**Ex:** Two blocks are connected by a string that passes over a pulley of $R = 5 \text{ cm}$ with $I = 0.0025 \text{ kg} \cdot \text{m}^2$. If $m_1 = 5 \text{ kg}$ and $m_2 = 7 \text{ kg}$, the surface is frictionless, and the system is initially at rest, find the acceleration of the system.

This problem **must** begin by drawing free-body diagrams for all of the relevant systems.

Also realize that we will have to employ both the translational and rotational form of Newton’s $2^{nd}$ law.

\[ \Sigma F = ma \quad \Sigma \tau = I \alpha \]
○ Begin with Newton’s 2\textsuperscript{nd} Law for translations:

\[ \Sigma F_x = m_1 a = T_1 \quad (1) \quad \Sigma F_y = m_2 a = m_2 g - T_2 \quad (2) \]

○ Now use Newton’s 2\textsuperscript{nd} Law for rotations:

\[ \Sigma \tau = I \alpha = RT_2 - RT_1 = I \alpha = I \frac{a}{R} \]

or \[ T_2 - T_1 = \frac{I a}{R^2} \quad (3) \]

**Note:** \( T_2 \) will not equal \( T_1 \) in this example or the pulley would not turn!!

We now have 3 equations for 3 unknowns \( (T_1, T_1, a) \). Solve for \( a \).

\[ a = \frac{m_2 g}{m_1 + m_2 + I/R^2} = \frac{7 \text{ kg} \cdot 9.81 \text{ m/s}^2}{5 \text{ kg} + 7 \text{ kg} + (0.0025 \text{ kg} \cdot \text{m}^2/0.05 \text{ m}^2)} \]

\[ a = 5.28 \text{ m/s}^2 \quad (a_{I=0} = 5.72 \text{ m/s}^2) \]