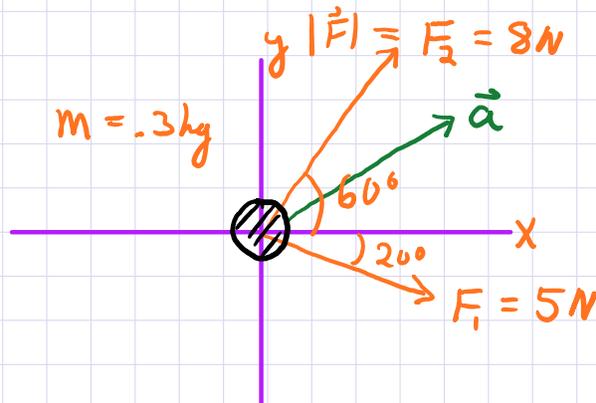
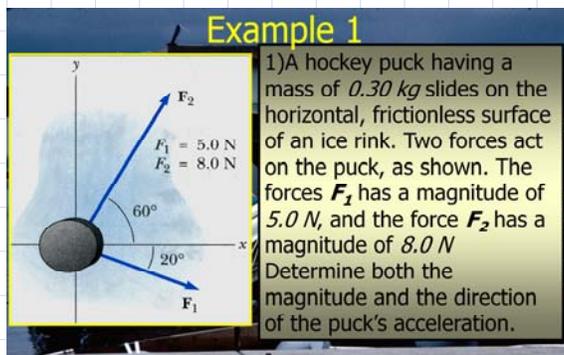


Example 1

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$$\sum \vec{F}_x = m a_x$$

$$F_1 \cos(20^\circ) + F_2 \cos(60^\circ) = m a_x$$

$$a_x = \frac{F_1 \cos(20^\circ) + F_2 \cos(60^\circ)}{m} = \frac{(5\text{ N}) \cos(20^\circ) + (8\text{ N}) \cos(60^\circ)}{0.3\text{ kg}}$$

$$a_x = 28.99 \text{ m/s}^2 \approx 29 \text{ m/s}^2$$

$$\sum F_y = m a_y$$

$$-F_1 \sin(20^\circ) + F_2 \sin(60^\circ) = m a_y$$

$$a_y = \frac{-F_1 \sin(20^\circ) + F_2 \sin(60^\circ)}{m} = \frac{-(5\text{ N}) \sin(20^\circ) + (8\text{ N}) \sin(60^\circ)}{0.3\text{ kg}}$$

$$a_y = 17.4 \text{ m/s}^2$$

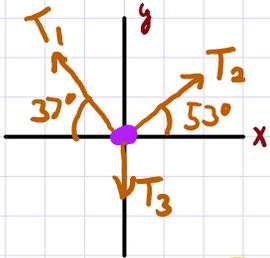
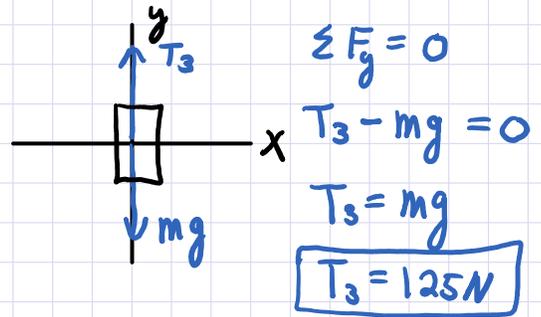
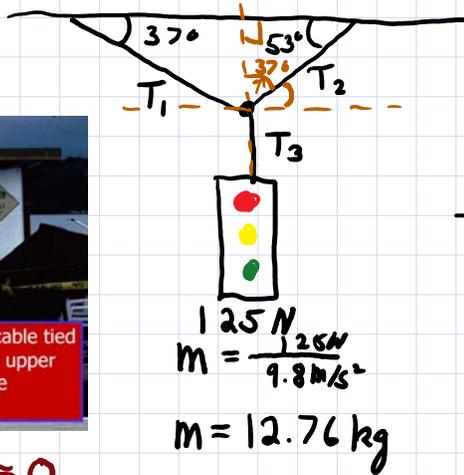
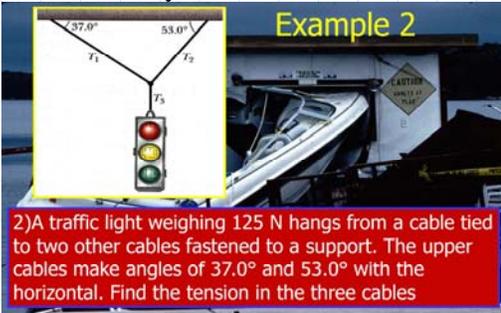
$$|\vec{a}| = \sqrt{a_x^2 + a_y^2} = \sqrt{(29 \text{ m/s}^2)^2 + (17.4 \text{ m/s}^2)^2} = 33.82 \text{ m/s}^2$$

