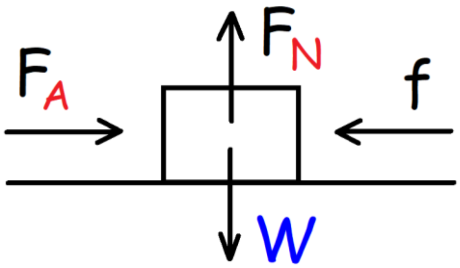
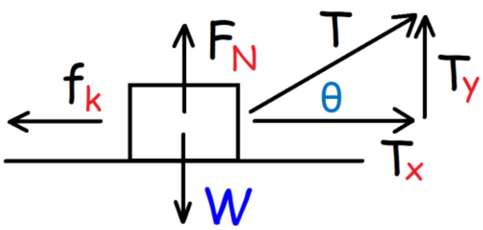
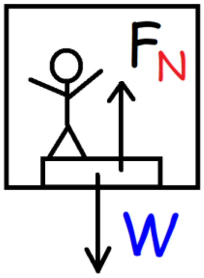
Forces – Formula Sheet:

Newton's 1st Law:	An object at rest will remain at rest and an object in motion will continue in motion unless acted on by a net external force.
Newton's 2nd Law:	$\boldsymbol{F_{net}} = ma$
Newton's 3rd Law:	For every action force, there's an equal and opposite reaction force. $F_{AB} = -F_{BA}$
	**Weight Force:** $\boldsymbol{W} = mg$ **Normal Force:** $\boldsymbol{F_N} = mg$ **Net Force:** $\boldsymbol{F_{net}} = \sum F_x = F_A - f$ $\boldsymbol{F_{net}} = \sum F_y = F_N - W$ **Kinetic Friction:** $\boldsymbol{f_k} = u_k F_N$ **Static Friction:** $\boldsymbol{f_s} \leq u_s F_N$
	**Net Force:** $\boldsymbol{F_{net}} = \sum F_x = T_x - f_k$ $\boldsymbol{F_{net}} = \sum F_y = F_N + T_Y - W$ **Normal Force:** $\boldsymbol{F_N} = mg - T_y$ **Tension Force:** $\boldsymbol{T} = \sqrt{T_x{}^2 + T_y{}^2}$ $\boldsymbol{T_x} = T\cos\theta$ $\boldsymbol{T_y} = T\sin\theta$



The Elevator Problem:

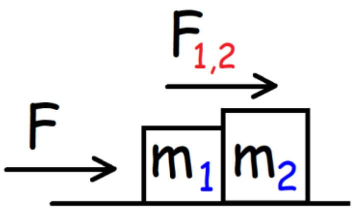
$$\sum \boldsymbol{F_y} = F_N - W$$

$$ma_y = F_N - mg$$

Normal Force:

$$\boldsymbol{F_N} = m(a_y + g)$$

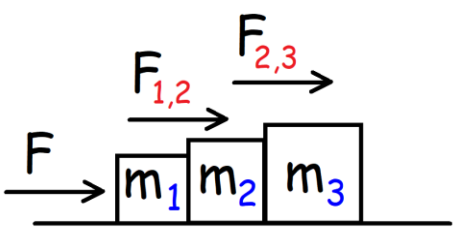
$$g = +9.8\ m/s^2$$



Contact Force: (Without Friction)

$$\boldsymbol{F_{1,2}} = \frac{m_2}{m_T}F$$

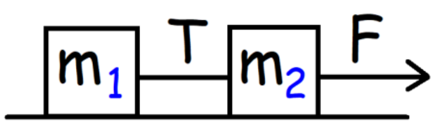
$$\boldsymbol{a} = \frac{F}{m_T} \qquad \boldsymbol{m_T} = m_1 + m_2$$



Contact Force: (Without Friction)

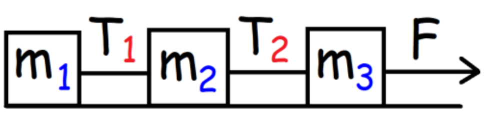
$$\boldsymbol{a} = \frac{F}{m_T} \qquad \boldsymbol{m_T} = m_1 + m_2 + m_3$$

$$\boldsymbol{F_{1,2}} = \frac{m_2 + m_3}{m_T}F \qquad \boldsymbol{F_{2,3}} = \frac{m_3}{m_T}F$$



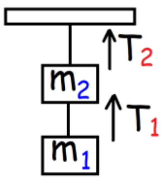
Tension Force:

$$\boldsymbol{T} = \frac{m_1}{m_T}F \qquad \boldsymbol{a} = \frac{F}{m_T} \qquad \boldsymbol{m_T} = m_1 + m_2$$



Tension Force:

