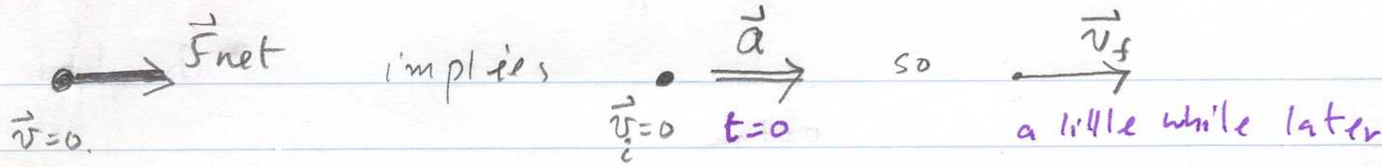
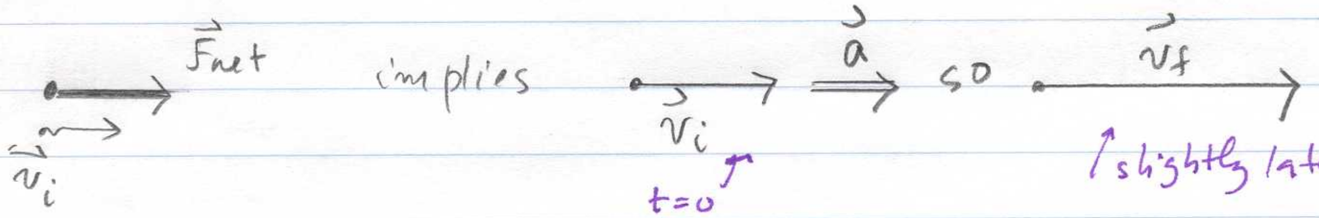
HW 6 Solutions, Phys 161, Spring 2003.

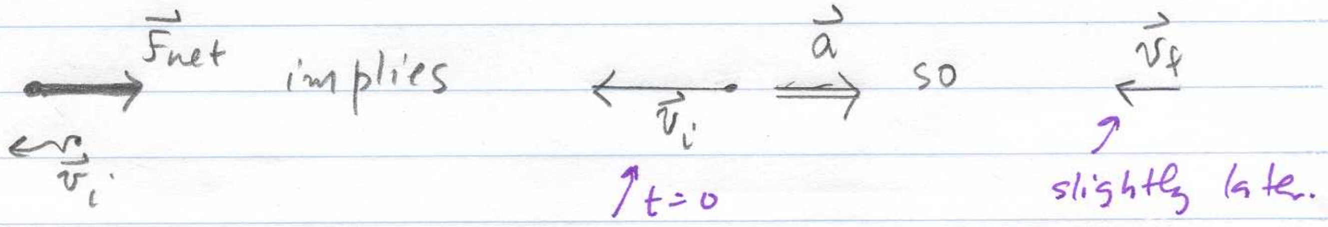
S1/. FBD:



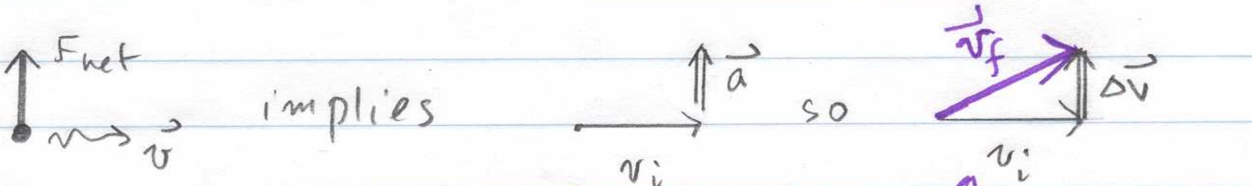
(b). FBD:



(c). FBD:



d). FBD:



at $t=0$ slightly later.

(Recall $\vec{a} = \frac{d\vec{v}}{dt} = \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t}$

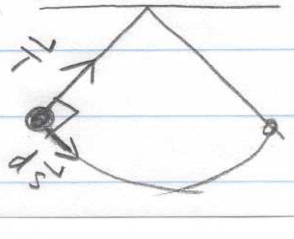
and $\Delta\vec{v} = \vec{v}_f - \vec{v}_i$ so $\vec{v}_f = \vec{v}_i + \Delta\vec{v}$.)

