Today 5.1 & 5.2

$\boxed{L15}$

Today $\underbrace{5.1 \text{ \& } 5.2}$

$\boxed{L15}$

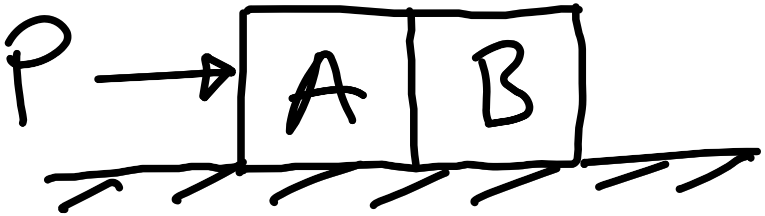
Newton's 1st & 2nd Law

Today 5.1 & 5.2

Wednesday 5.3

$\boxed{L15}$

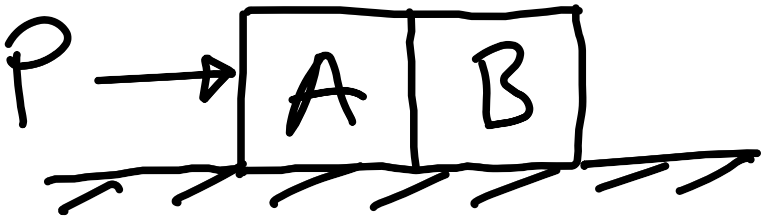
Example problem



find

$F_{A \to B}$

Example problem

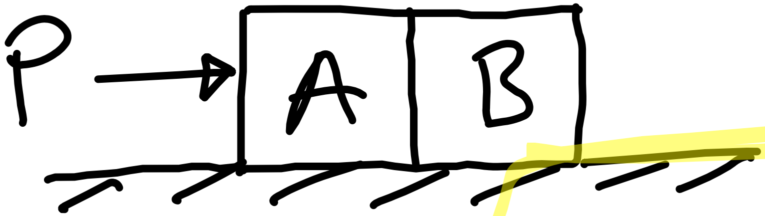


find

$F_{A \to B}$

Solve 2 ways:
- * find acceleration for system & apply to B
- * 3rd law formalism

Example problem



find

F_{AoB}

Solve 2 ways:
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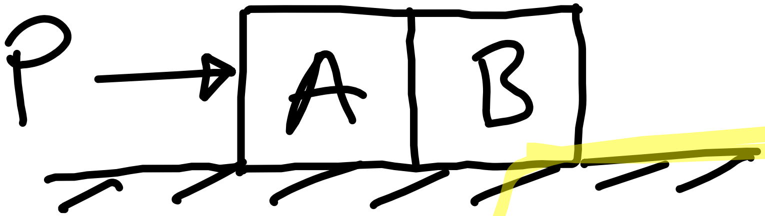
system $F=ma$

Example problem



find

$F_{A\to B}$

Solve 2 ways:
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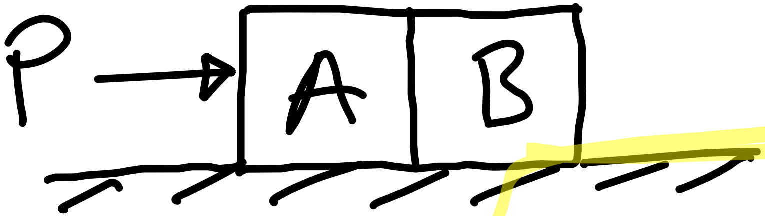
system

$F = ma \Rightarrow P = (m_A + m_B)a$

Example problem



find

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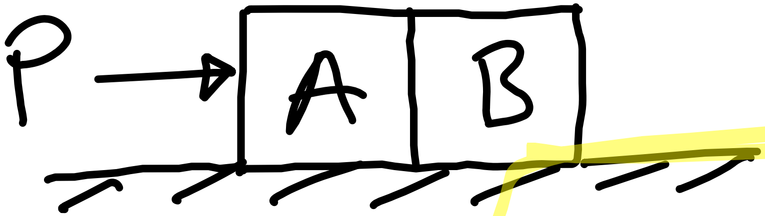
system

$$F = ma \Rightarrow P = (m_A + m_B)a \Rightarrow a = \frac{P}{m_A + m_B}$$

Example problem



find

$F_{A\to B}$

Solve 2 ways:

- * find acceleration for system & apply to B
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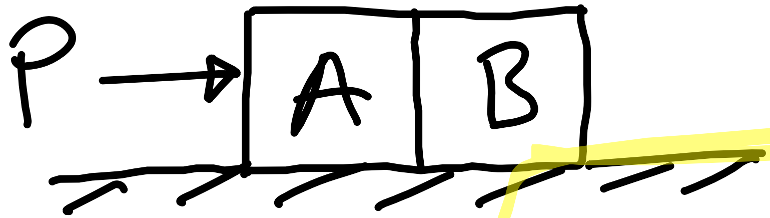
system $F=ma \Rightarrow P=(m_A+m_B)a \Rightarrow a=\frac{P}{m_A+m_B}$

B $F=ma \Rightarrow F_{A\to B}=m_B a$

Example problem



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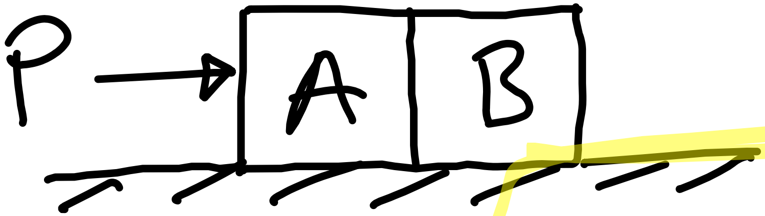

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system $F=ma \Rightarrow P=(m_A+m_B)a \Rightarrow a=\frac{P}{m_A+m_B}$

B $F=ma \Rightarrow F_{A\to B}=m_B a \Rightarrow \boxed{F_{A\to B}=m_B\left(\frac{P}{m_A+m_B}\right)}$

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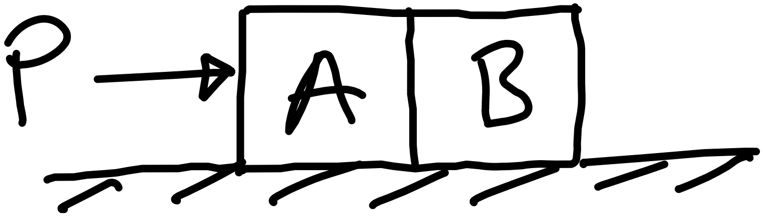

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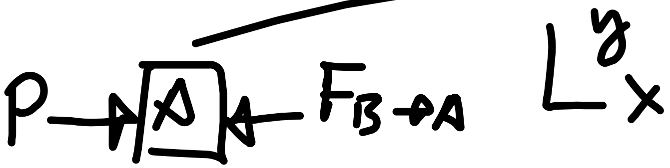

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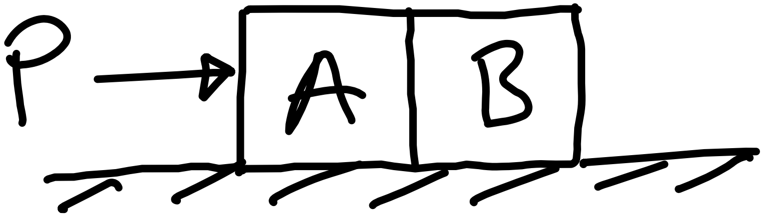

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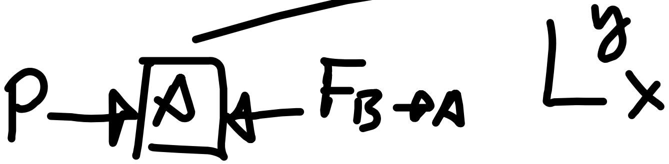
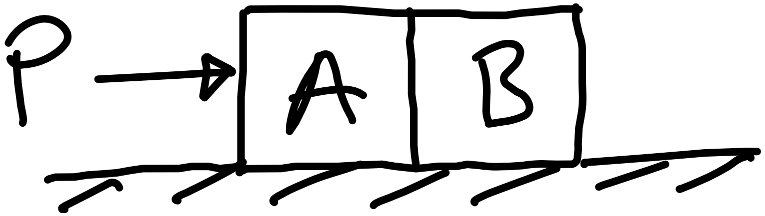


$\sum F_x = ma$

Example problem



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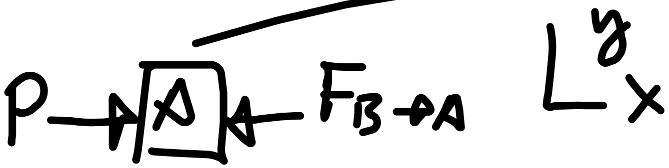
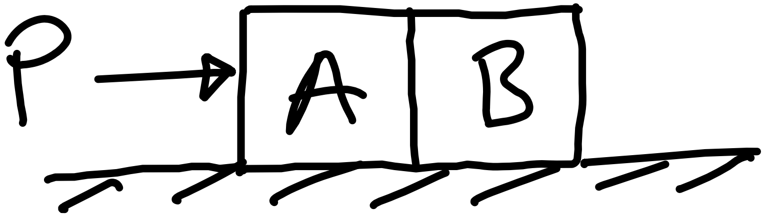


$$\Sigma F_x = ma \Rightarrow P - F_{B \to A} = m_A a$$

Example problem



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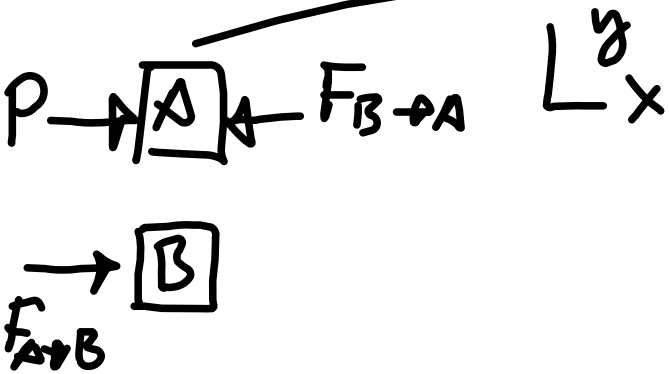

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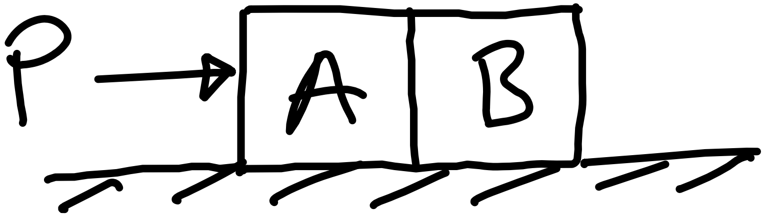

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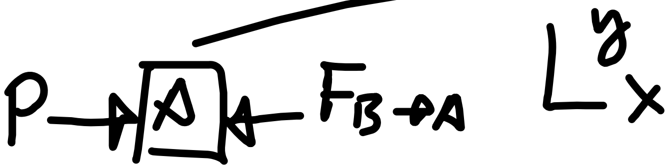
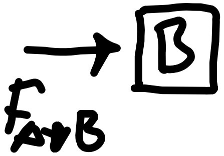
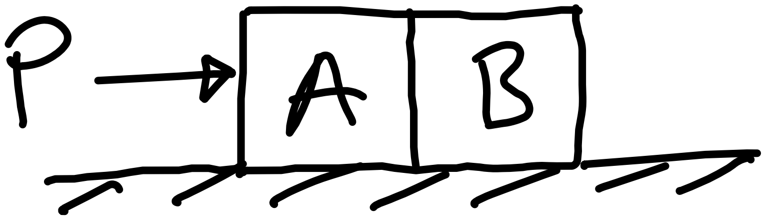


$\Sigma F_x = m a_x \Rightarrow \quad P - F_{B\to A} = m_A a$



$\Sigma F_x = m a_x \Rightarrow \quad F_{A\to B} = m_B a$

Example problem



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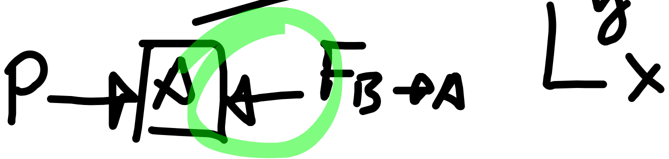
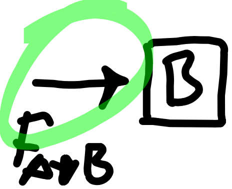


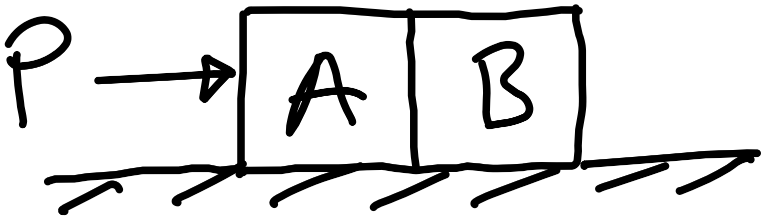
$$\Sigma F_x = ma_x \Rightarrow \quad P - F_{B\to A} = m_A a$$



$$\Sigma F_x = ma_x \Rightarrow \quad F_{A\to B} = m_B a$$

Notice that $\vec{F}_{B\to A} = -\vec{F}_{A\to B}$ means that the arrows are equal & in opposite directions

Example problem



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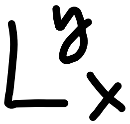
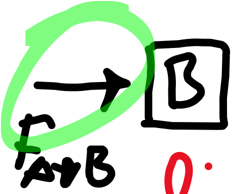


$\Sigma F_x = m a_x \Rightarrow \quad P - F_{B \to A} = m_A a$

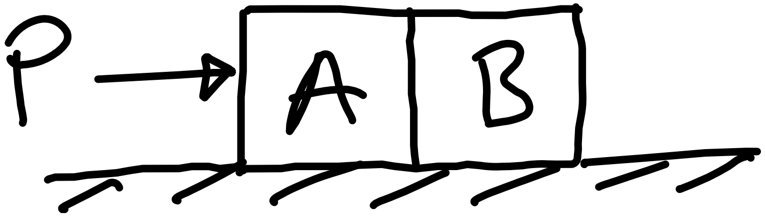


$\Sigma F_x = m a_x \Rightarrow \quad F_{A \to B} = m_B a$

Also, if directions shown are correct, the value of $F_{A \to B}$ & $F_{B \to A}$ will be positive.