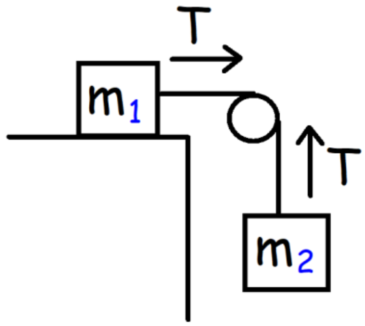
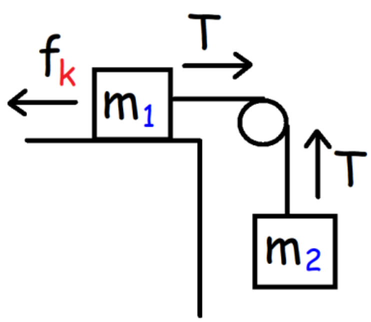
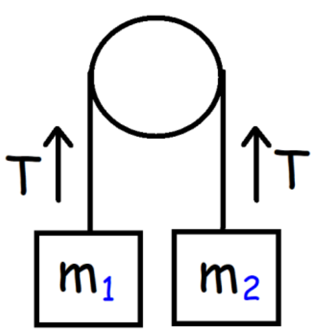
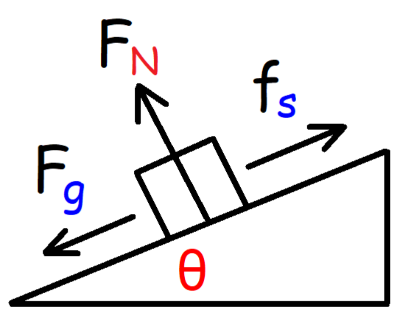
$$\boldsymbol{T_1} = \frac{m_1}{m_T}F \qquad \boldsymbol{T_2} = \frac{m_1 + m_2}{m_T}F$$

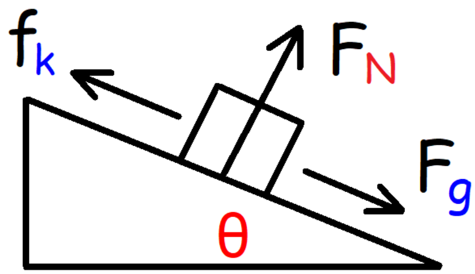


Tension Force:

$$\boldsymbol{T_1} = m_1 g \qquad \boldsymbol{T_2} = (m_1 + m_2)g$$

Note: For examples with friction, see my physics video playlist at ***www.Video-Tutor.net***

 	**Acceleration:** $\boldsymbol{a} = \frac{m_2}{m_T} g \qquad \boldsymbol{m_T} = m_1 + m_2$ **Tension Force:** $\boldsymbol{T} = m_1 a_x \qquad \boldsymbol{T} = m_2(a_y + g)$ $\boldsymbol{a} = \lvert a_x \rvert = \lvert a_y \rvert \qquad \boldsymbol{g} = +9.8\ m/s^2$ **Note:** $a_y = -$ $since\ m_2\ is\ falling\ and\ a_x = +for\ m_1$.
 	**Acceleration:** $\boldsymbol{a} = \frac{m_2 - u_k m_1}{m_T} g \qquad \boldsymbol{m_T} = m_1 + m_2$ **Tension Force:** $\boldsymbol{T} = m_1(a_x + u_k g) \qquad \boldsymbol{T} = m_2(a_y + g)$ $\boldsymbol{a} = \lvert a_x \rvert = \lvert a_y \rvert \qquad \boldsymbol{g} = +9.8\ m/s^2 \qquad a_y = - \qquad a_x = +$
 $\boldsymbol{a_y} = +for\ \boldsymbol{m_1}\ since\ it's\ going\ up.$ $\boldsymbol{a_y} = -\ for\ \boldsymbol{m_2}\ since\ it's\ going\ down.$	**Acceleration:** (If $\mathbf{m_2} > \mathbf{m_1}$) $\boldsymbol{a} = \frac{m_2 - m_1}{m_T} g \qquad \boldsymbol{m_T} = m_1 + m_2$ **Tension Force:** $\boldsymbol{T} = m_1(a_y + g) \qquad \boldsymbol{T} = m_2(a_y + g)$ $\boldsymbol{a} = \lvert a_y \rvert \qquad \boldsymbol{g} = +9.8\ m/s^2$
 	**Minimum Angle Needed for the Box to Begin Sliding:** $\boldsymbol{\theta} = tan^{-1}(u_s)$ $\boldsymbol{f_s} \le u_s F_N$ $\boldsymbol{F_g} = mg\sin\theta \qquad \boldsymbol{F_N} = mg\cos\theta$



Acceleration: (Without Friction)