$$\theta = \tan^{-1}\left(\frac{a_y}{a_x}\right) = \tan^{-1}\left(\frac{17.4 \text{ m/s}^2}{29 \text{ m/s}^2}\right) = 30.96^\circ \approx 31^\circ$$

Example 2

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$W = mg$



$\sum F_x = 0$
 $+T_2 \cos(53^\circ) - T_1 \cos(37^\circ) = 0$

$T_2 \cos(53^\circ) = T_1 \cos(37^\circ)$

$T_2 = T_1 \frac{\cos(37^\circ)}{\cos(53^\circ)} = (75.23 N) \frac{\cos(37^\circ)}{\cos(53^\circ)} = \boxed{99.83 N}$

$\sum F_y = 0$
 $+T_1 \sin(37^\circ) + T_2 \sin(53^\circ) - T_3 = 0$

$T_1 \sin(37^\circ) + T_1 \frac{\cos(37^\circ)}{\cos(53^\circ)} \sin(53^\circ) = T_3$

$T_1 \left[\sin(37^\circ) + \frac{\cos(37^\circ)}{\cos(53^\circ)} \sin(53^\circ) \right] = T_3$

$T_1 = \frac{T_3}{\sin(37^\circ) + \frac{\cos(37^\circ)}{\cos(53^\circ)} \sin(53^\circ)}$

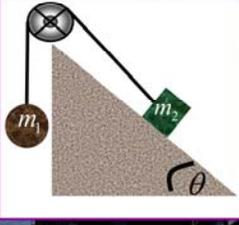
$T_1 = \frac{125 N}{\sin(37^\circ) + \frac{\cos(37^\circ)}{\cos(53^\circ)} \sin(53^\circ)}$

$\boxed{T_1 = 75.23 N}$

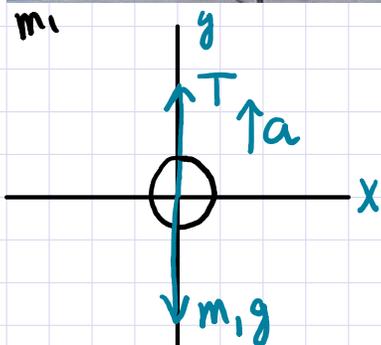
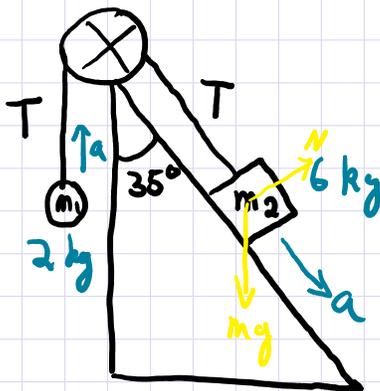
Example 3

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Example 3



3) Two masses are connected by a light string that passes over a frictionless pulley. If the incline is frictionless and if $m_1 = 2.00 \text{ kg}$ and $m_2 = 6.00 \text{ kg}$ and $\theta = 55.0^\circ$, find a) the acceleration of the masses, b) the tension in the string, and c) the speed of each mass 2.0 s after being released from rest.



