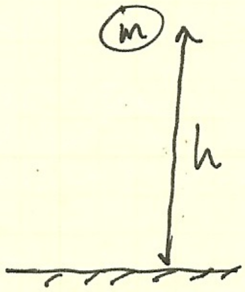
8.2



a) For the system defined as including the ball & the earth, we can consider the potential energy of that system, & see how that is converted to kinetic energy.

$$K_i + U_{gi} = U_{gf} + K_f$$

If we assume the ball has 0 J of U (with respect to the earth) at the end, we can write

$$U_{gi} = K_f$$

(initial) (final)

$$mgh = \frac{1}{2}mv^2$$

$$gh = \frac{v^2}{2}$$

$$\boxed{v = \sqrt{2gh}}$$

b) If we just look at the ball, itself, we aren't considering the potential energy with the earth.

The earth is <u>external</u> to the system, & does Work on the system via the Force of gravity.

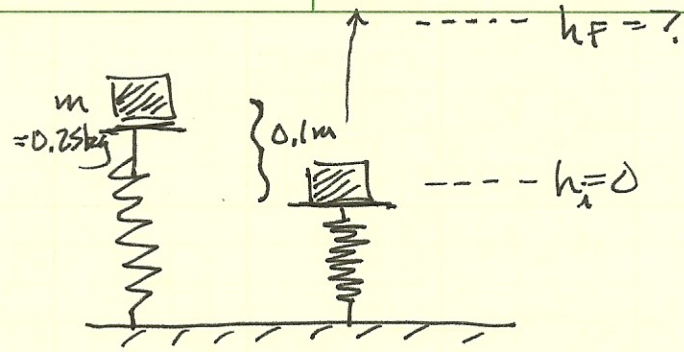
$$W_{gravity} = K_f$$

$$F_g x = \frac{1}{2}mv^2$$

$$mgh = \frac{1}{2}mv^2$$

$$\boxed{v = \sqrt{2gh}}$$

8.3



How high above the release point does the block rise? We need to track the spring's energy U_s, the gravitational potential energy U_g, & ... kinetic energy K? No! Block is momentarily at rest at the top & bottom of its path.

$$\Sigma E_i = \Sigma E_f$$

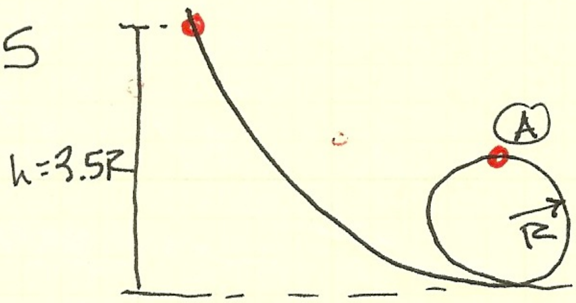
$$U_{s_i} + U_{g_i} = U_{s_f} + U_{g_f}$$

$$\tfrac{1}{2}kx_i^2 + mgh_i = \tfrac{1}{2}kx_f^2 + mgh_f$$

$$\tfrac{1}{2}(5000)(0.1\,m)^2 + (0.25)(9.8)(0) = 0 + (0.25)(9.8)h$$

$$h = \boxed{10.2\,m}$$

8.5



a) Find speed at point A for bead released from rest at height 3.5R.

By Conservation of Energy:

$$U_{gi} + K_i = U_{gf} + K_f$$

$$\cancel{m}gh_i + 0 = \cancel{m}gh_f + \tfrac{1}{2}\cancel{m}v_f^2$$

$$v_f = \sqrt{2g(h_i - h_f)}$$

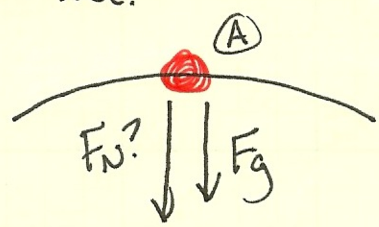
$$= \sqrt{2g(3.5R - 2R)}$$

$$= \sqrt{3gR}$$

Leave "g" as symbolic (not 9.8) unless solving for a numeric answer.

b) Normal force on bead at point A? Requires free-body diagram & $F_{net} = ma$!