(e). An object does <u>not</u> necessarily <u>move</u> in the direction of the total force. But according to N2, it <u>ALWAYS</u> accelerates in the direction of the net force. (net force = total force).

S2/. $\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta$

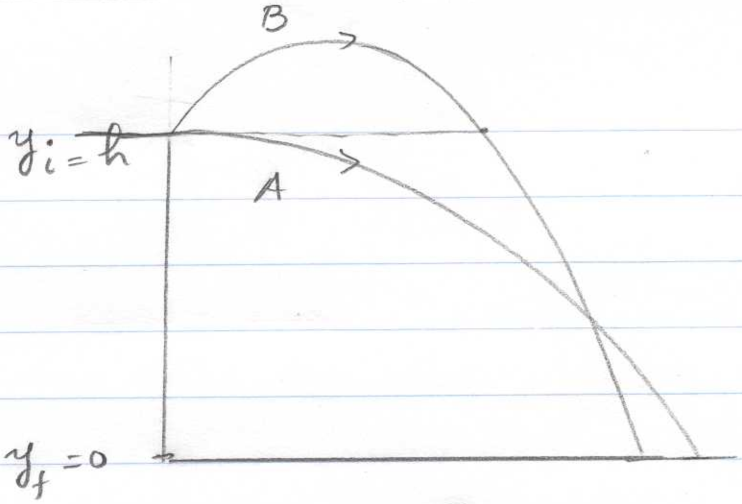
If $\vec{A}\cdot\vec{B}=0$, even if $|\vec{A}|\neq 0$ and $|\vec{B}|\neq 0$, we can still have $\vec{A}\cdot\vec{B}=0$ if $\cos\theta=0$ - i.e. if the angle between $\vec{A}$ & $\vec{B}$ is 90° or 270°. i.e. $\vec{A}\perp\vec{B}$.

(c). For a pendulum bob, the tension $\vec{T}$ and the displacement of the bob are perpendicular so the Tension force

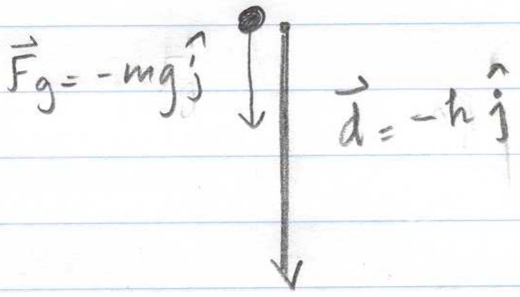


does no work.

S3/. (a). Note that the <u>displacement</u> in the y-direction is the <u>same</u> for both A & B. So the work done by gravity on each is given by:



$$W = \vec{F} \cdot \vec{d} = |F_g||\Delta y| \cos\theta$$
$$= (mg)(h) \cos 0^\circ$$
$$W = mgh$$



From the work-kinetic energy theorem:

$$W_{net} = K.E_f - K.E_i$$
$$\cancel{m} g h = \frac{1}{2} \cancel{m} v_f^2 - \frac{1}{2} \cancel{m} v_i^2$$
$$\Rightarrow \boxed{v_f^2 = 2gh + v_i^2}$$

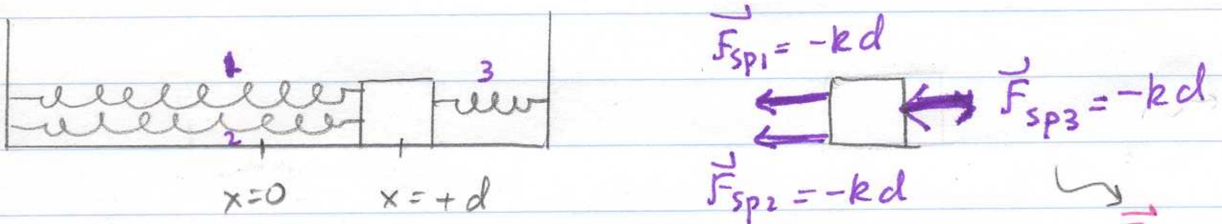
So the final speed is the <u>same</u> for both rocks A & B <u>even</u> if their masses are different — as long as their initial speeds are the same.