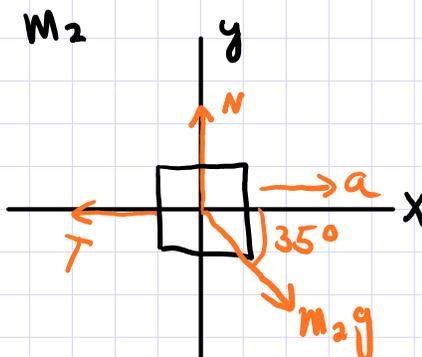
$$\sum F_y = ma_y$$

$$T - m_1 g = m_1 a$$

$$T = m_1 g + m_1 a = m_1 (g + a)$$

$$T = (2 \text{ kg}) (9.8 \text{ m/s}^2 + 3.57 \text{ m/s}^2)$$

$$T = 26.74 \text{ N}$$



$$\sum F_x = ma_x$$

$$m_2 g \cos(35^\circ) - T = m_2 a$$

$$m_2 g \cos(35^\circ) - (m_1 g + m_1 a) = m_2 a$$

$$m_2 g \cos(35^\circ) - m_1 g - m_1 a = m_2 a$$

$$m_1 a + m_2 a = m_2 g \cos(35^\circ) - m_1 g$$

$$a (m_1 + m_2) = m_2 g \cos(35^\circ) - m_1 g$$

$$a = \frac{m_2 g \cos(35^\circ) - m_1 g}{m_1 + m_2} = g \frac{(m_2 \cos(35^\circ) - m_1)}{m_1 + m_2}$$

$$a = (9.8 \text{ m/s}^2) \frac{(6 \text{ kg}) \cos(35^\circ) - (2 \text{ kg})}{8 \text{ kg}}$$

$$a = 3.57 \text{ m/s}^2$$

$$v = v_0 + a t$$

$$v = (3.57 \text{ m/s}^2)(2 \text{ s})$$

$$\sum F_y = 0$$

$$N - m_2 g \sin(35^\circ) = 0$$

$$N = m_2 g \sin(35^\circ)$$

$$v = 7.14 \text{ m/s}$$

Example 4

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Example 4

650 N → 80 kg 110 kg

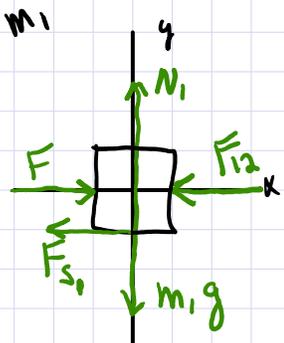
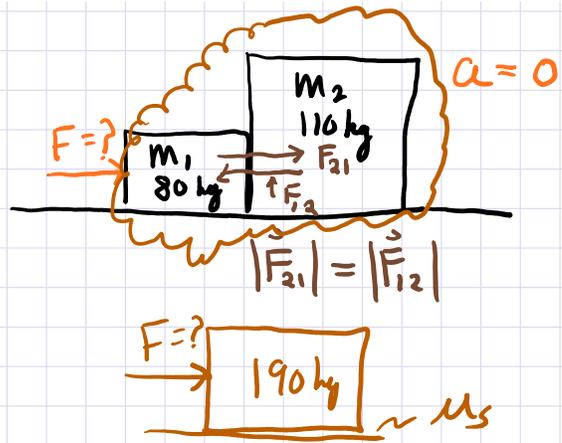
4) Two crates, of mass 80 kg and 110 kg are in contact and at rest on a horizontal surface. $\mu_s = 0.3$

a) What is the maximum force that can be exerted on the 80 kg crate before the crates start to move?

A 650 N force is then exerted on the 80 kg crate. If the coefficient of kinetic friction is 0.20, calculate:

b) The acceleration of the system.

c) The force that each crate exerts on the other.