I'm going to assume F_{normal} is down — if my answer comes out negative, I'll know it must be "up"!



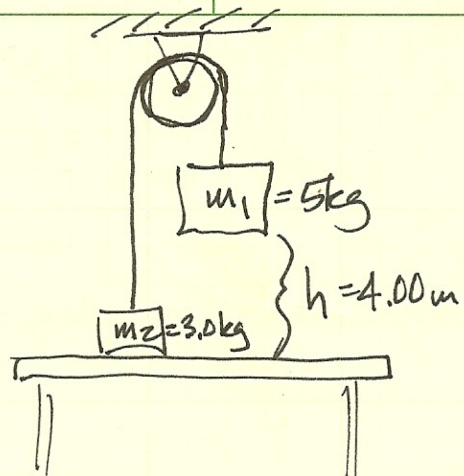
$$\Sigma F_c = \frac{mv^2}{r} \Longrightarrow F_N + F_g = \frac{mv^2}{r}$$

$$F_N = \frac{mv^2}{r} + -mg$$

$$= \frac{(0.005)\left(\sqrt{3gR}\right)^2}{R} + -(0.005)(9.8)$$

$$= \boxed{0.098\,N} \;\boxed{\text{down}}$$

8.7



a) Determine speed of m_2 just as m_1 hits table.

Energy analysis — what kinds of energy are important here?

K, U_g, but not W_{ext}, U_s, or ΔE_{int}

There are 2 masses, so we'll need to track both of them.

$$K_{1_i} + U_{g1_i} + K_{2_i} + U_{g2_i} = K_{1f} + U_{g1f} + K_{2f} + U_{g2f}$$

$$\tfrac{1}{2}m_1 v_{1i}^2 + m_1 g h_{1i} + \tfrac{1}{2}m_2 v_{2i}^2 + m_2 g h_{2i} = \tfrac{1}{2}m_1 v_{1f}^2 + m_1 g h_{1f} + \tfrac{1}{2}m_2 v_{2f}^2 + m_2 g h_{2f}$$

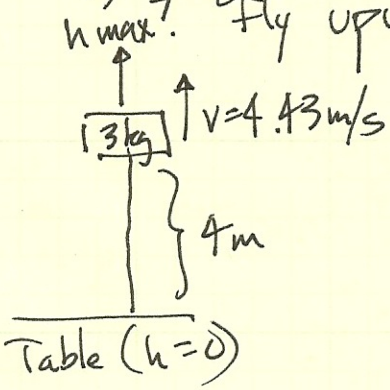
Choose 0 values for heights? Can choose any we want, but I'm going to call table ~~height~~ surface = 0 for both masses. So,

$$0 + m_1 g h_1 + 0 + \cancel{m_2 g h_2}^{\,0} = \tfrac{1}{2}m_1 v_{1f}^2 + 0 + \tfrac{1}{2}m_2 v_{2f}^2 + m_2 g h_2$$

$$(5)(9.8)(4) = \tfrac{1}{2}(5)v^2 + \tfrac{1}{2}(3)v^2 + (3)(9.8)(4)$$

Solve for v to get $v = \boxed{4.43\,m/s}$

b) m_2 is traveling with this speed, & continues to fly upwards a little ways to a max height = ?