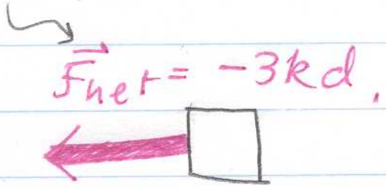
b/. Of course the magnitude of the y-component of the velocity for rock B is <u>larger</u> because when rock B passes $y = h$ on its way down, its velocity in the y-direction is non-zero and it only gets bigger as the rock falls due to acceleration due to gravity in the negative y-direction.
At $y = h$, rock A has zero velocity in the y-direction. So, compared to rock B, it will have a smaller v_y at $y = 0$.

541. To find the force, first draw a picture with the block displaced to the right (or left, there's no difference) by an amount d.

(1)

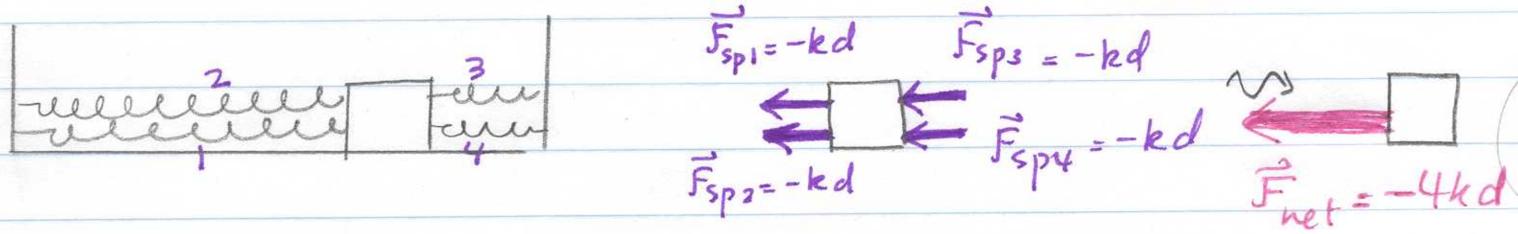
(2)





Note: Spring 3 doesn't like being compressed so it is also pushing the block to the left.

(3)



$\Rightarrow \ |\vec{F}_{net}^{(3)}| > |F_{net}^{(2)}| > |F_{net}^{(1)}|$. Note that if the block were displaced to the left, the force due to each spring would be in the opposite direction but its magnitude would still be the same. So the ranking above would be the same.

(c). $W_{sp}^{(1)} = \int_0^d F_{net,x}\, dx = \int_0^d (-2kx)\, dx$

$\Rightarrow W_{sp}^{(1)} = -2k \cdot \frac{1}{2} x^2 \Big|_0^d = -kd^2$.

$W_{sp}^{(2)} = \int_0^d (-3kx)\, dx = -\frac{3}{2} kd^2$.

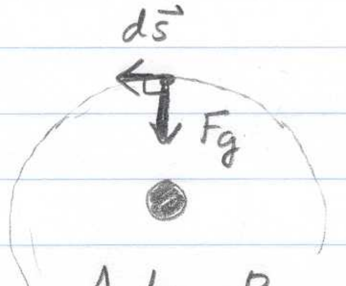
Similarly, $W_{sp}^{(3)} = -2kd^2$.

In general $W_{sp} = -\frac{1}{2} k_{effective} d^2$.

