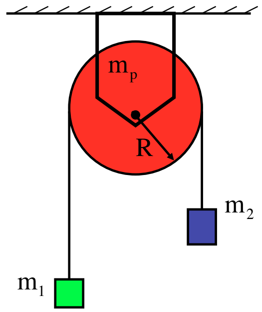
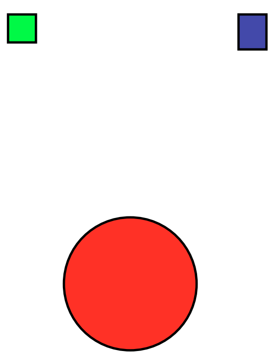
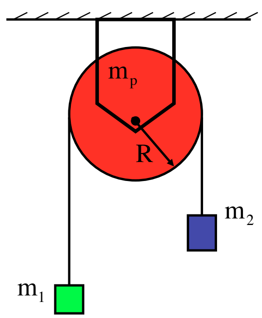
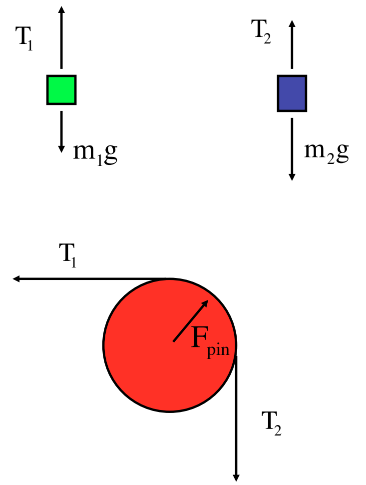
#8.40 a.) Why must the tensions be different? To get a pulley to rotate, it must experience a net torque. If the tensions were the same, each would have torque "TR" with one being positive (i.e., motivating the pulley to angularly accelerate in the counterclockwise direction) and one being negative. If the tensions were the same, in other words, the sum of the two torques would add to zero . . . which they can't . . . so the tensions must not be equal.

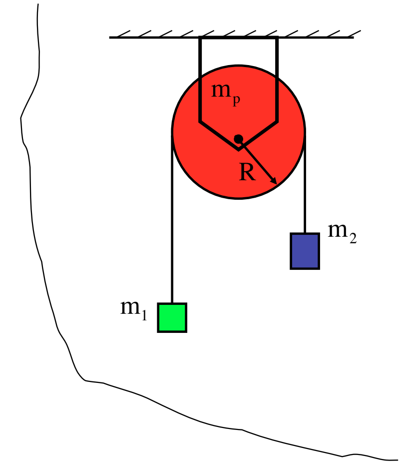


b.) Start with a freebody diagram for each of the bodies in the system.

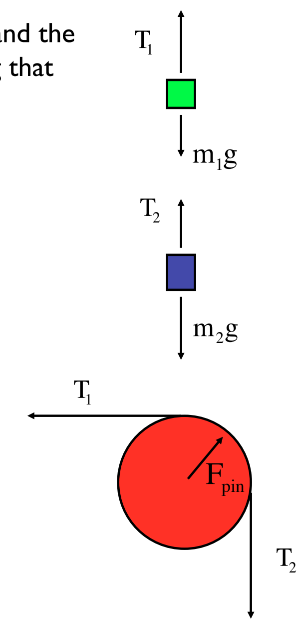








Summing the forces on both hanging masses and the torque on the pulley yields (and remembering that $a = R\alpha$):



Summing the forces on both hanging masses and the torque on the pulley yields (and remembering that $a = R\alpha$):

$\sum F_{y,m_1}$:

$$T_1 - m_1 g = m_1 a$$

$$\Rightarrow \quad T_1 = m_1 g + m_1 a$$

$\sum F_{v,m_2}$:

$$T_2 - m_2 g = -m_2 a$$

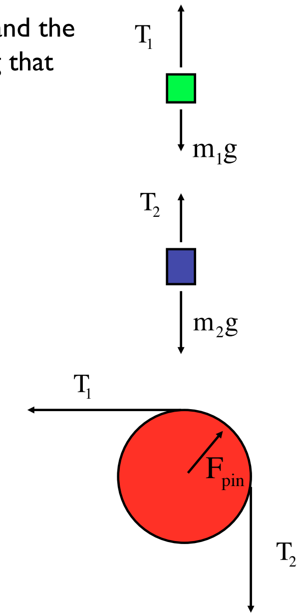
$$\Rightarrow \quad T_2 = m_2 g - m_2 a$$

$\sum \Gamma_{pulley,cm}$:

$$T_1 R - T_2 R = -I_{cm}\alpha$$

$$= -\left(\frac{1}{2}MR^2\right)\left(\frac{a}{R}\right)$$

$$\Rightarrow \quad T_1 - T_2 = -\left(\frac{1}{2}M\right)a$$



Using the equations:

$$T_1 = m_1 g + m_1 a$$

$$T_2 = m_2 g - m_2 a$$

$$T_1 - T_2 = -\left(\frac{1}{2}M\right)a$$

we can write:

$$T_1 \quad - \quad T_2 \quad = -\left(\frac{1}{2}M\right)a$$

$$(m_1 g + m_1 a) - (m_2 g - m_2 a) = -\left(\frac{1}{2}M\right)a$$

$$\Rightarrow \quad a = \frac{m_2 g - m_1 g}{\left(m_1 + m_2 + M/2\right)}$$