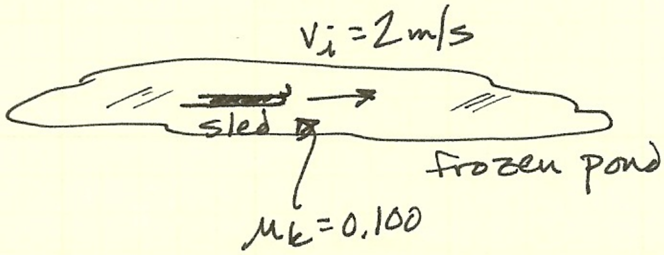
$$K_i + U_{gi} = K_f + U_{gf}$$

$$\tfrac{1}{2}\cancel{m}v_i^2 + \cancel{m}gh_i = 0 + \cancel{m}gh_f$$

$$h_f = \frac{\frac{v^2}{2} + gh_i}{g} = \frac{\frac{(4.43)^2}{2} + (9.8)(4)}{9.8}$$

$h_f = \boxed{5m \text{ above table top}}$

8.12



Using energy, how far does the sled travel before it stops?

$$\Sigma E_{initial} = \Sigma E_{final}$$

$$K_i - \Delta E_{int} = K_f$$

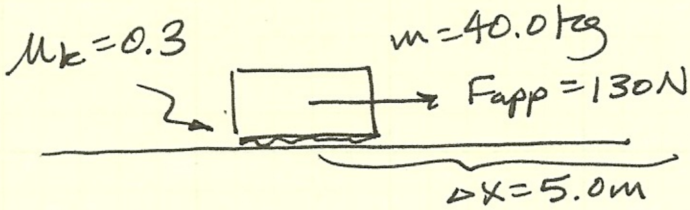
$$\frac{1}{2}mv^2 - F_f x = 0$$ Because sled stops

$$F_f = \mu F_N = \mu m g$$

$$\frac{1}{2}\cancel{m}v^2 = \mu \cancel{m} g x$$

$$x = \frac{v^2}{2\mu g} = \frac{(2)^2}{2(0.1)(9.8)} = \boxed{2.04\,m}$$

8.14



a) Work done by applied Force?

$$W = Fx = (130\,N)(5\,m) = \boxed{650\,J}$$

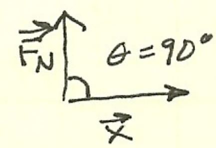
b) Increase in internal energy of box-floor system due to friction?

$$\Delta E_{interna} = fx$$

$$f = \mu N = \mu mg$$

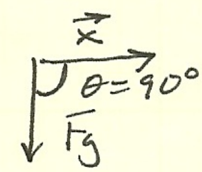
$$\Delta E_{int} = \mu mgx = (0.3)(40)(9.8)(5) = \boxed{588\,J}$$

c) Work done by Normal force $= 0$



$$W = Fx\cos\theta$$
$$= Fx\cos 90°$$
$$= \boxed{0}$$

d) Work done by gravity $= 0$



e) Change in kinetic energy of the box:

$$K_i + W_{ext} - \Delta E_{int} = K_f$$

$0 + 650$ (from (a) above) $- 588$ (from (b)) $= \cancel{\tfrac{1}{2}mv^2}$ K_f

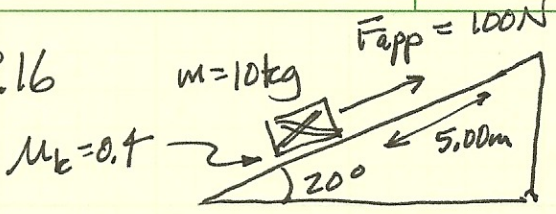
$$\Delta K = \boxed{62\,J}$$

f) Final speed of box:

$$K_f = \frac{1}{2}mv^2$$

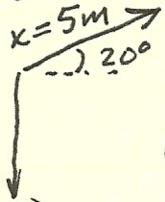
$$v = \sqrt{\frac{2K_f}{m}} = \sqrt{\frac{2 \cdot 62}{40}} = \boxed{1.76\,m/s}$$

8.16



$v_i = 1.50 m/s$

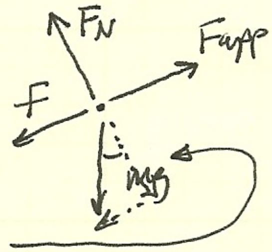
a) How much Work done by gravity Force on crate?