So magnitude of work ranking is:

$$|W_{sp}^{(3)}| > |W_{sp}^{(2)}| > |W_{sp}^{(1)}|.$$

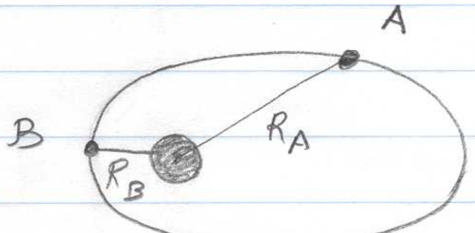
S6/ (a)

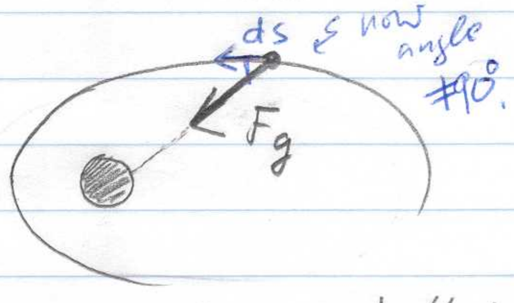


The force on the satellite is in the radial direction. At each point along its path from A to B, the force on the satellite is perependicular to it's displacement since the displacement at each point is tangential to the circle. So the work done by the force of gravity on the satellite as it moves from point A to B is ZERO.

(ii) Since $W_{net} = W_g = 0 \Rightarrow \Delta K.E = 0$ so $v_A = v_B$.

S6 b/. In the case of the elliptic path, the satellite is a shorter radial distance away from the earth at point B than at A. So the radial displacement is non-zero. Moreover, since the force of gravity on the satellite is always directed towards the earth, now the work done is not zero. Since the satellite moved closer to the earth, (i) the work done by gravity is positive and therefore (ii) $W_g = \Delta K.E > 0$ $\Rightarrow K.E_f > K.E_i$ so $v_B > v_A$.



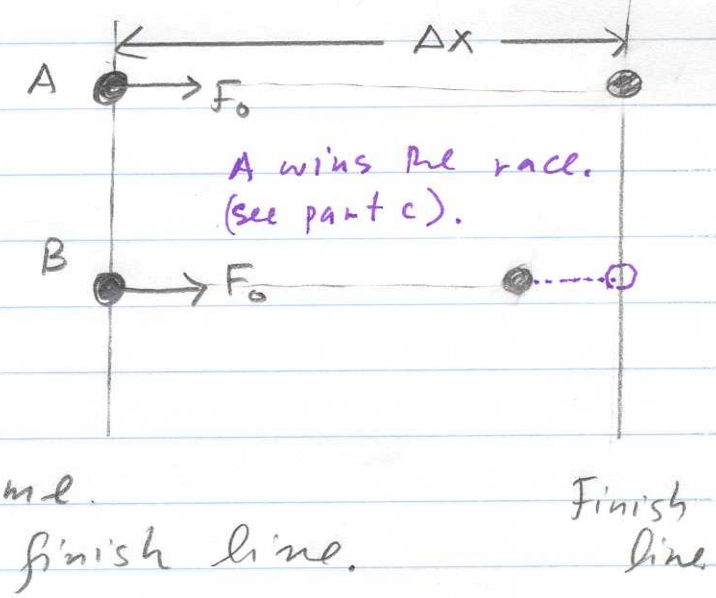


Problems:

P1. see attached solution at the end.

P2/. $v_{Ai} = v_{Bi} = 0$.

$m_B = 3m_A$.



a/. Since the <u>same force</u> acts on each puck over the <u>same</u> displacement, the change in K.E for each puck is the same at the time each crosses the finish line.

i.e.
$$F_0 \Delta x = \Delta K.E$$
$$= K.E_f - \cancel{K.E_i}^{\,0}$$
$$F_0 \Delta x = K.E_f \implies K.E_f^{A} = K.E_f^{B}.$$

So at the finish line, the kinetic energy each puck has is the same.

(b). Since puck B is more massive than puck A and they each have the same K.E, we expect puck B to have a smaller speed i.e. expect $\frac{v_B}{v_A} < 1$. Let's find it exactly.

$$K.E^A = K.E^B$$
$$\frac{1}{2} m_A v_{Af}^2 = \frac{1}{2} m_B v_{Bf}^2$$
$$\implies \frac{m_A}{m_B} = \frac{v_{Bf}^2}{v_{Af}^2} \implies \frac{v_{Bf}}{v_{Af}} = \sqrt{\frac{m_A}{m_B}}$$

using $m_B = 3m_A$, we find

$$\frac{v_{Bf}}{v_{Af}} = \sqrt{\frac{m_A}{3m_A}} \implies \boxed{\frac{v_{Bf}}{v_{Af}} = \sqrt{\frac{1}{3}}}$$

This is less than 1 as expected.