$F_s = \mu_s N$

$\sum F_y = m a_y$

$N_1 - m_1 g = 0$

$N_1 = m_1 g$

$\sum F_x = m a_x$

$F - F_{12} - F_{s1} = 0$

$F - F_{s2} - F_{s1} = 0$

$F = F_{s2} + F_{s1}$

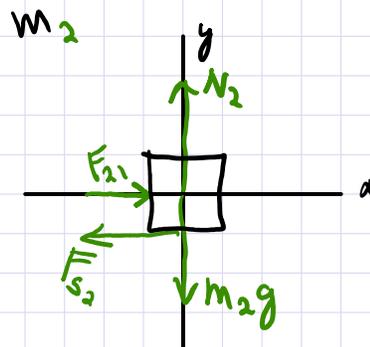
$F = \mu_s N_2 + \mu_s N_1$

$F = \mu_s m_2 g + \mu_s m_1 g$

$F = \mu_s g (m_1 + m_2)$

$F = (0.3)(9.8 \text{ m/s}^2)(190 \text{ kg})$

$F = 558.6 \text{ N}$



$\sum F_y = m a_y$

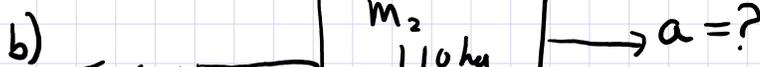
$N_2 - m_2 g = 0$

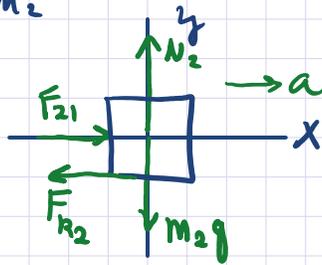
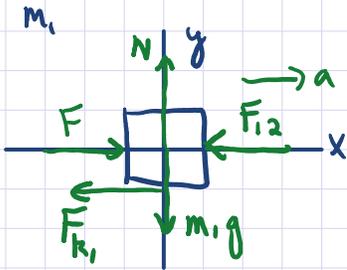
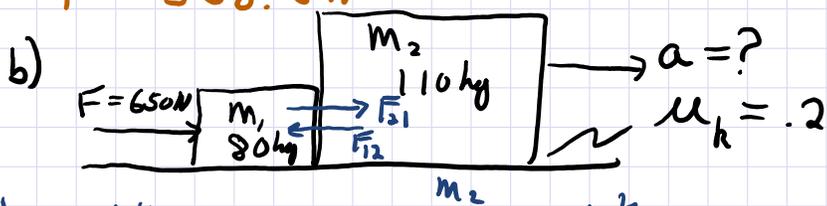
$N_2 = m_2 g$

$\sum F_x = m a_x$

$F_{21} - F_{s2} = 0$

$F_{21} = F_{s2}$





$$\sum F_y = ma_y$$

$$N_2 - m_2 g = 0$$

$$N_2 = m_2 g$$

$$\sum F_y = ma_y$$

$$N - m_1 g = 0$$

$$N = m_1 g$$

$$\sum F_x = ma_x$$

$$F - F_{12} - F_{k1} = m_1 a$$

$$F - (F_{k2} + m_2 a) - F_{k1} = m_1 a$$

$$F - F_{k2} - m_2 a - F_{k1} = m_1 a$$

$$m_1 a + m_2 a = F - F_{k2} - F_{k1}$$

$$a (m_1 + m_2) = F - \mu_k N_2 - \mu_k N_1$$

$$a (m_1 + m_2) = F - \mu_k m_2 g - \mu_k m_1 g$$

$$a = \frac{F - \mu_k m_2 g - \mu_k m_1 g}{(m_1 + m_2)}$$

$$a = \frac{650\text{ N} - (0.2)(9.8\text{ m/s}^2)(190\text{ kg})}{190\text{ kg}}$$

