511. FBD: \[ \vec{F}_{\text{net}} \iff \vec{a} \Rightarrow \ \vec{v} \Rightarrow \ \vec{v}_f \]
(a) \[ \vec{v}_i = 0, \ \vec{v}_f \] a little while later
(b) \[ \vec{v}_i \Rightarrow \vec{F}_{\text{net}} \Rightarrow \vec{a} \Rightarrow \vec{v} \Rightarrow \vec{v}_f \]
\[ t = 0 \] slightly later
(c) \[ \vec{v}_i \Rightarrow \vec{F}_{\text{net}} \Rightarrow \vec{a} \Rightarrow \vec{v} \Rightarrow \vec{v}_f \]
\[ t = 0 \] slightly later
(d) \[ \vec{v}_i \Rightarrow \vec{F}_{\text{net}} \Rightarrow \vec{a} \Rightarrow \vec{v} \Rightarrow \vec{v}_f \]
\[ \Delta \vec{v} = \vec{v}_f - \vec{v}_i \] slightly later
\[ \vec{v}_f = \vec{v}_i + \Delta \vec{v} \]
(Recall \[ \vec{a} = \frac{d^2 \vec{v}}{dt^2} \] and \[ \Delta \vec{v} = \frac{d\vec{v}}{dt} \]

521. \[ \vec{A} \cdot \vec{B} = |A||B| \cos \theta \]
If \[ \vec{A} \cdot \vec{B} = 0 \], even if \[ |A| \neq 0 \] and \[ |B| \neq 0 \], we can
still have \[ \vec{A} \cdot \vec{B} = 0 \] if \[ \cos \theta = 0 \]. i.e. \[ \theta = 90^\circ \] or \[ 270^\circ \]. 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 net tension force \[ \vec{T} \] does no work.
31. (a) Note that the displacement in the y-direction is the same for both A & B. So the work done by gravity on each is given by:

\[ W = F \cdot d = (m \cdot g) \cdot (\Delta y) \cos \theta \]

\[ W = mgh \]

From the work-kinetic energy theorem:

\[ W_{net} = K_f - K_i \]

\[ \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 = gh \]

\[ v_f^2 = 2gh + v_i^2 \]

So the final speed is the same for both rocks A & B even 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 larger 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.
To find the force, first draw a picture with the block displaced to the right (or left, no difference) by an amount $d$.

\[ F_{s1} = -kd \quad F_{net} = -2kd \]

\[ F_{sp2} = -kd \]

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

\[ F_{sp1} = -kd \quad F_{sp3} = -kd \]

\[ F_{net} = -3kd \]

\[ F_{sp2} = -kd \quad F_{sp4} = -kd \]

\[ F_{net} = -4kd \]

\[ |F_{net}^{(3)}| > |F_{net}^{(2)}| > |F_{net}^{(1)}| \]

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.

\( W_{sp}^{(1)} = \int_0^d F_{net} dx = \int_0^d (-2kx) dx \)

\[ W_{sp}^{(1)} = -k \left[ \frac{x^2}{2} \right]_0^d = -kd^2 \]

\( W_{sp}^{(2)} = \int_0^d (-3kx) dx = \frac{3}{2}kd^2 \).
Similarly, \( W_{Sp}^{(3)} = -2kd_2^2 \).

In general \( W_{Sp} = -\frac{1}{2}Keffect'Ve^2 \).

So magnitude of work ranking is:

\[ |W_{Sp}^{(3)}| > |W_{Sp}^{(2)}| > |W_{Sp}^{(1)}| \]
821. $V_{A1} = V_{B1} = 0$. 
$m_B = 3m_A$.

(a) Since the same force acts on each puck over the same displacement, the change in KE for each puck is the same. Therefore, at the time each crosses the finish line, the KE is the same. 

\[
F_0 \Delta x = \Delta KE \\
\Rightarrow F_0 \Delta x = K_{E_B} - K_{E_A} \\
F_0 \Delta x = K_{E_B} \Rightarrow K_{E_A} = K_{E_B}
\]

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 KE, we expect puck B to have a smaller speed. We expect $V_B < 1$. Let's find it exactly.

\[
\frac{1}{2} m_A V_{A_f}^2 = \frac{1}{2} m_B V_{B_f}^2
\]

\[
\Rightarrow \frac{m_A}{m_B} = \frac{V_{B_f}^2}{V_{A_f}^2} \Rightarrow \frac{V_{B_f}}{V_{A_f}} = \sqrt{\frac{m_A}{m_B}}
\]

Using $m_B = 3m_A$, we find

\[
\frac{V_{B_f}}{V_{A_f}} = \sqrt{\frac{1}{3}} \Rightarrow \frac{V_{B_f}}{V_{A_f}} = \frac{1}{\sqrt{3}}
\]

This is less than 1 as expected.
(c): They both start at rest. The same net force acts on them, but they each have a different mass, so their accelerations are not the same. Let’s see:

\( F_{net} = mA \Rightarrow \sum F_x = ma \) so

\[ F_0 = m_A a_A \quad \text{and} \quad F_0 = m_B a_B. \]

\[ \Rightarrow a_A = \frac{F_0}{m_A} \quad \text{and} \quad a_B = \frac{F_0}{m_B} \]

Since \( m_B > m_A \implies a_A < a_B \) 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.

