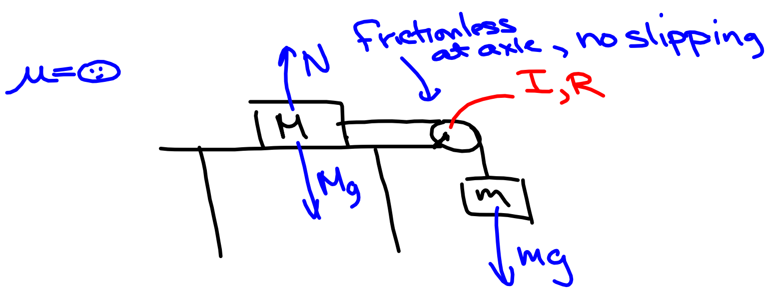
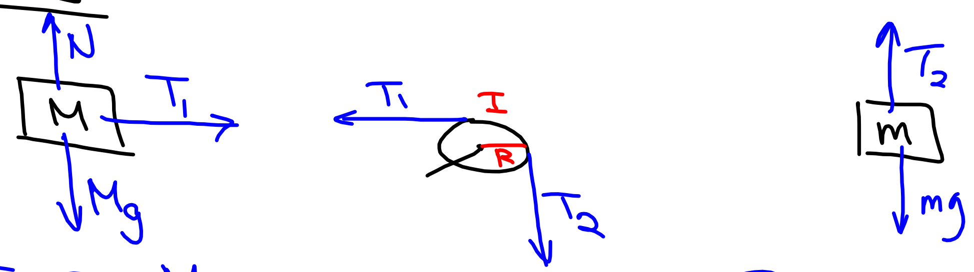
Torque and Pulleys



$$\Sigma F = mg = m a$$?

FBDs



$$\Sigma F = T_1 = Ma$$

$$\Sigma \tau = T_2 R - T_1 R = I\alpha \qquad \Sigma F = mg - T_2 = ma$$

$$(T_2 - T_1)R = I\frac{a}{R}$$

$$T_2 = T_1 + \frac{I}{R^2}a$$

$$\Sigma F = mg - \left(T_1 + \frac{I}{R^2}a\right) = ma$$

$$mg - ma - \frac{I}{R^2}a = T_1$$

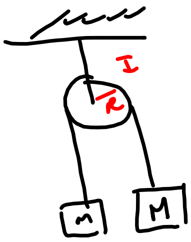
$$mg - ma - \frac{I}{R^2}a = Ma$$

$$mg = \left(m + M + \frac{I}{R^2}\right)a$$

$\Sigma F = \underbrace{\quad}\, a$ ← effective mass of the system

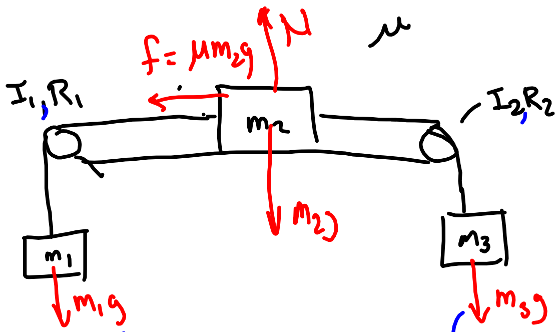
$$a = \frac{mg}{m + M + \frac{I}{R^2}}$$

$\frac{I}{R^2}$ only = mass of pulley if pulley is a point mass or hoop.



$$\Sigma F = (M - m)g = \left(m + M + \frac{I}{R^2}\right)a$$

Show $$a = \frac{M - m}{m + M + I/R^2}\, g$$



assume m_3 is sufficiently large to accelerate the system (m_3 moves downward).

$$\Sigma F = (m_3 - m_1 - \mu m_2) g = \left(m_1 + m_2 + m_3 + \frac{I_1}{R_1^2} + \frac{I_2}{R_2^2}\right) a$$

So
$$a = \frac{m_3 - m_1 - \mu m_2}{m_1 + m_2 + m_3 + \frac{I_1}{R_1^2} + \frac{I_2}{R_2^2}} g$$