A negative indicates arrow flipped

Example problem



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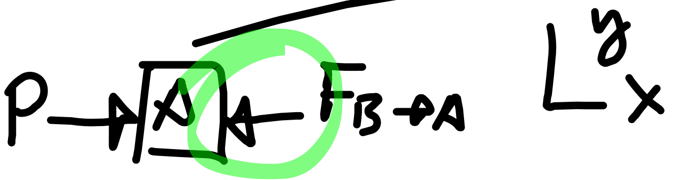
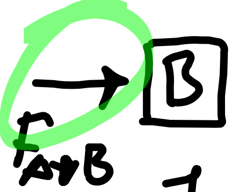


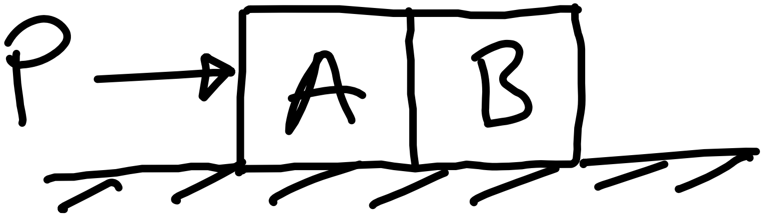
$\sum F_x = m a_x \Rightarrow \quad P - F_{B\to A} = m_A a$ (1)



$\sum F_x = m a_x \Rightarrow \quad F_{A\to B} = m_B a$ (2)

from eqns 1&2 : $a = \frac{P}{m_A} - \frac{F_{B\to A}}{m_A}$ & $a = \frac{F_{A\to B}}{m_B}$

Example problem



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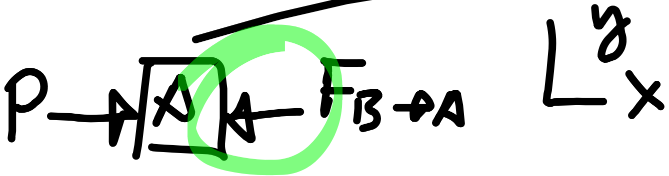

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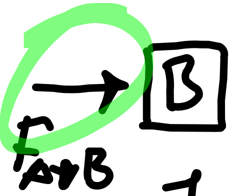
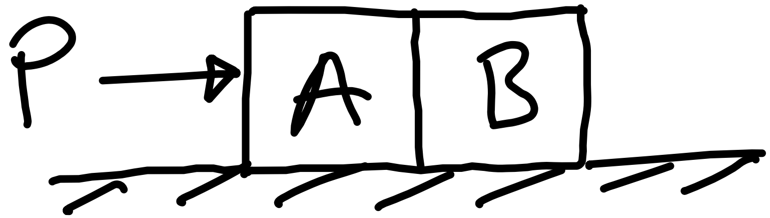


$\Sigma F_x = m a_x \Rightarrow \quad F_{A\to B} = m_B a$ (2)

from eqns 1&2: $a = \frac{P}{m_A} - \frac{F_{B\to A}}{m_A}$ & $a = \frac{F_{A\to B}}{m_B}$

$$\Rightarrow \frac{F_{A\to B}}{m_B} = \frac{P}{m_A} - \frac{F_{B\to A}}{m_A}$$

Example problem



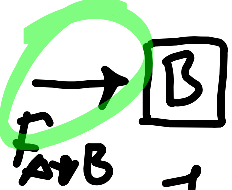
find $F_{A\to B}$

Solve 2 ways:
- * find acceleration for system & apply to B
- * 3rd law formalism

y

x

$$\Sigma F_x = m a_x \Rightarrow \quad P - F_{B\to A} = m_A a \quad (1)$$



$$\Sigma F_x = m a_x \Rightarrow \quad F_{A\to B} = m_B a \quad (2)$$

from eqns 1&2: $a = \frac{P}{m_A} - \frac{F_{B\to A}}{m_A}$ & $a = \frac{F_{A\to B}}{m_B}$

$$\Rightarrow \frac{F_{A\to B}}{m_B} = \frac{P}{m_A} - \frac{F_{B\to A}}{m_A} \Rightarrow F_{A\to B} m_A + F_{B\to A} m_B = P m_B$$

From previous slide:

$$F_{A \to B} m_A + F_{B \to A} m_B = P m_B$$

From previous slide:

$$F_{A\to B}\, m_A + F_{B\to A}\, m_B = P m_B$$

Here is the tricky part:

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Here is the tricky part: $\vec{F}_{A \to B} = -\vec{F}_{B \to A}$

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Here is the tricky part: $\vec{F}_{A \to B} = -\vec{F}_{B \to A}$

But the direction is being dealt with by our arrows on the diagrams & if correct, will yield $F_{A \to B}$ & $F_{B \to A}$ as positive.

From previous slide:

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Vector

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With that out of the way, the problem is easily solved for $F_{A\to B}$:

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$$\Rightarrow \quad F_{A\to B} = \frac{P m_B}{m_A + m_B}$$

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$$\Rightarrow \boxed{F_{A\to B} = \frac{P m_B}{m_A + m_B}} \rightarrow \text{Same as other solution}$$

An iceboat is at rest on a frictionless horizontal surface (Fig. 5.7a). Due to the blowing wind, 4.0 s after the iceboat is released, it is moving to the right at $6.0 \mathrm{~m/s}$ (about $22 \mathrm{~km/h}$, or $13 \mathrm{~mi/h}$). What constant horizontal force F_W does the wind exert on the iceboat? The combined mass of iceboat and rider is 200 kg.

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$\Delta V = 6\,m/s$, $\Delta t = 4s$

$\Rightarrow \quad a = \frac{\Delta V}{\Delta t}$

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$\delta V = 6\,m/s \;,\; \Delta t = 4s$

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$\delta v = 6 \, m/s \, , \, \Delta t = 4 s$

$\Rightarrow \quad a = \frac{\Delta v}{\Delta t} = (6/4) \, m/s^2 = 1.5 \, m/s^2$

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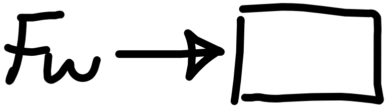

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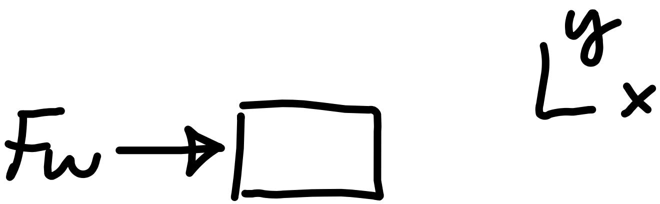
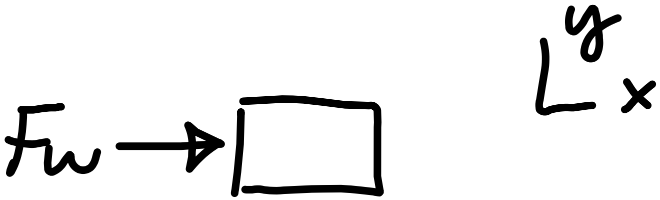


$\Sigma F_x = m a_x$

An iceboat is at rest on a frictionless horizontal surface (Fig. 5.7a). Due to the blowing wind, 4.0 s after the iceboat is released, it is moving to the right at 6.0 m/s (about 22 km/h, or 13 mi/h). What constant horizontal force F_W does the wind exert on the iceboat? The combined mass of iceboat and rider is 200 kg.

$\delta V = 6 \, m/s \, , \, \Delta t = 4s$

$\Rightarrow \quad a = \frac{\Delta V}{\Delta t} = (6/4) \, m/s^2 = 1.5 \, m/s^2$



$\Sigma F_x = m a_x \quad \Rightarrow \quad F_w = ma$

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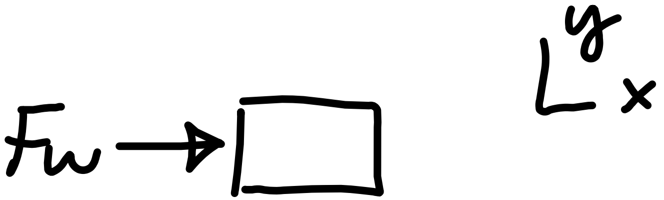

$\Sigma F_x = m a_x \quad \Rightarrow \quad F_w = ma$

$\Rightarrow \quad F_w = (200 kg)(1.5 \, m/s^2)$

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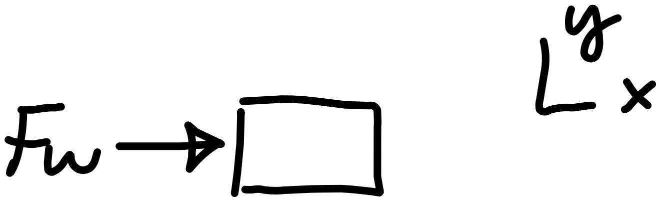

$\Sigma F_x = ma_x \quad \Rightarrow \quad F_w = ma$

$\Rightarrow \quad F_w = (200kg)(1.5\,m/s^2) \quad \Rightarrow$

$$\boxed{F_w = 300N}$$

Suppose a constant horizontal friction force with magnitude 100 N opposes the motion of the iceboat in Example 5.6. In this case, what constant force F_W must the wind exert on the iceboat to cause the same constant x-acceleration $a_x = 1.5\ \mathrm{m/s^2}$?

Suppose a constant horizontal friction force with magnitude 100 N opposes the motion of the iceboat in Example 5.6. In this case, what constant force F_{W} must the wind exert on the iceboat to cause the same constant x-acceleration $a_x = 1.5\ \mathrm{m/s^2}$?