P41. a1.

\[ \text{If } \vec{v} = \text{const } \Rightarrow a = 0. \]

\[ \sum F_{net, y} = ma_y \text{ for Bag, } \]

\[ T_2 - mg = 0 \]

\[ \Rightarrow T_2 = mg \]

\[ \sum F_{net, y} = m_{pulley} a_y \]

\[ 2T_1 - T_2 = 0 \]

\[ \Rightarrow T_1 = \frac{T_2}{2} \quad \Rightarrow \quad T_1 = \frac{mg}{2} \]

page 6.
b. Now, let’s assume that when the truck is rolling freely, the frictional forces are negligible.

For the truck:
\[ \Sigma F_x = M a_T \]
\[ T_1 = M a_T \]  
\[ \Rightarrow a_T \]

For the pulley:
\[ \Sigma F_y = m \text{ pulley} \cdot a_p \]
\[ = 0 \]
\[ 2T_1 + T_2 = 0 \]
\[ 2T_1 = T_2 \Rightarrow T_1 = \frac{T_2}{2} \]  
\[ \text{eq. 2} \]

For the bag:
\[ \Sigma F_y = m a_{by} \]
\[ m g - T_2 = m a_{by} \]
\[ m g - 2T_1 = m a_{by} \]  
\[ \text{eq. 3} \]

Note that \( a_T = 2a_{bag} \). E.g., if the truck moves 1 m, the pulley moves down \( \frac{1}{2} \) meter. So now:

From eq. 1:
\[ T_1 = M a_T = M (2a_{bag}) = 2M a_{bag} = T_1 \]

Substituting this in eq. 3:
\[ m g - 2T_1 = m a_{by} \]
\[ m g - 2(2M a_{bag}) = m a_{by} \]
\[ \Rightarrow m g - 4M a_{bag} = m a_{by} \]
\[ mg = (4M + m)a_B \]

So
\[ a_B = \left( \frac{m}{4M + m} \right) g \]

And \( a_T = 2a_B \) so
\[ a_T = \left( \frac{2m}{4M + m} \right) g \]

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\( \Sigma F_y = ma_y \)
\[ n + (70.0 \text{ N}) \sin 20.0^\circ - 147 \text{ N} = 0 \]

\( n = 123 \text{ N} \)

\( f_k = \mu \cdot n = 0.300 \times (123 \text{ N}) = 36.9 \text{ N} \)

(a) \( W = Fd \cos \theta \)
\[ = (70.0 \text{ N})(5.00 \text{ m}) \cos 20.0^\circ = 329 \text{ J} \]

(b) \( W = Fd \cos \theta = (123 \text{ N})(5.00 \text{ m}) \cos 90.0^\circ = 0 \text{ J} \)

(c) \( W = Fd \cos \theta = (147 \text{ N})(5.00 \text{ m}) \cos 90.0^\circ = 0 \text{ J} \)

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

(e) \( \Delta K = K_f - K_i = \Sigma W = 329 \text{ J} - 185 \text{ J} = 144 \text{ J} \)
Problem P3:  
S& B P36

Work done by gravity on the block
\[ W_g = F_g \cdot l \]
\[ = F_g \Delta y \]
\[ W_g = m g l \sin \alpha \]

If the spring is compressed by some amount \( x \), then
\[ W_{sp} = -\frac{1}{2} k x^2 \]

\[ W_{net} = \Delta K \cdot E \]
(since \( u_i = 0 \) & \( v_f = 0 \) \( \Delta K \cdot E = 0 \).

\[ \Rightarrow W_g + W_{sp} = 0 \]
\[ + m g l \sin \alpha - \frac{1}{2} k x^2 = 0 \]

\[ \Rightarrow 2 m g l \sin \alpha = x^2 \]

\[ \Rightarrow x = \sqrt{\frac{2 m g l \sin \alpha}{k}} \]

\[ = \sqrt{\frac{2 (12 \text{ kg})(9.8 \text{ m/s}^2) \sin 35.0^\circ (3 \text{ N/m})}{3 \text{ N/m} \times 10^4 \text{ N/m}}} \]

\[ x = 0.116 \text{ m} \]