$F_g = mg$
$= (10)(9.8)$
$= 98N$

$W = Fx\cos\theta$
$= (98N)(5m)\cos(90+20)$
$= \boxed{-168 J}$

b) Increase in ΔE internal due to friction.



$\Delta E_{int} = fx$
$f = \mu F_N$
$F_N = mg\cos 20$
$\Delta E_{int} = \mu mg \cos 20 \, x$
$= (0.4)(10)(9.8)(\cos 20)(5) = \boxed{184 J}$

c) $W = F_{app}x = 100N \cdot 5m = \boxed{500 J}$

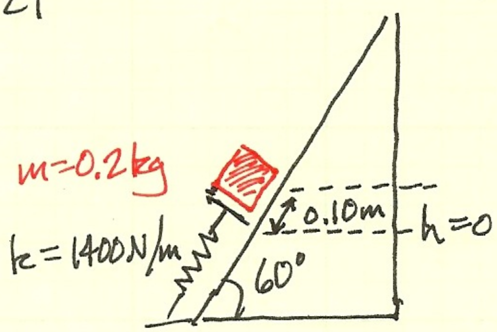
d) Change in K of crate?

$W_{ext} - \Delta E_{int} = \Delta K$
$W_{app} + W_g - \Delta E_{int} = \Delta K$
$500 + (-168) - 184 = \Delta K = \boxed{\cancel{249}\ 148 \ J}$

e) Speed of crate after 5.0 m distance?

$\Delta K = \cancel{249}\ 148 J = K_f - K_i$
$K_f = \cancel{249} + \frac{1}{2}mv^2$
$\frac{1}{2}mv_f^2 = \cancel{249} + \frac{1}{2}mv_i^2$
$v_f = \sqrt{\frac{2(\cancel{249}\ 148 + \frac{1}{2}(10)(1.5)^2)}{10}} = \boxed{\cancel{7.21}\ m/s}$
5.64

8.21



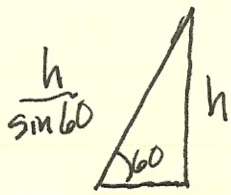
a) How far up does block travel when released under frictionless conditions?

$$\Sigma E_i = \Sigma E_f$$

Call initial position $h=0$

$$U_{gi} + U_{si} = U_{gf} + U_{sf}$$

$$0 + \frac{1}{2}kx^2 = mgh_f + 0$$



← Note that "up the incline" doesn't translate directly to vertical height.

$$\frac{1}{2}(1400)(0.1)^2 = (0.2)(9.8)h_f$$

$$h_f = 3.57\text{m (vertical)}$$

$$\text{Up the ramp} = \frac{3.57}{\sin 60} = \boxed{4.12\text{m}}$$

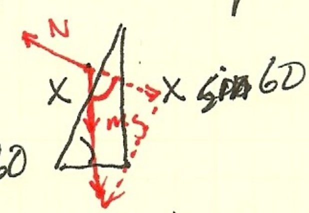
b) Repeat the problem w/ a μ_k of 0.400.

$$\frac{1}{2}kx_i^2 - \Delta E_{int} = mgh_f$$

$\Delta E_{int} = fx$, where x is the distance up the ramp.