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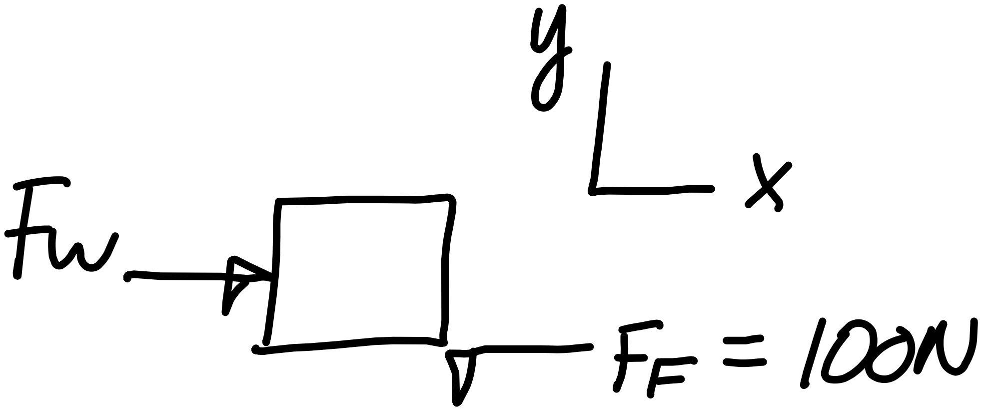

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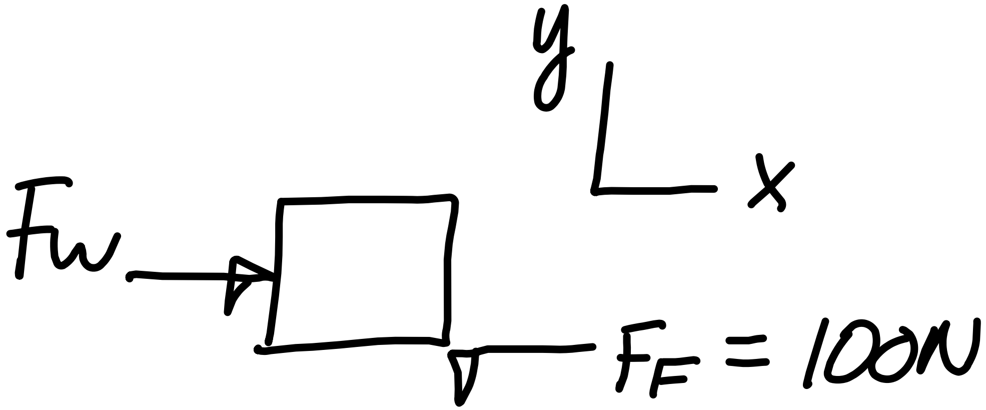

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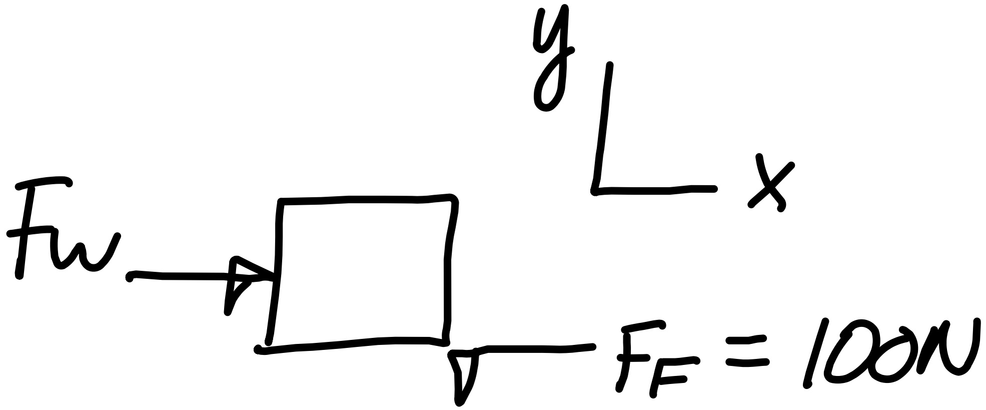

Find F_w

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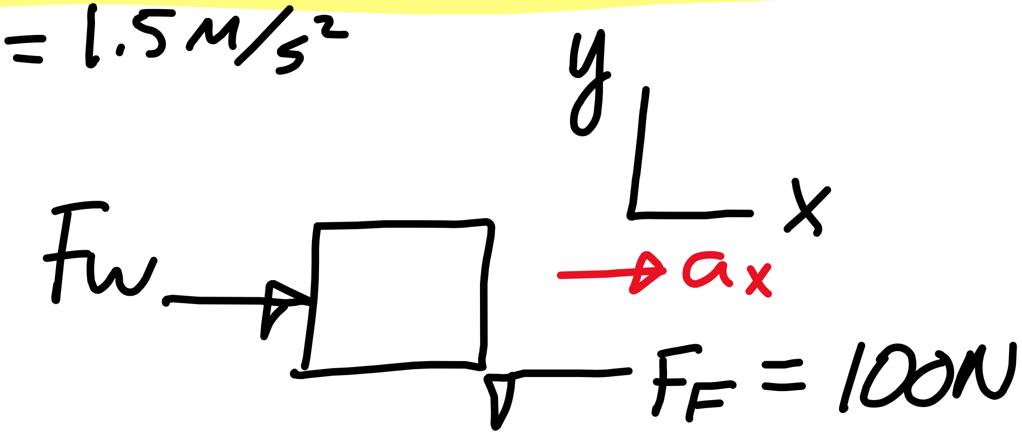
$a_x = 1.5 m/s^2$



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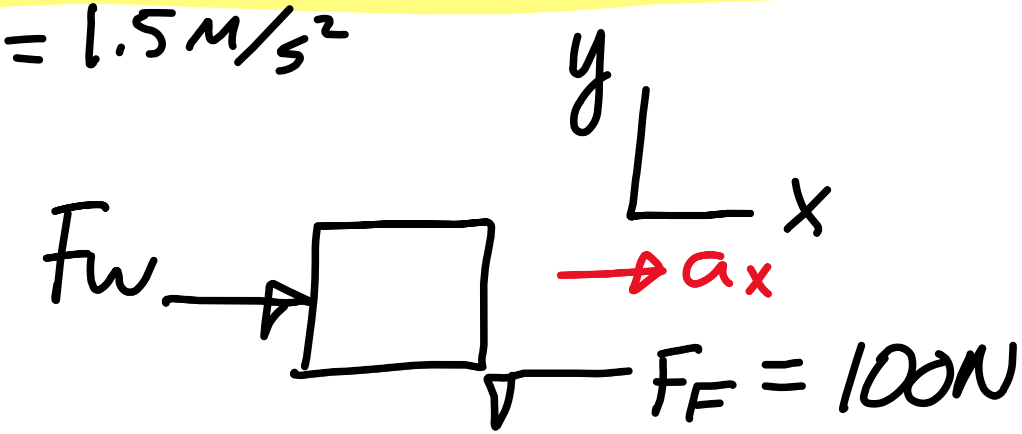

Find Fw:

$\Sigma F_x = m a_x$

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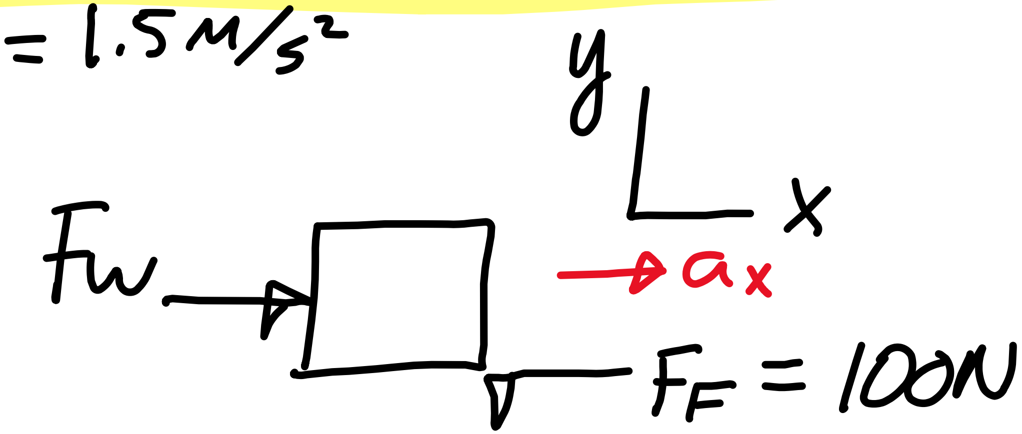

Find Fw :

$$\Sigma F_x = m a_x$$

$$\Rightarrow \quad F_W - F_F = m a$$

Suppose a constant horizontal friction force with magnitude 100 N opposes the motion of the iceboat in Example 5.6. In this case, what constant force F_W must the wind exert on the iceboat to cause the same constant x-acceleration $a_x = 1.5 \text{ m/s}^2$?

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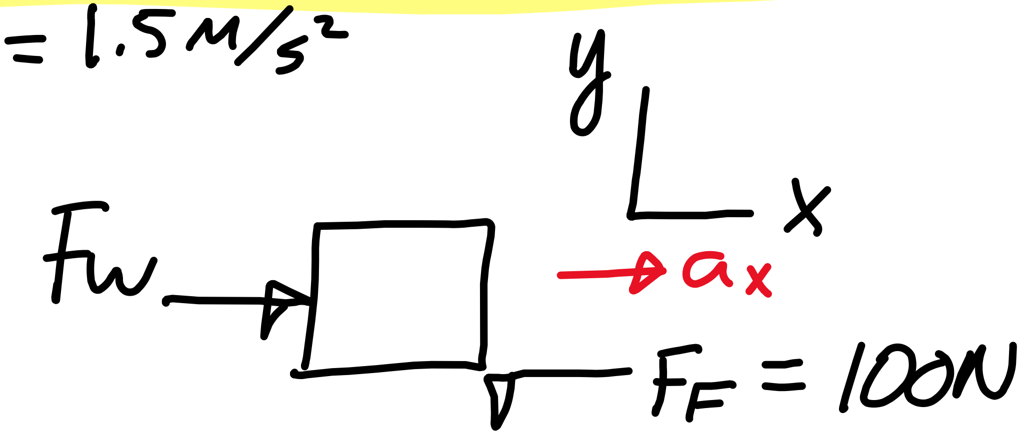

Find Fw :

$$\Sigma F_x = m a_x$$

$$\Rightarrow \quad F_w - F_F = ma \Rightarrow F_w = ma + F_F$$

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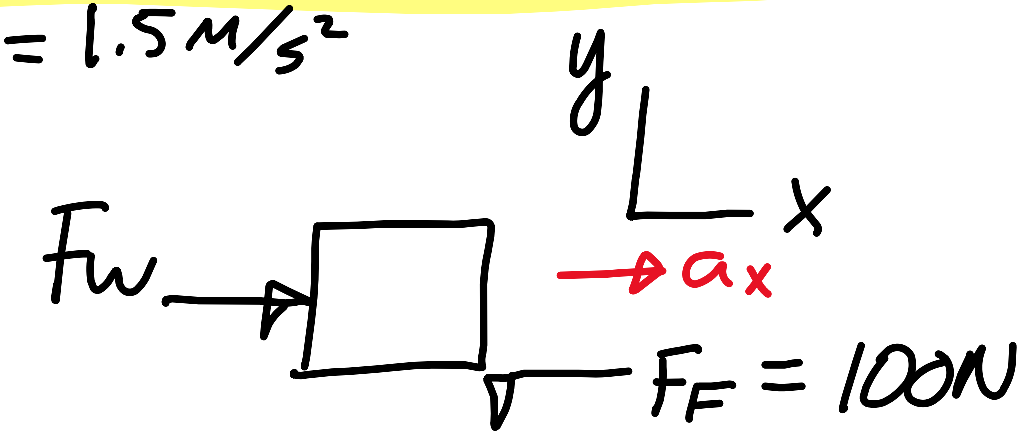

Find Fw : $\sum F_x = ma_x$

$\Rightarrow \quad F_w - F_F = ma \Rightarrow F_w = ma + F_F$

$\Rightarrow \quad F_w = 300N + 100N$

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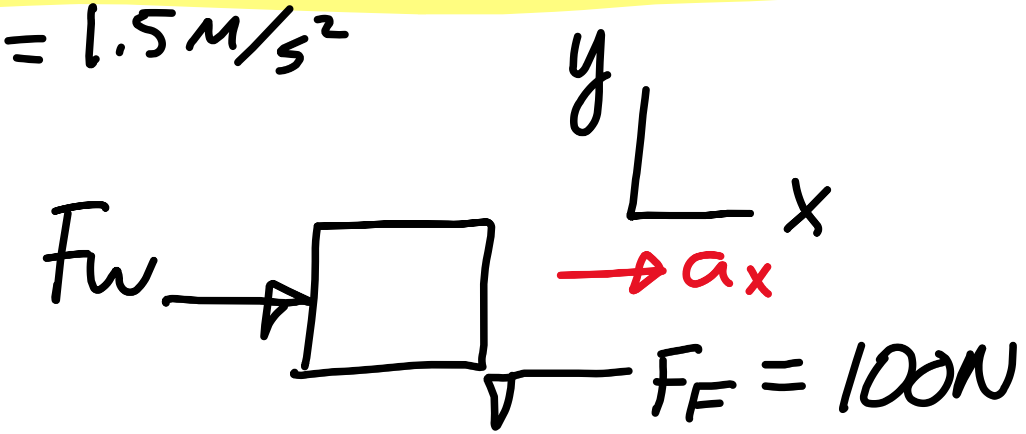


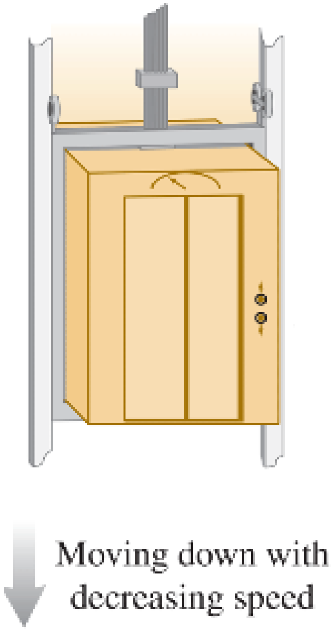
Find Fw: $\sum F_x = m a_x$

$\Rightarrow \quad F_w - F_F = ma \Rightarrow F_w = ma + F_F$

$\Rightarrow \quad F_w = 300N + 100N$

$\Rightarrow \quad \boxed{F_w = 400N}$

An elevator and its load have a combined mass of 800 kg (Fig. 5.9a). The elevator is initially moving downward at 10.0 m/s; it slows to a stop with constant acceleration in a distance of 25.0 m. What is the tension T in the supporting cable while the elevator is being brought to rest?