(C): They both start at rest. The same, constant net force acts on them. But they each have a different mass. So their accelerations are not the same. Let's see:

N2: $\vec{F}_{net} = m\vec{a} \Rightarrow \Sigma F_x = m a_x$. So

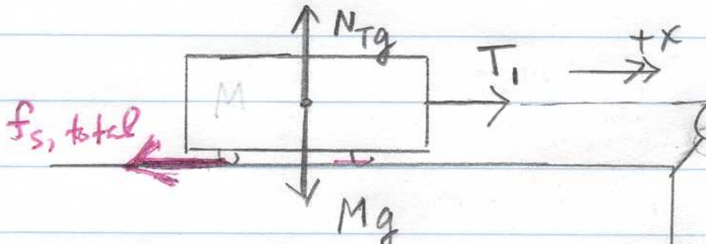
$$F_o = m_A a_A \quad \& \quad F_o = m_B a_B.$$

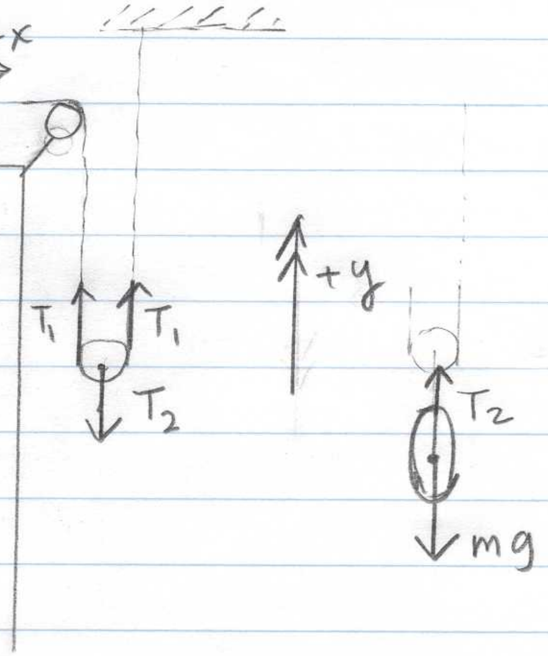
$$\Rightarrow a_A = \frac{F_o}{m_A} \quad \text{and} \quad a_B = \frac{F_o}{m_B}$$

since $m_B > m_A \Rightarrow \boxed{a_A > a_B}$ we know that their initial speeds are the same i.e $v_{iA} = 0$ & $v_{iB} = 0$. So A gets to the finish line first.

P3. See attached solution at the end.

P4/. a/.





a). If $v = \text{const} \Rightarrow a = 0$.

$\Sigma F_{net,y} = m a_y$ for Bag.