$$a = 1.46\text{ m/s}^2$$

$$\sum F_x = ma_x$$

$$F_{21} - F_{k2} = m_2 a$$

$$F_{21} = F_{k2} + m_2 a$$

$$F_{21} = \mu_k m_2 g + m_2 a$$

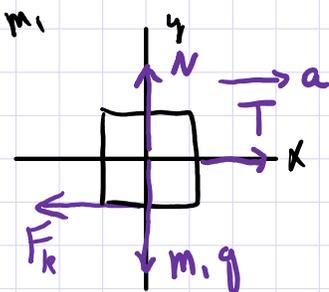
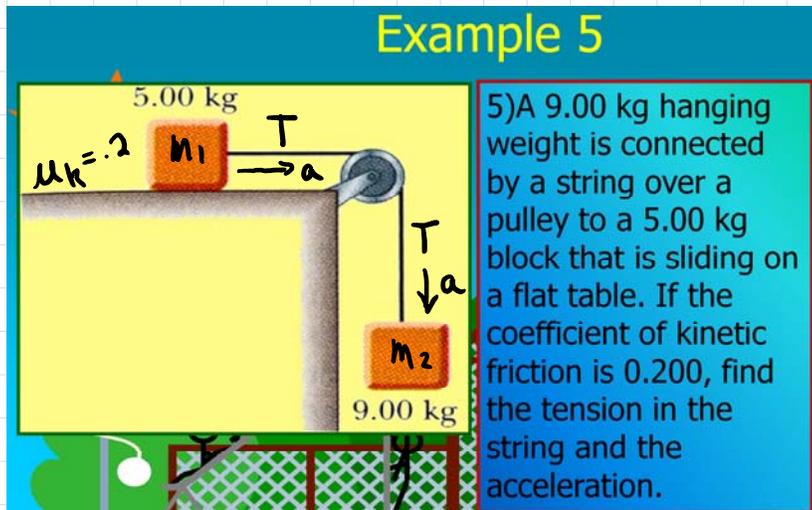
$$F_{21} = (110\text{ kg}) [(0.2)(9.8\text{ m/s}^2) + 1.46\text{ m/s}^2]$$

$$F_{21} = 376.2\text{ N}$$

$$F_k = \mu_k N$$

Example 5

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$$\sum F_y = m_1 a_y$$

$$N - m_1 g = 0$$

$$N = m_1 g$$

$$\sum F_x = m_1 a_x$$

$$T - F_k = m_1 a$$

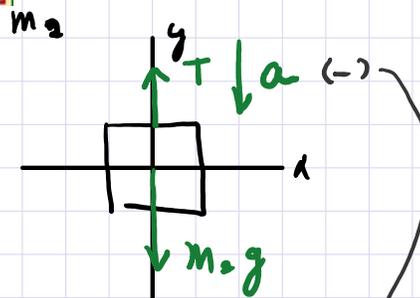
$$m_2 g - m_2 a - F_k = m_1 a$$

$$m_2 g - F_k = m_1 a + m_2 a$$

$$m_2 g - F_k = a(m_1 + m_2)$$

$$a = \frac{m_2 g - F_k}{m_1 + m_2} = \frac{m_2 g - \mu_k N}{m_1 + m_2} = \frac{m_2 g - \mu_k m_1 g}{m_1 + m_2}$$

$$a = g \frac{(m_2 - \mu_k m_1)}{(m_1 + m_2)} = (9.8 \text{ m/s}^2) \frac{[9 \text{ kg} - (.2)(5 \text{ kg})]}{9 \text{ kg} + 5 \text{ kg}}$$