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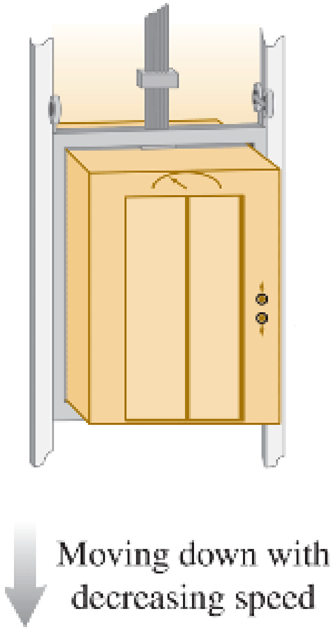

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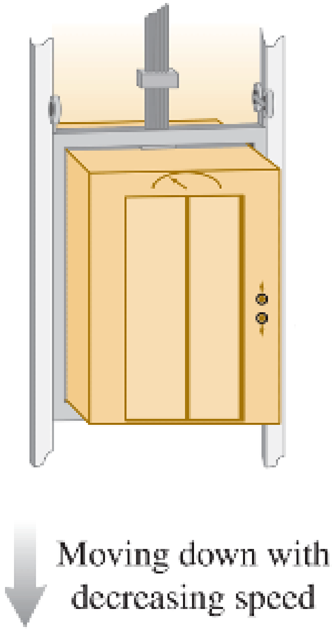
$m = 800 kg$ $v_0 = 10 \, m/s$



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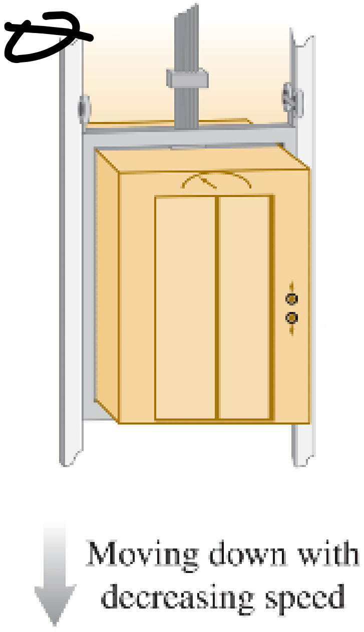
$\Delta y = 25 m$



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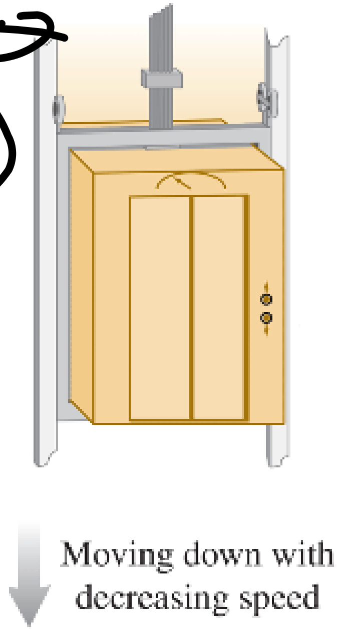
$\Delta y = 25\,m \quad a = v\frac{dv}{dy} \Rightarrow a\Delta y = \frac{1}{2}(\cancel{v_1^2} - v_0^2)$

$\Rightarrow \quad a = \frac{-v_0^2}{2\Delta y}$



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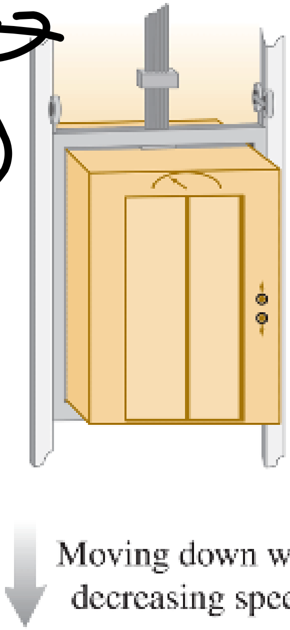

Moving down with decreasing speed

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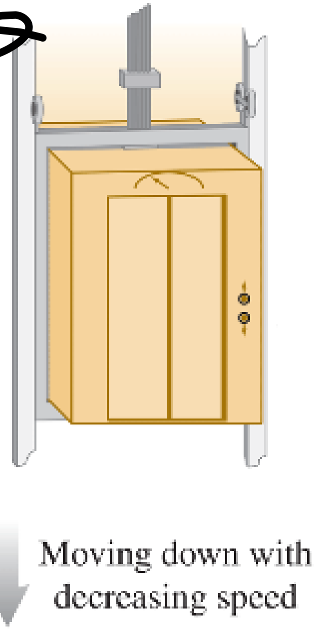

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$\Delta y = 25 m \quad a = v\frac{\delta v}{\delta y} \Rightarrow a\Delta y = \frac{1}{2}(\cancel{v_1^2} - v_0^2)$

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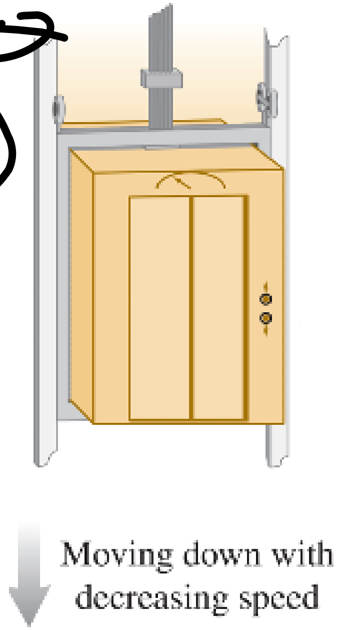

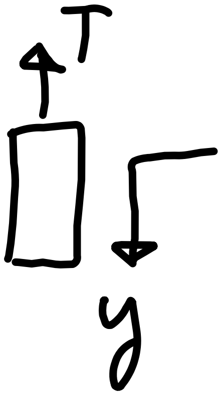

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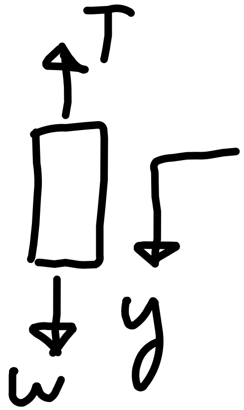
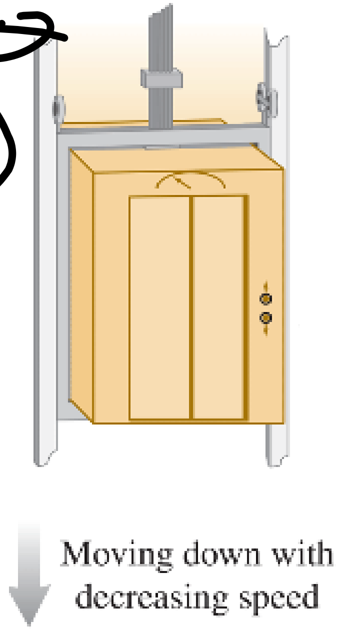


$\Sigma F_y = ma_y$



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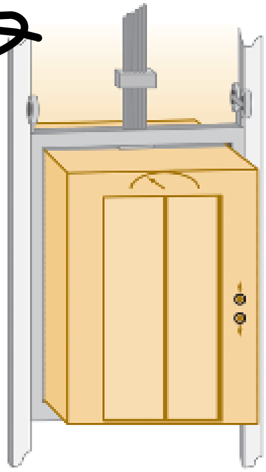
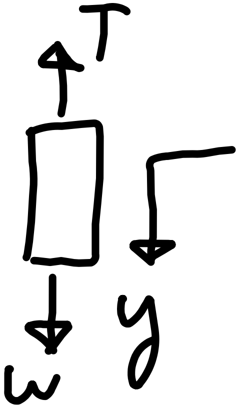
$m = 800 kg$ $\quad v_0 = 10 m/s, v_1 = 0$



Moving down with decreasing speed

$\Delta y = 25 m \quad a = v\frac{dv}{dy} \Rightarrow a\Delta y = \frac{1}{2}(\cancel{v_1^2} - v_0^2)$

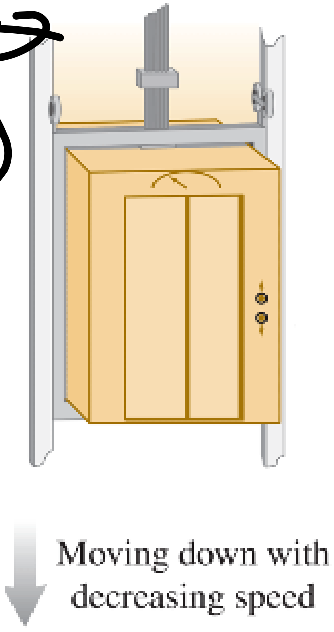
$\Rightarrow \quad a = \frac{-v_0^2}{2\Delta y} = -\frac{100}{50}\left(\frac{m}{s^2}\right) = -2 m/s^2$



$\sum F_y = ma_y \Rightarrow$

$-T + mg = ma_y$

An elevator and its load have a combined mass of 800 kg (Fig. 5.9a). The elevator is initially moving downward at 10.0 m/s; it slows to a stop with constant acceleration in a distance of 25.0 m. What is the tension T in the supporting cable while the elevator is being brought to rest?



$m = 800\,kg \quad V_0 = 10\,m/s, \; V_1 = 0$

$\Delta y = 25\,m \quad a = v\frac{dv}{dy} \Rightarrow a\Delta y = \frac{1}{2}(\cancel{V_1^2} - V_0^2)$

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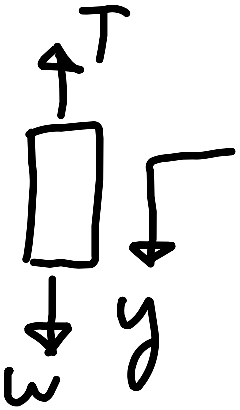

$\Sigma F_y = ma_y \Rightarrow$

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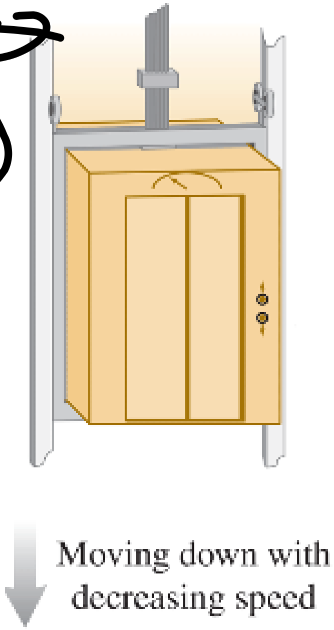
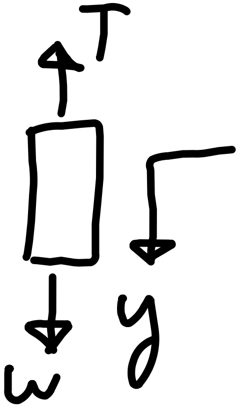


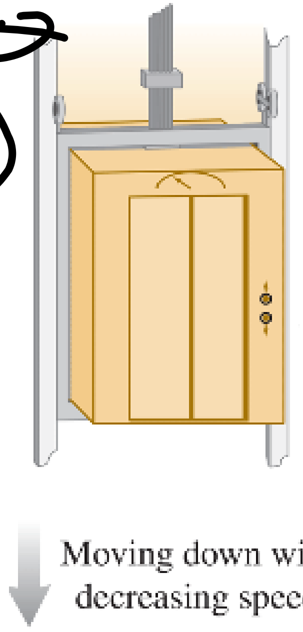


$\sum F_y = m a_y \Rightarrow$

$-T + mg = m a_y$

$\Rightarrow -T = m a_y - mg \Rightarrow T = m(g - a_y)$

An elevator and its load have a combined mass of 800 kg (Fig. 5.9a). The elevator is initially moving downward at 10.0 m/s; it slows to a stop with constant acceleration in a distance of 25.0 m. What is the tension T in the supporting cable while the elevator is being brought to rest?