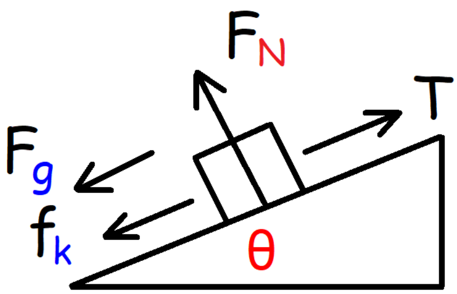
$$\boldsymbol{a} = g\sin\theta$$

Acceleration: (With Friction)

$$\boldsymbol{a_x} = g\sin\theta - u_k g\cos\theta$$

$$\sum F_x = F_g - f_k$$

$$\boldsymbol{F_g} = mg\sin\theta \qquad \boldsymbol{F_N} = mg\cos\theta \qquad \boldsymbol{f_k} = u_k F_N$$

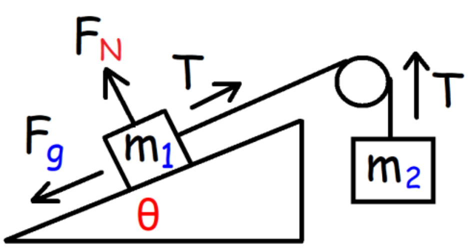


Net Force:

$$\sum \boldsymbol{F_x} = T - f_k - F_g$$

$$ma_x = T - u_k mg\cos\theta - mg\sin\theta$$

Note: f_k will always point opposite to the direction of motion.



$\boldsymbol{m_2 g > m_1 g \sin\theta}$

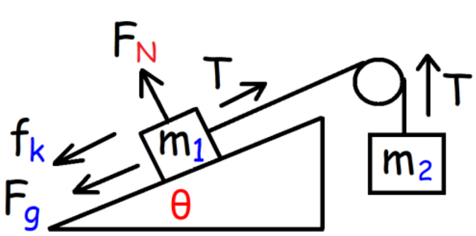
If $\boldsymbol{m_2 g > m_1 g \sin\theta}$ *, the system will move to the right.*

Acceleration: (Without Friction) $\boldsymbol{a} = |a_x| = |a_y|$

$$\boldsymbol{a} = \frac{\sum F_x}{m_T} = \frac{m_2 - m_1\sin\theta}{m_T}g \qquad a = +$$

Tension: (Without Friction) $a_x = +$ *and* $a_y = -$

$$\boldsymbol{T} = m_1(a_x + g\sin\theta) \qquad \boldsymbol{T} = m_2(a_y + g)$$



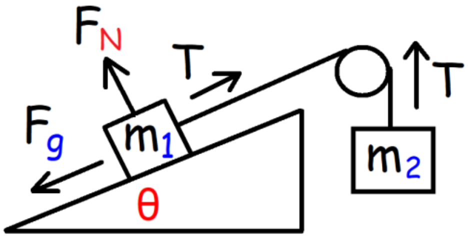
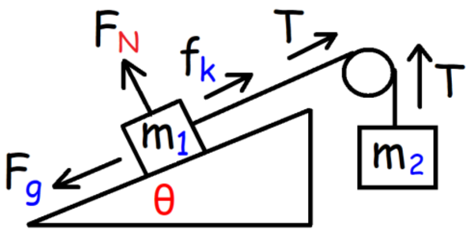
$\boldsymbol{m_2 g > m_1 g \sin\theta}$

Acceleration: (With Friction) $\boldsymbol{a} = |a_x| = |a_y|$

$$\boldsymbol{a} = \frac{\sum F_x}{m_T} = \frac{m_2 - m_1\sin\theta - u_k m_1\cos\theta}{m_T}g$$

Tension: (With Friction) $a_x = +$ *and* $a_y = -$

$$\boldsymbol{T} = m_1(a_x + g\sin\theta + u_k\, g\cos\theta) \qquad \boldsymbol{T} = m_2(a_y + g)$$

 $\boldsymbol{m_2 g < m_1 g \sin\theta}$	$If\ \boldsymbol{m_2 g < m_1 g \sin\theta}, the\ system\ will\ move\ to\ the\ left.$ (a = -) **Acceleration:** (Without Friction) $\boldsymbol{a} = \lvert a_x \rvert = \lvert a_y \rvert$ $\boldsymbol{a} = \frac{\sum F_x}{m_T} = \frac{m_2 - m_1 \sin\theta}{m_T} g \quad a = -$ **Tension:** (Without Friction) $a_x = - \ and \ a_y = +$ $\boldsymbol{T} = m_1(a_x + g\sin\theta) \qquad \boldsymbol{T} = m_2(a_y + g)$
 $\boldsymbol{m_2 g < m_1 g \sin\theta}$	**Acceleration:** (With Friction) $\boldsymbol{a} = \lvert a_x \rvert = \lvert a_y \rvert$ $\boldsymbol{a} = \frac{\sum F_x}{m_T} = \frac{m_2 - m_1 \sin\theta + u_k m_1 \cos\theta}{m_T} g \quad a = -$ **Tension:** (With Friction) $a_x = - \ and \ a_y = +$ $\boldsymbol{T} = m_1(a_x + g\sin\theta - u_k\, g\cos\theta) \qquad \boldsymbol{T} = m_2(a_y + g)$