$T_2 - mg = 0$

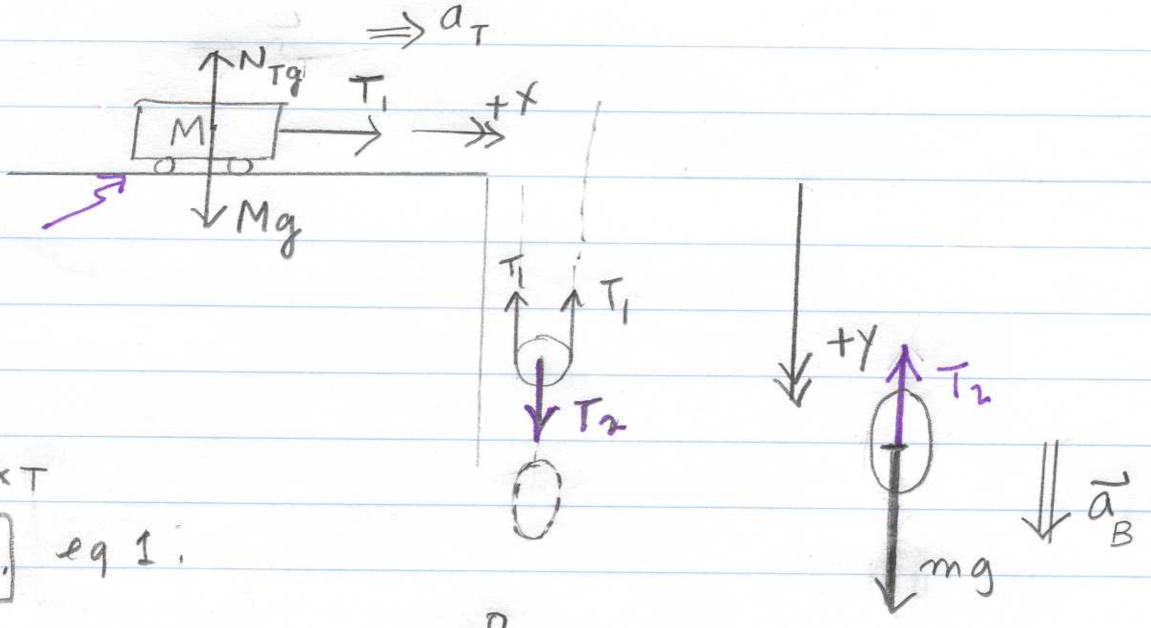
$\Rightarrow \boxed{T_2 = mg}$

$\Sigma F_{net,y} = m_{pulley} \cancel{a_y}^{\,0}$

$2T_1 - T_2 = 0$

$$\Rightarrow \boxed{T_1 = \frac{T_2}{2}} \Rightarrow \boxed{T_1 = \frac{mg}{2}}$$

b/. Now, let's assume that when the truck is rolling freely, the frictional forces are negligible.



assuming negligible friction –

For the truck:

$\Sigma F_x = M a_{xT}$

$\boxed{T_1 = M a_T}$ eq 1.

For the pulley: $\Sigma F_y = \cancel{m_{pulley}}^{\,0}\, a_p$ recall, mass of pulley negligible

$\Rightarrow -2T_1 + T_2 = 0$

pay attention to coordinate system.

$\boxed{2T_1 = T_2} \Rightarrow \boxed{T_1 = \frac{T_2}{2}}$ eq 2.

For the Bag $\Sigma F_y = m a_{By}$

$mg - T_2 = m a_B$ or

$\boxed{mg - 2T_1 = m a_B}$ eq 3.

Note that $a_T = 2 a_{Bag}$. e.g. if the truck moves 1 m, the pulley moves down $\frac{1}{2}$ meter. So now,

From eq 1: $T_1 = M a_T = M(2 a_B) = \boxed{2 M a_B = T_1}$

substituting this in eq 3,

$mg - 2T_1 = m a_B$

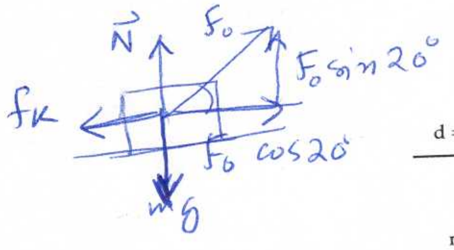
$mg - 2(2 M a_B) = m a_B$

$\Rightarrow mg - 4 M a_B = m a_B.$

$$\Rightarrow \quad mg = (4M + m)\,a_B$$

so $\boxed{a_B = \left(\dfrac{m}{4M+m}\right) g}$

and $a_T = 2a_B$ so $\boxed{a_T = \dfrac{(2m)}{(4M+m)}\, g}$



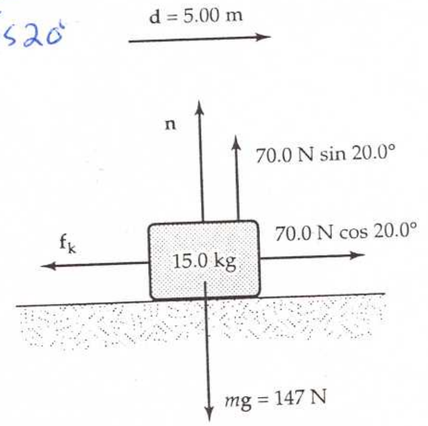
7.6 $\Sigma F_y = ma_y$

P1

$n + (70.0\text{ N})\sin 20.0° - 147\text{ N} = 0$

$n = 123\text{ N}$

$f_k = \mu_k n = 0.300\,(123\text{ N}) = 36.9\text{ N}$



(a) $W = Fd\cos\theta$

$= (70.0\text{ N})(5.00\text{ m})\cos 20.0° = \boxed{329\text{ J}}$

(b) $W = Fd\cos\theta = (123\text{ N})(5.00\text{ m})\cos 90.0° = \boxed{0\text{ J}}$