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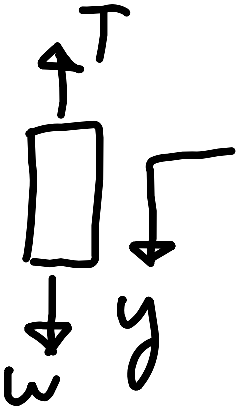


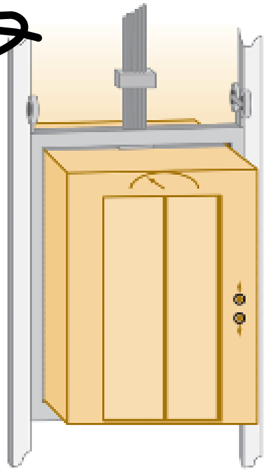
$\Sigma F_y = ma_y \Rightarrow$

$-T + mg = ma_y$

$\Rightarrow \quad -T = ma_y - mg \Rightarrow T = m(g - a_y)$

$\Rightarrow T = (800\,kg)(9.8 - (-4))\,m/s^2$

An elevator and its load have a combined mass of 800 kg (Fig. 5.9a). The elevator is initially moving downward at 10.0 m/s; it slows to a stop with constant acceleration in a distance of 25.0 m. What is the tension T in the supporting cable while the elevator is being brought to rest?



Moving down with decreasing speed

$m = 800\,kg \quad V_0 = 10\,m/s,\ V_1 = 0$

$\Delta y = 25\,m \quad a = v\frac{dv}{dy} \Rightarrow a\Delta y = \frac{1}{2}(\cancel{V_1^2} - V_0^2)$

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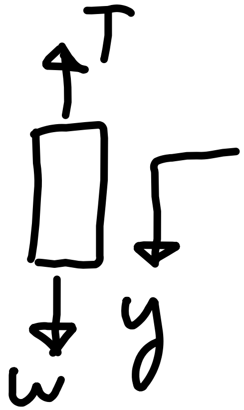


$\sum F_y = ma_y \Rightarrow$

$-T + mg = ma_y$

$\Rightarrow -T = ma_y - mg \Rightarrow T = m(g - a_y)$

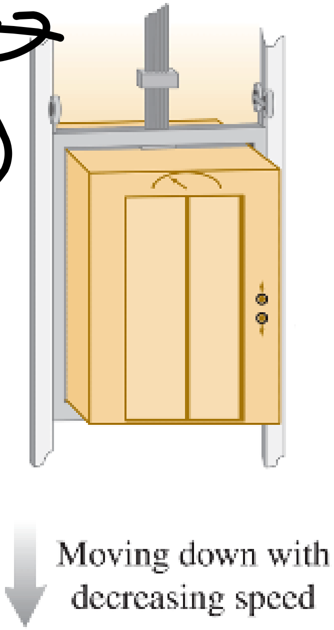
$\Rightarrow T = (800kg)(9.8 - (-2))\,m/s^2 = 800 * 11.8\,N$

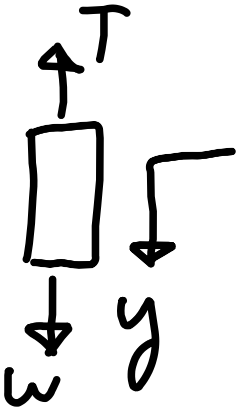
An elevator and its load have a combined mass of 800 kg (Fig. 5.9a). The elevator is initially moving downward at 10.0 m/s; it slows to a stop with constant acceleration in a distance of 25.0 m. What is the tension T in the supporting cable while the elevator is being brought to rest?

$m = 800\,kg \quad V_0 = 10\,m/s,\ V_1 = 0$

$\Delta y = 25\,m \quad a = v\frac{\partial v}{\partial y} \Rightarrow a\Delta y = \frac{1}{2}(\cancel{V_1^2} - V_0^2)$

$\Rightarrow \quad a = \frac{-V_0^2}{2\Delta y} = \frac{-100}{50}\left(\frac{m}{s^2}\right) = -2\,m/s^2$


Moving down with decreasing speed



$\Sigma F_y = ma_y \Rightarrow$

$-T + mg = ma_y$

$\Rightarrow \quad -T = ma_y - mg \Rightarrow T = m(g - a_y)$

$\Rightarrow T = (800\,kg)(9.8 - (-2))\,m/s^2 = 800 * 11.8\,N$

$\Rightarrow \quad \boxed{T = 9440\,N}$

A 50.0 kg woman stands on a bathroom scale while riding in the elevator in Example 5.8. While the elevator is moving downward with decreasing speed, what is the reading on the scale?

Moving down with decreasing speed

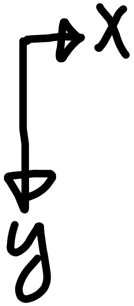
A 50.0 kg woman stands on a bathroom scale while riding in the elevator in Example 5.8.

While the elevator is moving downward with decreasing speed, what is the reading on the scale?

$m = 50kg$

A 50.0 kg woman stands on a bathroom scale while riding in the elevator in Example 5.8. While the elevator is moving downward with decreasing speed, what is the reading on the scale?

$m = 50 kg$ $a = -2 m/s^2$



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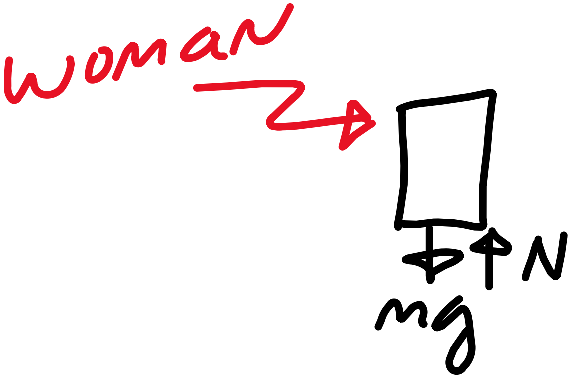

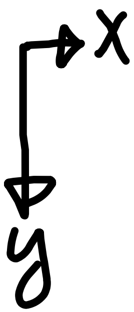

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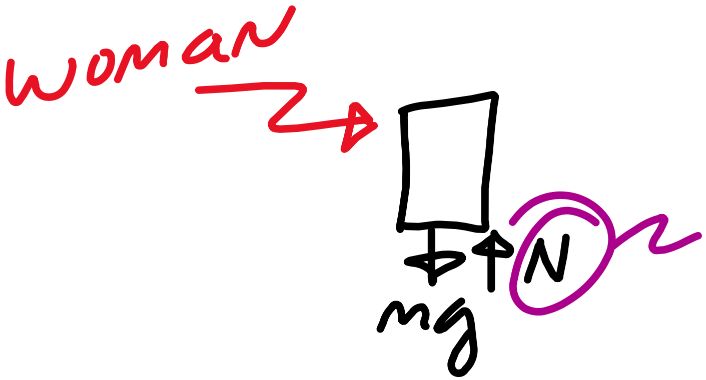
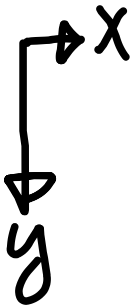


same as scale reading



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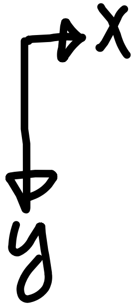

$$\sum \vec{F}_y = ma_y$$

Moving down with decreasing speed

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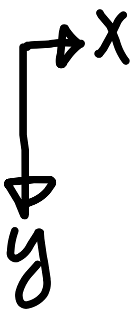

$\sum F_y = ma_y$

$\Rightarrow mg - N = ma$

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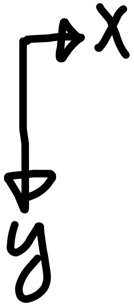

Moving down with decreasing speed

$$\sum F_y = ma_y$$

$$\Rightarrow mg - N = ma$$

$$\Rightarrow -N = m(a-g)$$

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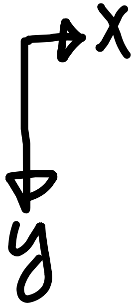

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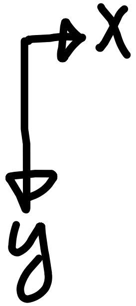

$$\Sigma F_y = m a_y$$

$$\Rightarrow mg - N = ma$$

$$\Rightarrow -N = m(a-g) \Rightarrow N = m(g-a)$$

$$\Rightarrow N = (50kg)(9.8 - (-2))\, m/s^2 = 50 * 11.8 N$$

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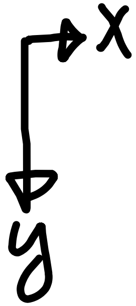
$m = 50 \text{kg}$ $\quad a = -2 \, \text{m/s}^2$



Moving down with decreasing speed

$$\sum F_y = m a_y$$

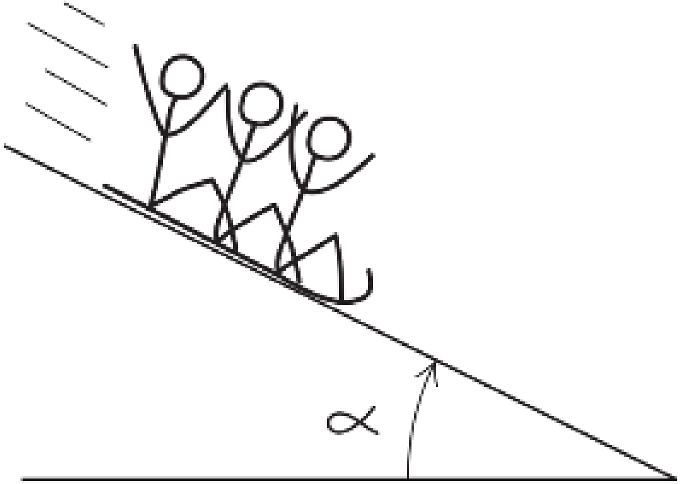
$$\Rightarrow \quad mg - N = ma$$

$$\Rightarrow \quad -N = m(a-g) \Rightarrow N = m(g-a)$$

$$\Rightarrow \quad N = (50 \text{kg})(9.8 - (-2)) \, \text{m/s}^2 = 50 * 11.8 \text{N}$$

$$\Rightarrow \quad N = 590 \text{N}$$

A toboggan loaded with students (total weight w) slides down a snow-covered hill that slopes at a constant angle α. The toboggan is well waxed, so there is virtually no friction. What is its acceleration?



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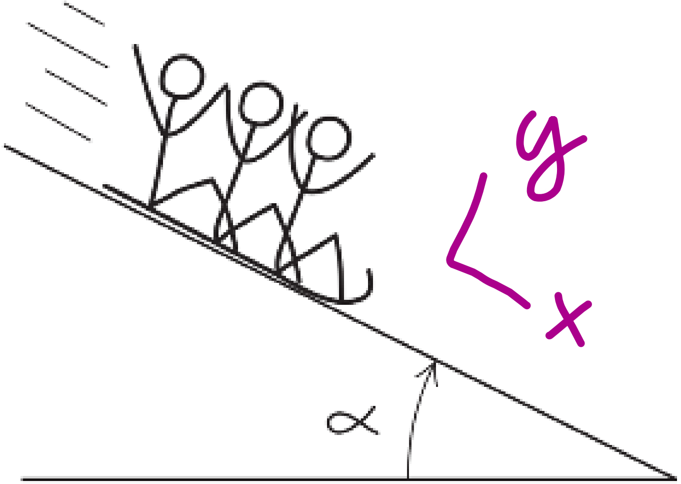

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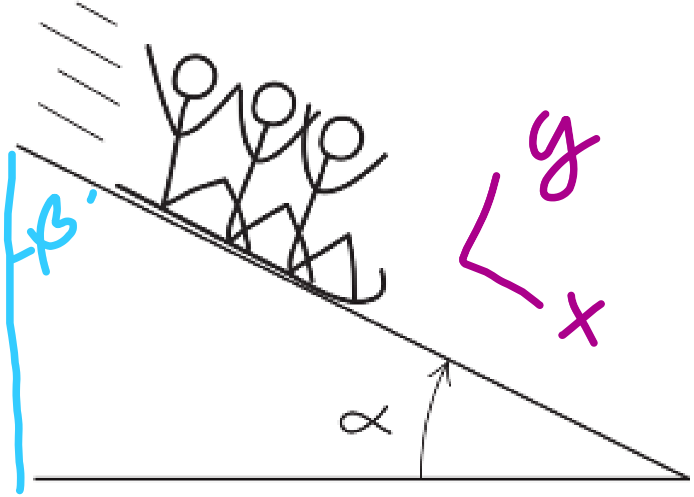