$$f = \mu N = \mu mg\cos 60$$

$$\frac{1}{2}kx_i^2 - \mu mg\cos 60(x_{total}) = mg\,x_{total}\cos 60$$

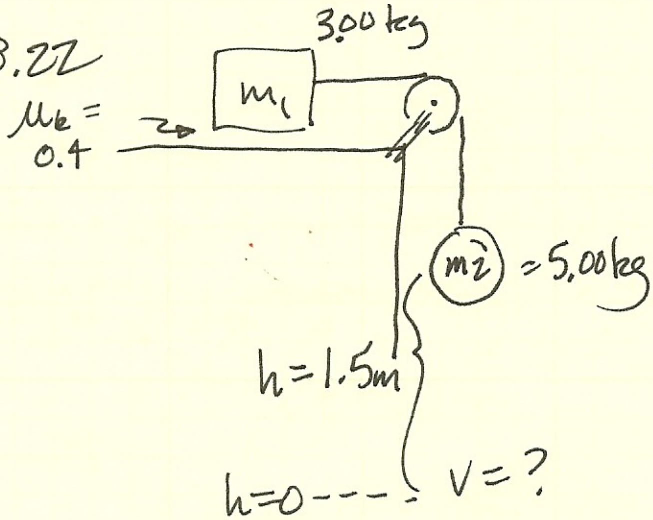


$$\frac{1}{2}(1400)(0.1)^2 - (0.4)(0.2)(9.8\cos 60)\,x_{total} = (0.2)(9.8)(x_{total})(\cancel{\sin}60)$$

$$7 - 0.392x = \cancel{0.98}\ 1.70\,x$$

$$x = \boxed{3.35\text{m}}$$

8.22



$$\Sigma E_i = \Sigma E_f$$

$$U_2 + K_1 + K_2 - \Delta E_{int} = K_1' + K_2' + U_2'$$

Call h = 0 at bottom of fall.

$$m_2 g h_i + 0 + 0 - f x = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 + 0$$

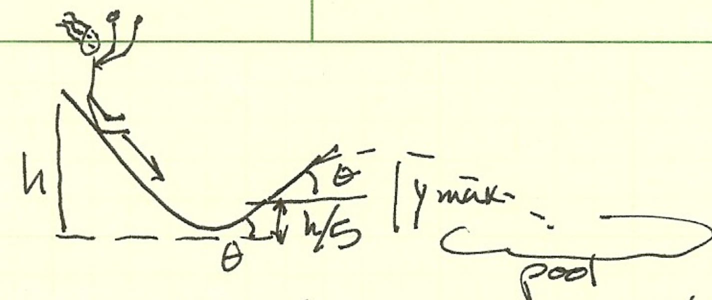
$$m_2 g h_i - \mu_k m_1 g x = \frac{1}{2}(m_1 + m_2) v^2$$

$$(5)(9.8)(1.5) - (0.4)(3)(9.8)(1.5) = \frac{1}{2}(3+5) v^2$$

$$73.5 - 17.6 = \frac{1}{2}(8) v^2$$

$$v = \boxed{3.74 \text{ m/s}}$$

8.27



a) The child-earth system is isolated because there are no other energy transfers (via Work external or $\Delta E_{internal}$) occurring. The only energies we're examining here are U_g & K.

b) There are no non-conservative forces acting in this system. (Friction)

c) At top of slide, child is at rest, & has height h above the water level, where h=0.

E_{total} for system = $\boxed{mgh}$

d) At launching point, $E_{total} = \boxed{\frac{1}{2}mv_i^2 + mg\,h/5}$

e) At highest point in projectile motion, $E_{total} = \boxed{\frac{1}{2}mv_y^2 + mg\,y_{max}}$

f) $\Sigma E_i = \Sigma E_f$, so E_{total} doesn't change

mgh (at top) $= \frac{1}{2}mv_i^2 + mg\frac{h}{5}$ (at launch point)

Solve for v:

$$\cancel{m}gh - \frac{\cancel{m}gh}{5} = \frac{1}{2}\cancel{m}v^2$$

$$v = \sqrt{2\,\frac{4}{5}gh} = \boxed{\sqrt{\frac{8}{5}gh}}$$

g) Max airborne height $y_x = ?$

$\Sigma E_{initial} = \Sigma E$ at ymax.

$$mgh = \frac{1}{2}mv_{xi}^2 + mg\,y_{max}$$

This is only the x component of v_i. The y-component =0 at ymax.