$$\sum F_y = m a_y$$

$$T - m_2 g = -m_2 a$$

$$T = m_2 g - m_2 a$$

$$T = m_2 (g - a)$$

$$T = (9 \text{ kg})(9.8 \text{ m/s}^2 - 5.6 \text{ m/s}^2)$$

$$T = 37.8 \text{ N}$$

$$a = 5.6 \text{ m/s}^2$$

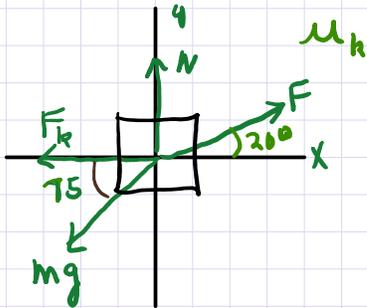
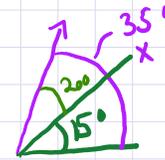
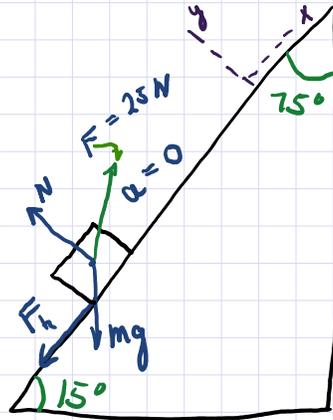
Example 6

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Example 6

6) A boy drags his 60.0 N sled at constant speed up a 15.0° hill. He does so by pulling with 25.0 N force on a rope attached to the sled. If the rope is inclined at 35.0° to the horizontal, a) what is the coefficient of kinetic friction between sled and hill? b) At the top of the hill he jumps on the sled and slides down the hill. What is his acceleration?



$$\sum F_y = 0$$

$$N + F \sin(20^\circ) - mg \sin(75^\circ) = 0$$

$$N = mg \sin(75^\circ) - F \sin(20^\circ) \leftarrow$$

$$\sum F_x = 0$$

$$F \cos(20^\circ) - mg \cos(75^\circ) - F_k = 0$$

$$F \cos(20^\circ) - mg \cos(75^\circ) - \mu_k N = 0$$

$$F \cos(20^\circ) - mg \cos(75^\circ) - \mu_k [mg \sin(75^\circ) - F \sin(20^\circ)] = 0$$

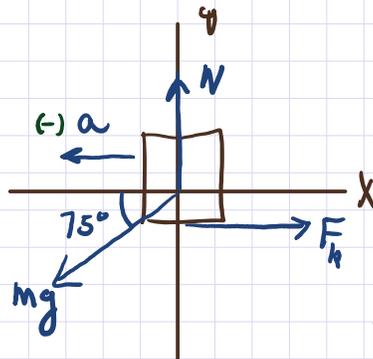
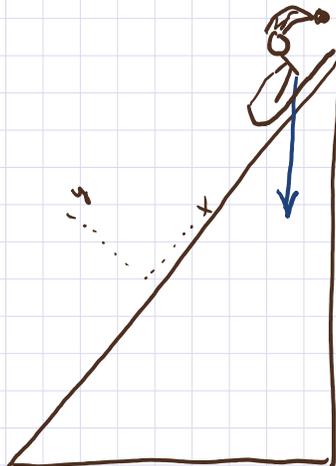
$$\mu_k [mg \sin(75^\circ) - F \sin(20^\circ)] = F \cos(20^\circ) - mg \cos(75^\circ)$$

$$\mu_k = \frac{F \cos(20^\circ) - mg \cos(75^\circ)}{mg \sin(75^\circ) - F \sin(20^\circ)}$$

$$\mu_k = \frac{(25 \text{ N}) \cos(20^\circ) - (60 \text{ N}) \cos(75^\circ)}{(60 \text{ N}) \sin(75^\circ) - (25 \text{ N}) \sin(20^\circ)}$$

$$\mu_k = .16$$

b)



$$\sum F_y = 0$$

$$N - mg \sin(75^\circ) = 0$$

$$N = mg \sin(75^\circ)$$

$$\sum F_x = ma_x$$

$$F_k - mg \cos(75^\circ) = -ma$$

$$\mu_k N - mg \cos(75^\circ) = -ma$$

$$\begin{aligned}\mu_k [mg \sin(75^\circ)] - mg \cos(75^\circ) &= -m/a \\ a &= g [\cos(75^\circ) - \mu_k \sin(75^\circ)] \\ a &= (9.8 \text{ m/s}^2) [\cos(75^\circ) - (0.16) \sin(75^\circ)] \\ a &= 1.02 \text{ m/s}^2\end{aligned}$$