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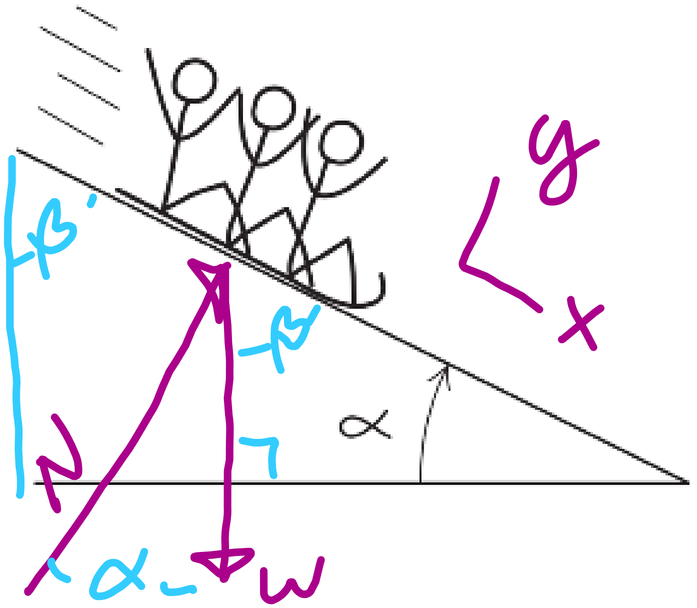

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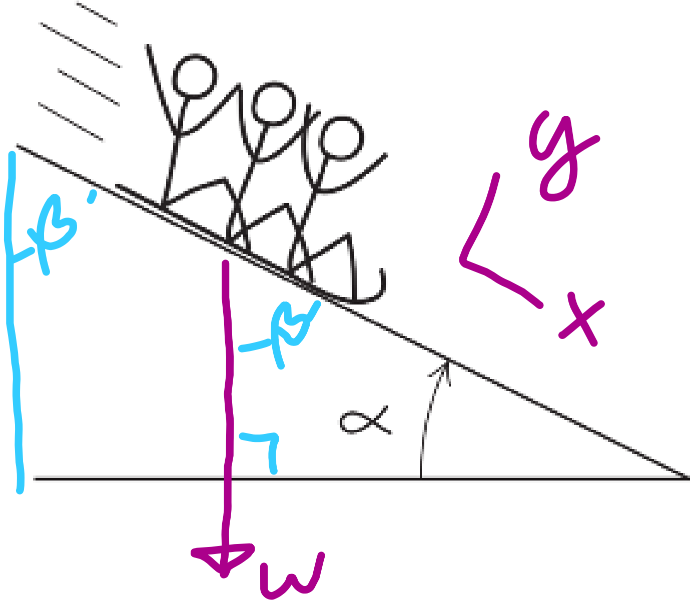

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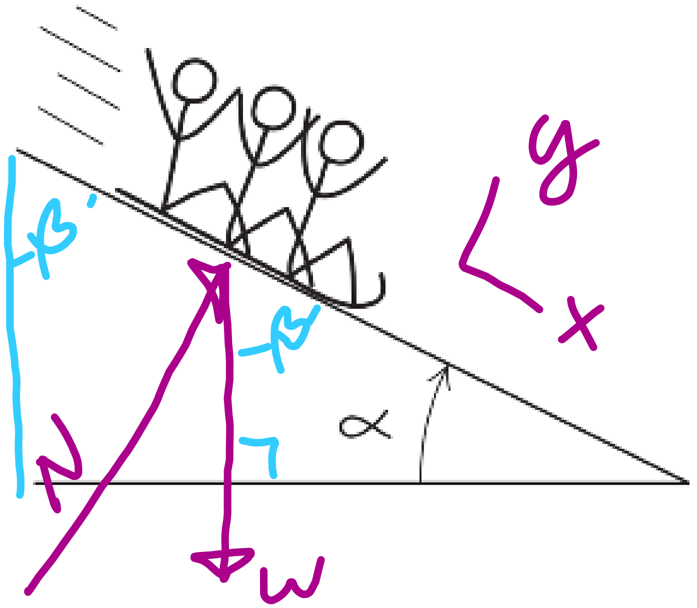

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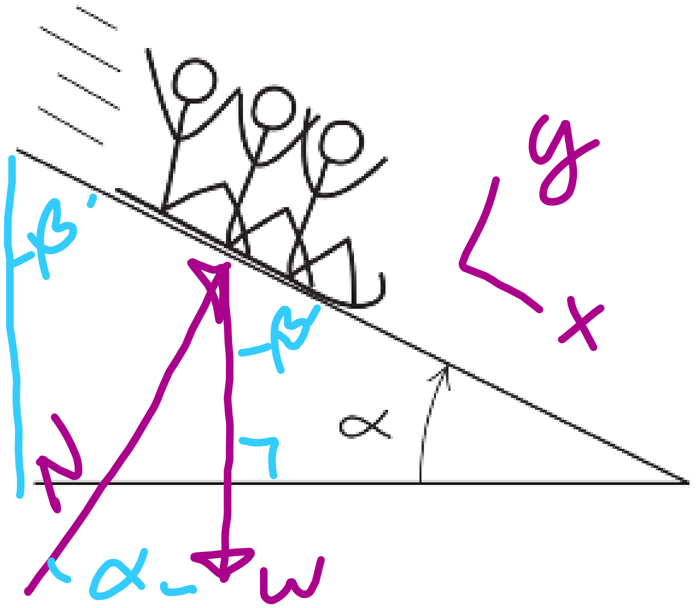
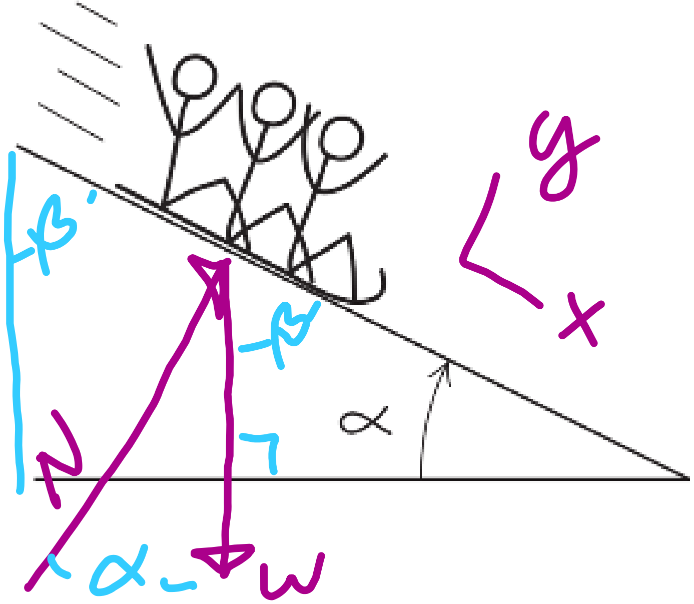


A toboggan loaded with students (total weight w) slides down a snow-covered hill that slopes at a constant angle α. The toboggan is well waxed, so there is virtually no friction. What is its acceleration?

$$\vec{w} = w\hat{i}\sin\alpha - w\hat{j}\cos\alpha$$



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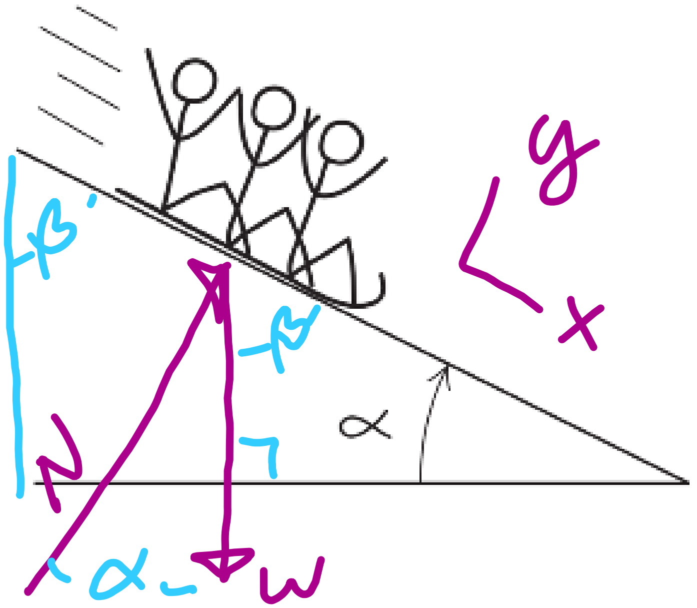

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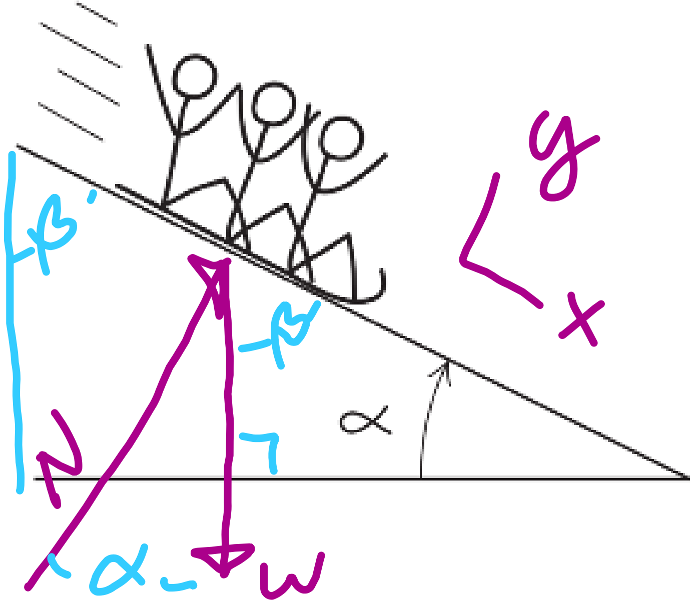

$$\sum F_x = m a_x$$

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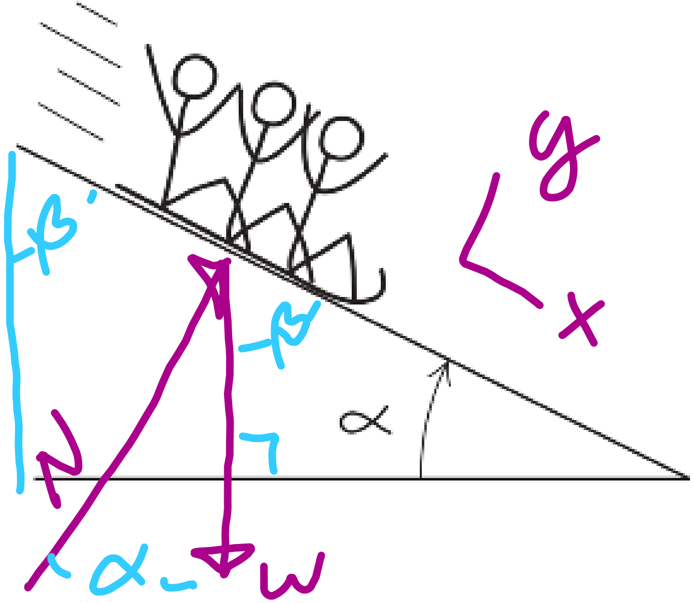

$$\sum F_x = m a_x$$

$$\Rightarrow \quad w_x = a_x m \Rightarrow$$

$$a = \frac{w_x}{m}$$

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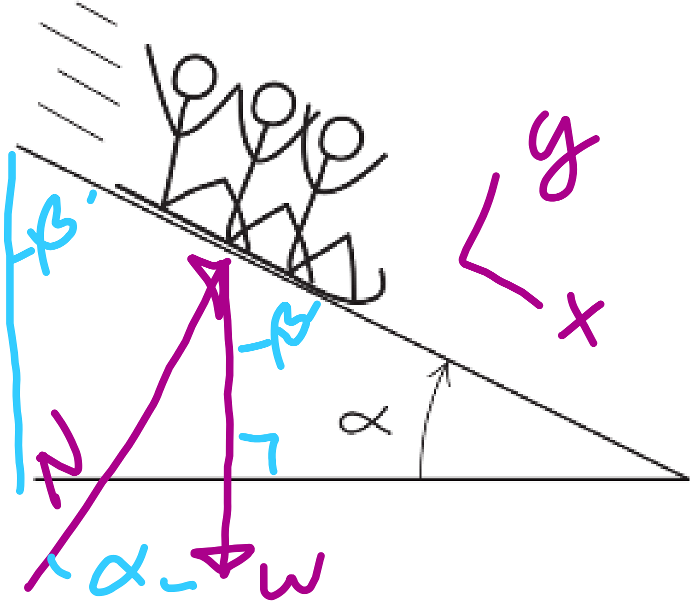

$$\sum F_x = ma_x$$

$$\Rightarrow \quad w_x = a_x m \Rightarrow$$

$$a = \frac{w_x}{m} \Rightarrow a = \frac{w\sin\alpha}{m}$$

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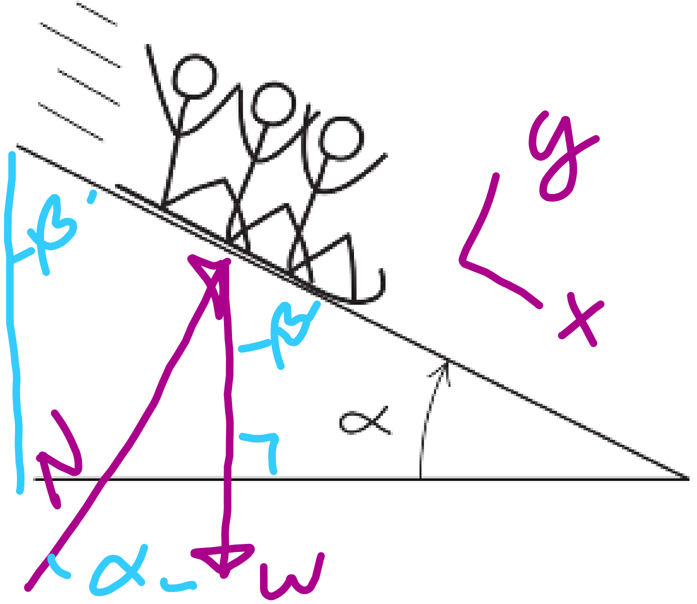

$$\sum F_x = m a_x$$

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$$a = \frac{w_x}{m} \Rightarrow a = \frac{w\sin\alpha}{m}$$ But $w = mg$