$$gh = \frac{1}{2}(v\cos\theta)^2 + g\,y_{max}$$

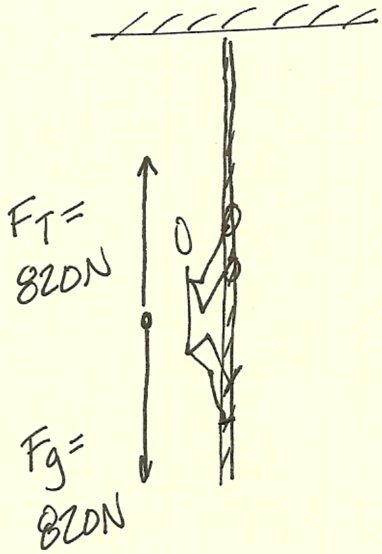
$$gh = \frac{1}{2}\left(\sqrt{\frac{8}{5}gh}\cos\theta\right)^2 + g\,y_{max}$$

$$h = \frac{4}{5}h\cos^2\theta + y_{max}$$

$$y_{max} = \boxed{h\left(1 - \frac{4}{5}\cos^2\theta\right)}$$

h) If waterslide has friction, velocities will be less, as well as ymax — some energy will have been converted to ΔE internal.

8.29



$$\Sigma F = ma = 0$$

ascending at constant speed

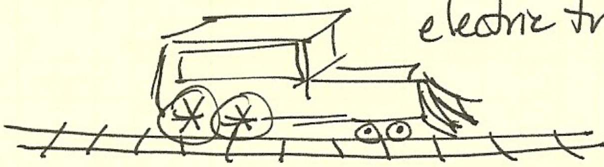
$$F_T - F_g = 0$$

$$F_T = F_g = \underline{820N}$$

$$\text{Power} = \frac{\text{Work}}{\text{time}} = \frac{Fx}{t} = F \cdot v$$

$$\text{Power} = 820N \cdot \frac{12m}{8s} = \boxed{1230 \text{ Watts}}$$

8.30



electric train

$v_i = 0$

$v_f = 0.620\,m/s$

$t = 0.021\,s$

$m = 0.875\,kg$

a) Minimum Power necessary to get train moving?

$$P = \frac{W}{t}$$

$$W = \Delta K = K_f - K_i$$

$$W = \frac{1}{2}mv_f^2 - 0, \text{ so}$$

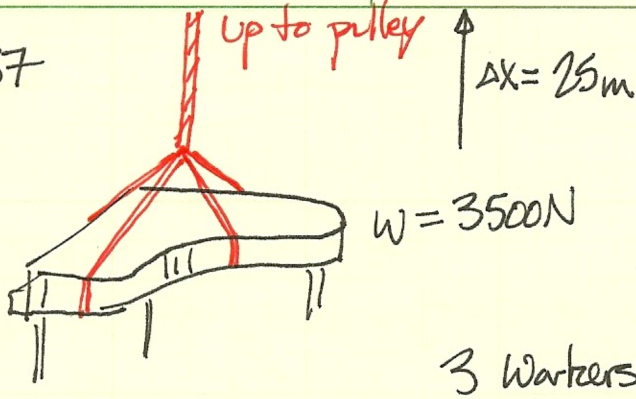
$$P = \frac{\frac{1}{2}mv_f^2}{t}$$

$$P = \frac{(0.875)(0.620\,m/s)^2}{2(0.021\,s)}$$

$$P_{min} = \boxed{8.00\,W}$$

b) This is the minimum Power required, assuming perfect efficiency so that all the electricity goes into getting the train moving. In reality, there will be energy losses due to friction in the engine & on the track, electrical heating of the wires & motor, etc.

8.37



3 Workers × 165 W = 495 W of Power

but system is only 75% efficient,

so 495 × 0.75 = 371 W of Power

How much time to lift the piano 25 meters?

$$\text{Power} = \frac{\text{Work}}{\text{time}}, \text{ so } \quad t = \frac{W}{P}$$

W ← Work to lift piano

P ← supplied by workers

$$W = Fd = (3500N)(25m) = 8.75e4\,J$$

$$t = \frac{8.75e4\,J}{371\,W} = \boxed{236\,s}$$