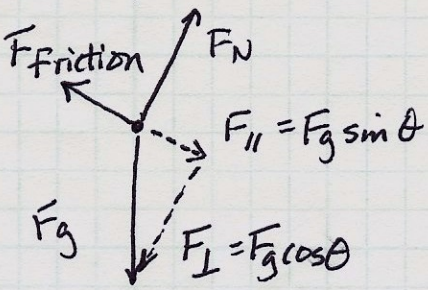
$$\mu_s = \frac{m(\cancel{10.25})\ 40.99}{m(9.8)}$$

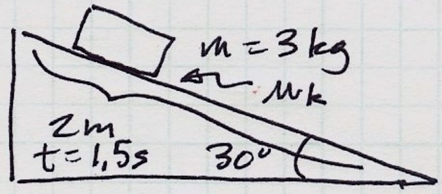
$$\mu_s = \boxed{\cancel{1.05}}\ \boxed{4.18}$$

b) A car engine w/ greater power will <u>increase</u> the time of the run. Applying more force than the road/rubber interface can handle will cause the tire to slip, & a smaller friction force will result, which produces a smaller acceleration.

5.43

Free-body diagram





a) acceleration of block

$$\Delta x = v_i t + \frac{1}{2}at^2$$

$$a = \frac{2x}{t^2} = \frac{2(2m)}{(1.5s)^2}$$

$$= \boxed{1.78\,m/s^2}$$

b) $\mu_k = ?$

$$\Sigma F_x = ma_x$$

$$F_{\parallel} - F_f = ma$$

$$mg\sin\theta - F_f = ma$$

$$mg\sin\theta - \mu F_N = ma$$

Note that $F_N \neq mg$!

$$\Sigma F_y = ma = 0$$

$$F_N - F_{\perp} = 0$$

$$F_N = mg\cos\theta$$

$$\cancel{m}g\sin\theta - \mu \cancel{m}g\cos\theta = \cancel{m}a$$

$$\mu_k = \frac{g\sin\theta - a}{g\cos\theta} = \frac{9.8\sin 30 - 1.78}{9.8\cos 30}$$

$$\mu_k = \boxed{0.368}$$

c) $\cancel{v_f = v_i + at}$

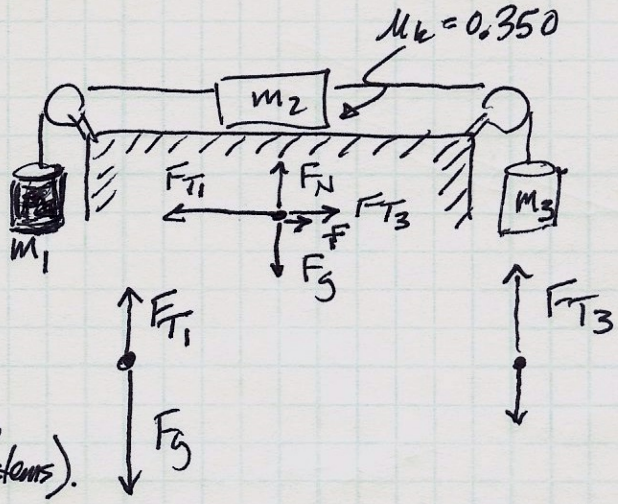
$\cancel{= 0 + (1.78)t}$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$v_f = \sqrt{0^2 + 2(1.78)(2)}$$

$$= \boxed{2.67\,m/s}$$

5.46



a) Free-body diagrams shown at right

b) System must be accelerating "to the left".

Solve for acceleration by considering as a single 3-mass system (can also solve as 3 1-mass systems).

$\Sigma F = ma$, consider "left" to be positive direction.

$F_{mass1} - F_{Friction\,2} - F_{mass3} = m_{total}\, a$

$m_1 g - \mu F_N - m_3 g = (m_1 + m_2 + m_3)\, a$

$F_N = m_2 g$

No need to account for Tensions, which is internal to the system.

$$\frac{4g - (0.35)(1)(g) - 2g}{4 + 1 + 2} = a = \boxed{2.31\ m/s^2 \text{ to the left}}$$

m_1 is accelerating down
m_3 is accelerating up

c). Solve for Tensions in cords.

Focusing on m_1:

$F_{net} = ma$

$F_g - T_1 = ma$

$m_1 g - T_1 = m_1 a$

$T_1 = m_1 g - m_1 a = 4(9.8 - 2.31) = \boxed{30.0\,N}$

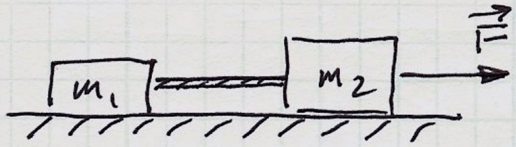
m_3: $T_3 - m_3 g = m_3 a$

$T_3 = m_3(a + g) = 2(2.31 + 9.8) = \boxed{24.2\,N}$

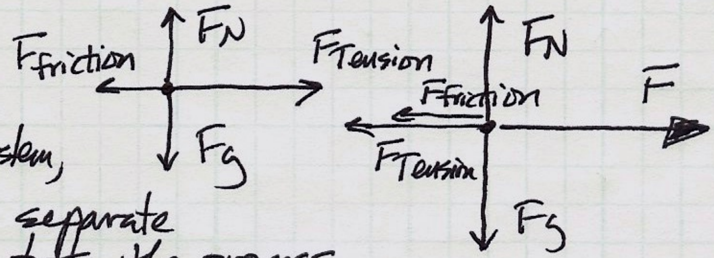
d) If table top were frictionless, acceleration would be greater for the system, implying T_1 would be less, & T_3 would be more.

5.47

a) Free-body diagrams:



b) Determine acceleration of system. Can solve as a single system, but I'll solve as two separate systems here to illustrate the process.



m_1: $\Sigma F = ma$

$F_{Tension} - F_{friction} = ma$

$T - \mu m_1 g = m_1 a$

$T - (0.1)(12)(9.8) = 12a$

$T - 11.8 = 12a$

m_2: $\Sigma F = ma$

$F - T - F_{friction} = ma$

$F - T - \mu m_2 g = m_2 a$

$68 - T - (0.1)(18)(9.8) = 18a$

$50.4 - T = 18a$

2 eqn, 2 unknowns

$T = 12a + 11.8$

$50.4 - 12a - 11.8 = 18a$

$30a = \cancel{62.2}\ 38.6$

$\cancel{a = 2.07\ m/s^2}$

$a = \boxed{1.29\ m/s^2}$

c) T in rope? Sub back in:

$T - 11.8 = 12a$

$T = 11.8 + 12(1.29)$

$T = \boxed{27.3\ N}$