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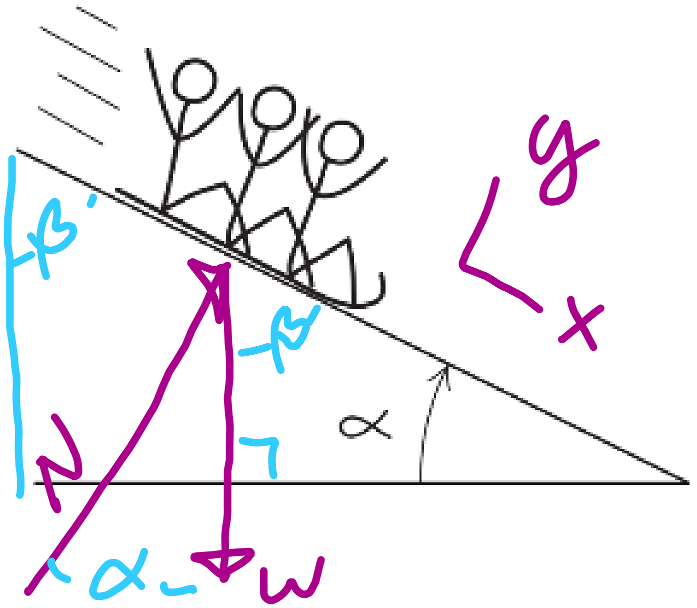

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$$\Rightarrow \quad w_x = a_x m \Rightarrow$$

$$a = \frac{w_x}{m} \Rightarrow a = \frac{w\sin\alpha}{m}$$ But $w = mg$

So $\boxed{a = g\sin\alpha}$

You push a 1.00 kg food tray through the cafeteria line with a constant 9.0 N force. The tray pushes a 0.50 kg milk carton (Fig. 5.14a). The tray and carton slide on a horizontal surface so greasy that friction can be ignored. Find the acceleration of the tray and carton and the horizontal force that the tray exerts on the carton.

You push a 1.00 kg food tray through the cafeteria line with a constant 9.0 N force. The tray pushes a 0.50 kg milk carton (Fig. 5.14a). The tray and carton slide on a horizontal surface so greasy that friction can be ignored. Find the acceleration of the tray and carton and the horizontal force that the tray exerts on the carton.

$m_F = 1kg$

$m_M = 0.5kg$

$P = 9N$

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System

$\Sigma F = ma$

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System

$\Sigma F = ma \Rightarrow P = (m_F + m_M)a$

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System

$$\Sigma F = ma \Rightarrow \quad P = (m_F + m_m)a \Rightarrow$$

$$a = \frac{P}{m_F + m_m}$$

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$M_F = 1 kg$

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System

$$\sum F = ma \Rightarrow \quad P = (M_F + M_M)a \Rightarrow$$

$$a = \frac{P}{M_F + M_M} = \frac{9}{1.5}\left(\frac{m}{s^2}\right)$$

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$m_F = 1kg$
$m_M = 0.5kg$
$P = 9N$

system

$$\Sigma F = ma \Rightarrow P = (m_F + m_M)a \Rightarrow$$

$$a = \frac{P}{m_F + m_M} = \frac{9}{1.5}\left(\frac{m}{s^2}\right) = 6\,m/s^2$$

milk $\Sigma F = ma \Rightarrow F_{F\to m} = m_m a$

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$m_F = 1\,kg$
$m_m = 0.5\,kg$
$P = 9\,N$

System

$$\Sigma F = ma \Rightarrow P = (m_F + m_m)a \Rightarrow$$

$$a = \frac{P}{m_F + m_m} = \frac{9}{1.5}\left(\frac{m}{s^2}\right) = 6\,m/s^2$$

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$$F_{F\to m} = (0.5\,kg)(6\,m/s^2)$$

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$M_F = 1\text{kg}$

$M_M = 0.5\text{kg}$

$P = 9N$

System

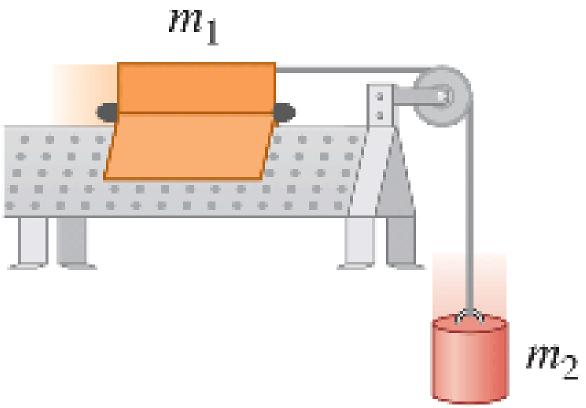
$\Sigma F = ma \Rightarrow P = (M_F + M_M)a \Rightarrow$

$$a = \frac{P}{M_F + M_M} = \frac{9}{1.5}\left(\frac{m}{s^2}\right) = 6\, m/s^2$$

milk $\Sigma F = ma \Rightarrow F_{F \to M} = M_M a \Rightarrow$

$$F_{F \to M} = (0.5\text{kg})(6\, m/s^2) \Rightarrow 3N$$

Figure 5.15a shows an air-track glider with mass m_1 moving on a level, frictionless air track in the physics lab. The glider is connected to a lab weight with mass m_2 by a light, flexible, nonstretching string that passes over a stationary, frictionless pulley. Find the acceleration of each object and the tension in the string.



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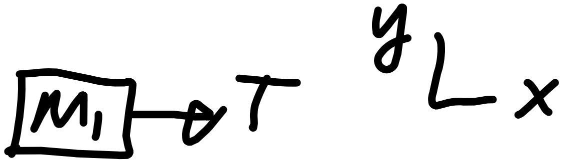

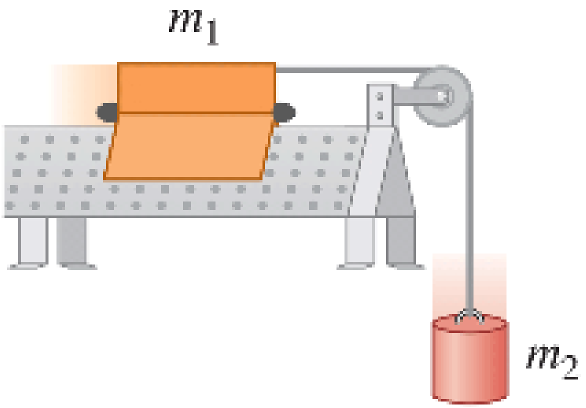

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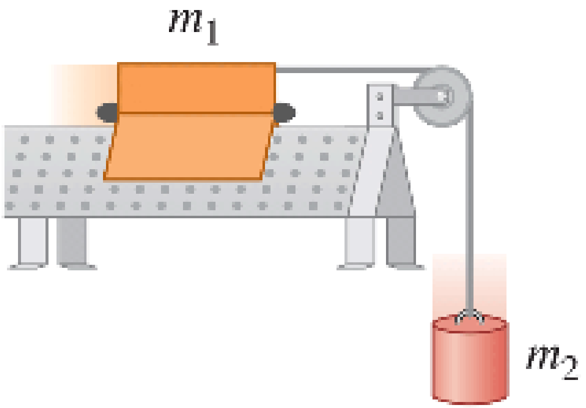

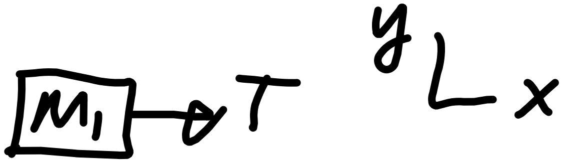

$$F = ma \Rightarrow T = m_1 a$$

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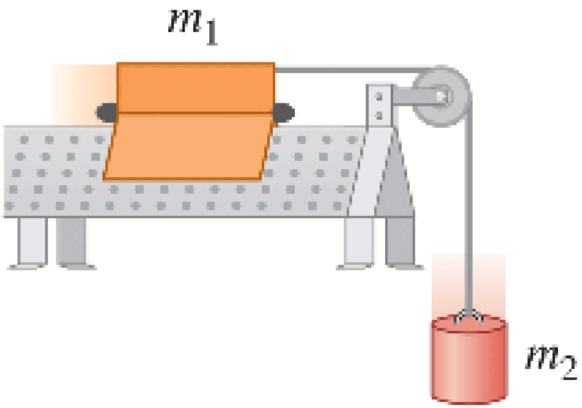

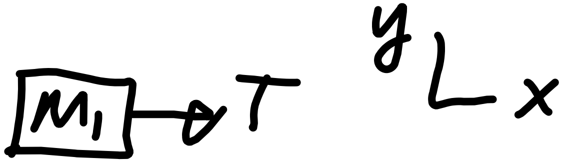

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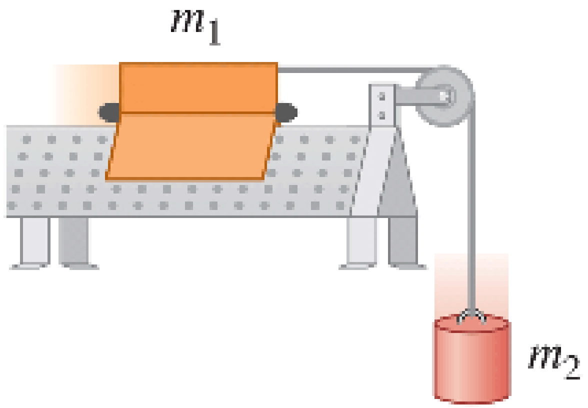

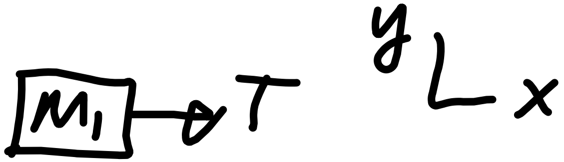

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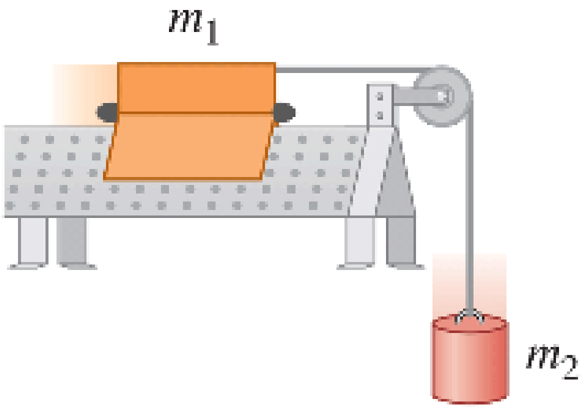

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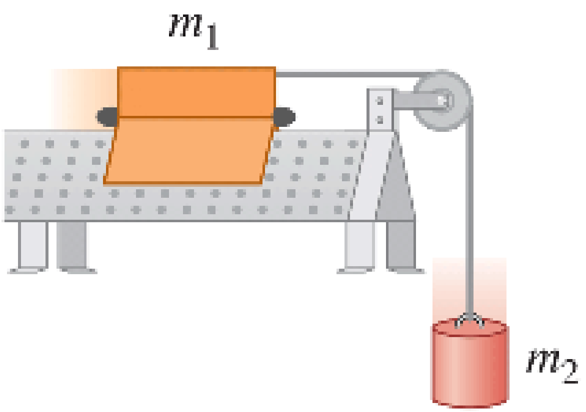

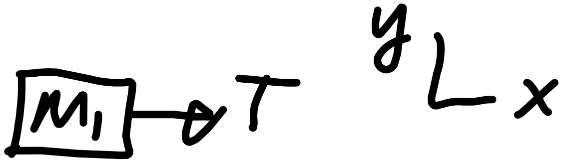

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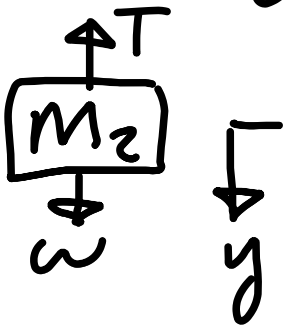