(c) $W = Fd\cos\theta = (147\text{ N})(5.00\text{ m})\cos 90.0° = \boxed{0}$

(d) $W = Fd\cos\theta = (36.9\text{ N})(5.00\text{ m})\cos 180° = \boxed{-185\text{ J}}$

(e) $\Delta K = K_f - K_i = \Sigma W = 329\text{ J} - 185\text{ J} = \boxed{+144\text{ J}}$

Problem P3:

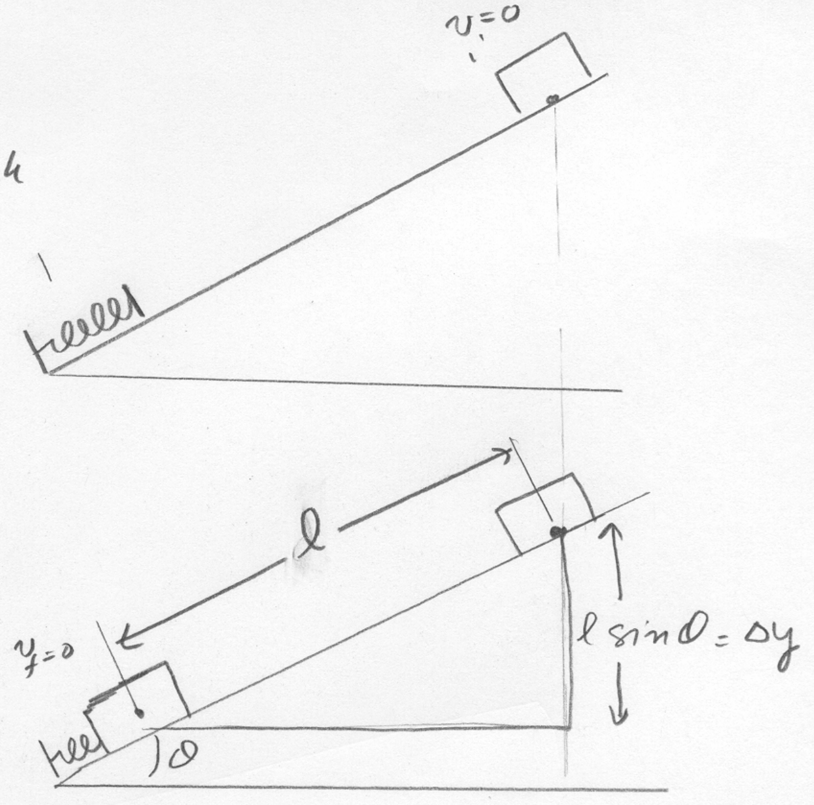
S & B P36

Work done by gravity on the block

$W_g = \vec{F} \cdot \vec{d}$

$= +F_g \Delta y$

$\boxed{W_g = mgl\sin\theta}$



If the spring is compressed by some amount x, then

$\boxed{W_{sp} = -\frac{1}{2}kx^2}$

$W_{net} = \Delta K.E$

(since $v_i = 0$ & $v_f = 0$ $\Delta K.E = 0$.

$\Rightarrow W_g + W_{sp} = 0$

$+mgl\sin\theta - \frac{1}{2}kx^2 = 0$

$\Rightarrow \frac{2mgl\sin\theta}{k} = x^2$

$\Rightarrow x = +\sqrt{\frac{2mgl\sin\theta}{k}}$

$= \sqrt{\frac{2(12.0\,kg)(9.80\,m/s^2)\sin 35.0^\circ(3.00\,m)}{3.00\times 10^4\,N/m}}$

$\boxed{x = 0.116\,m}$