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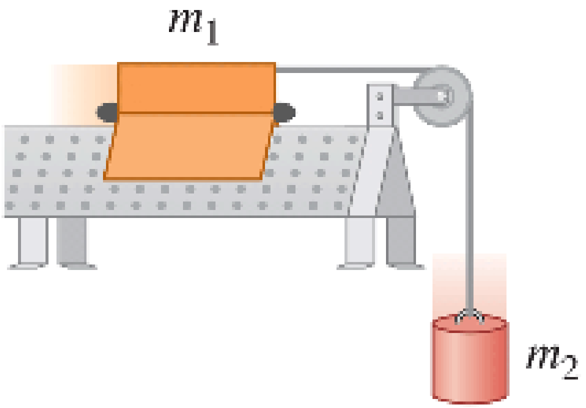

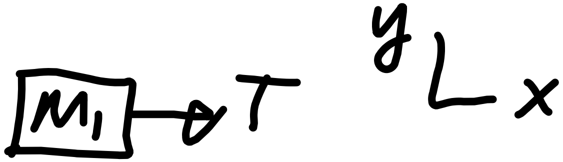

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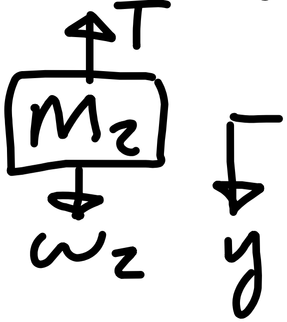

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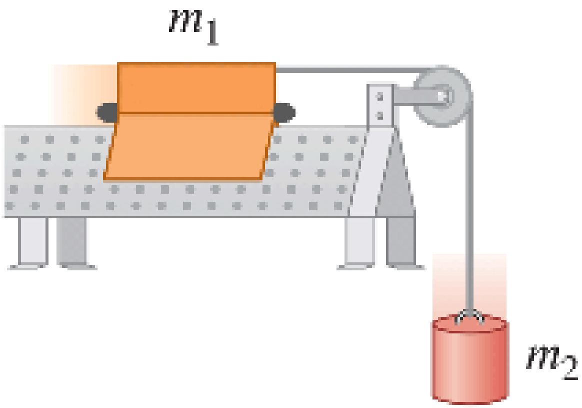

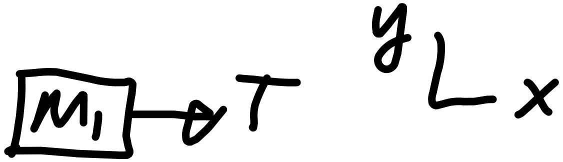

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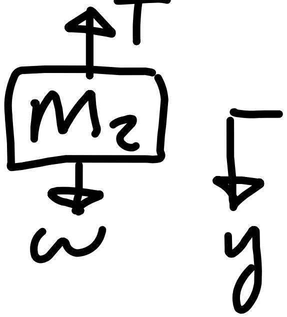

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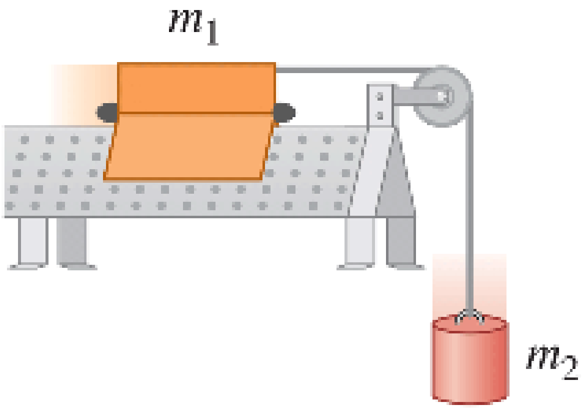

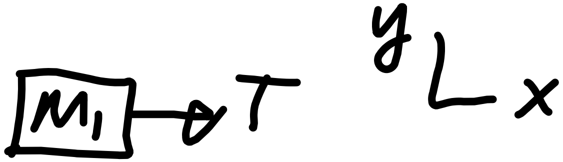

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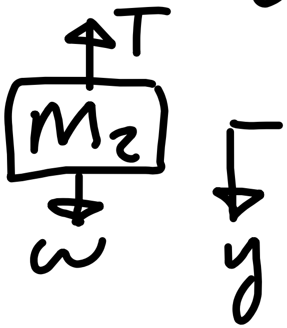

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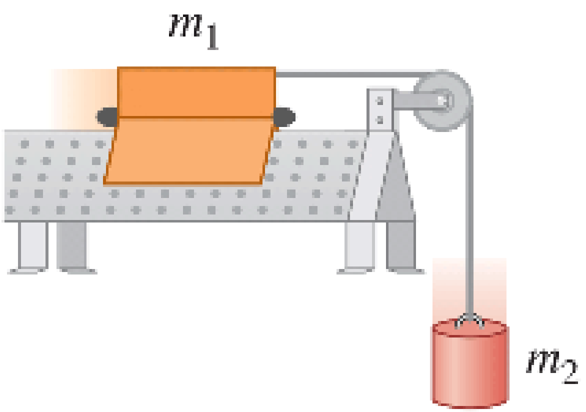

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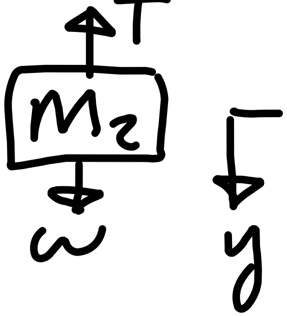

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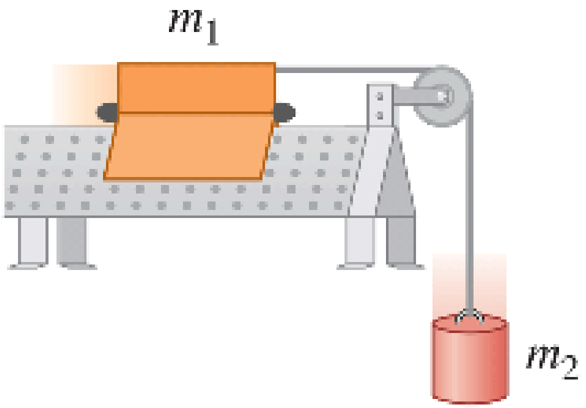

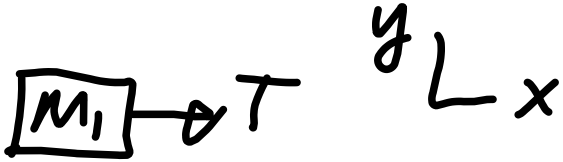

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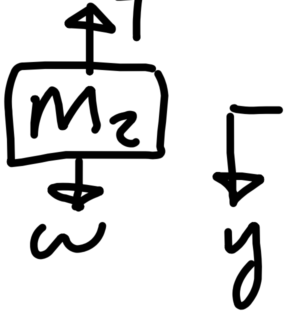

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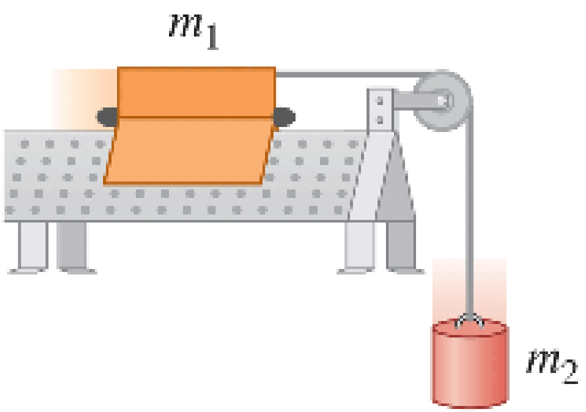

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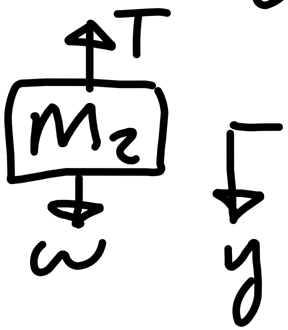

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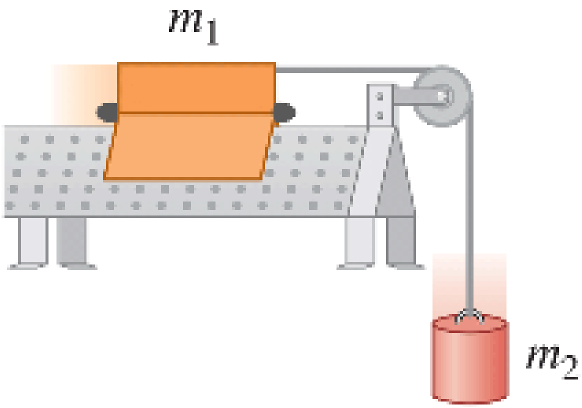

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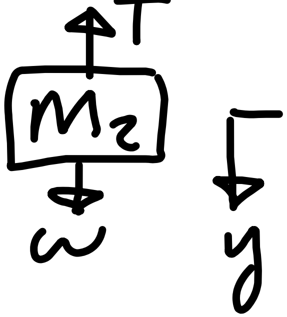

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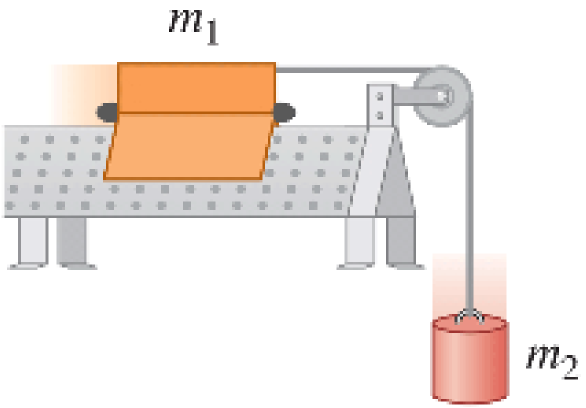

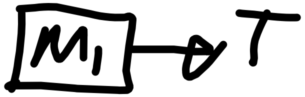

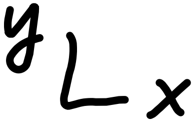

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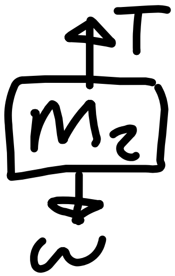

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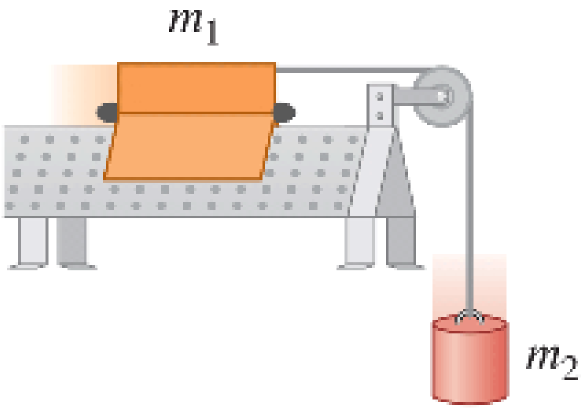

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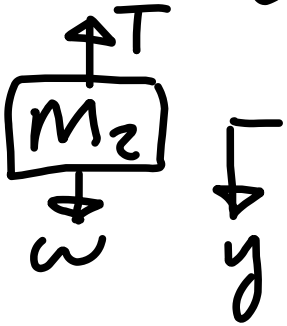

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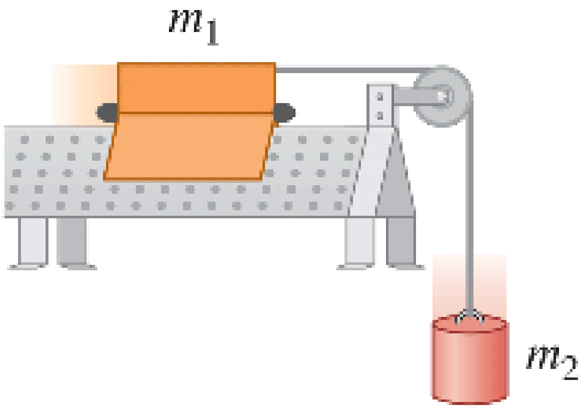

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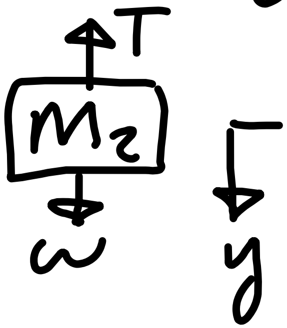

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