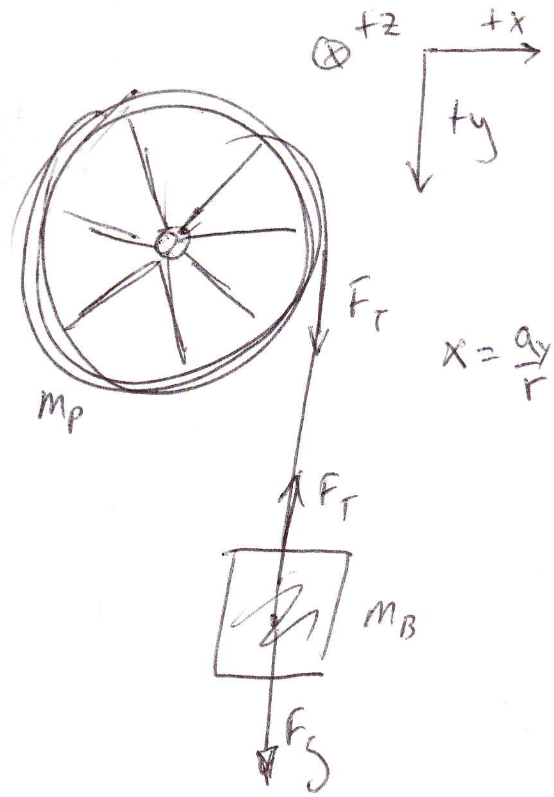

$\alpha = \frac{a_y}{r}$

Kinematics

$\sum \vec{\tau} = I\vec{\alpha}$

$rF_T = I\alpha$

$= I\frac{a_y}{r}$

$F_T = \frac{I}{r^2}a_y = \frac{m_p r^2 a_y}{r^2}$

$F_T = m_p a_y$

$\sum F = m_B a_y$

$F_g - F_T = m_B a_y$

$m_B g - m_p a_y = m_B a_y$

solve for a_y

$a_y = \frac{m_B}{m_p + m_B} g$

units ✓

$m_B \uparrow \; a = g$

$m_p \uparrow \; a = 0$

Assume string is massless

pulley is a ring $I = mr^2$

$$\boxed{\Delta y = \frac{1}{2} a_y t^2}$$

$v_i = 0 \, m/s$

Reasonable?

Compare to object in Free fall

$\sum F = ma$

$-F_g = mg = ma \quad a = -g$

$\Delta y = \frac{1}{2}(-g)t^2$

∴ since $a_y < g$ the bucket will take longer to drop the same distance.

Energy

$m_B g h = \frac{1}{2} m_B v^2 + \frac{1}{2} I \omega^2$

$= \frac{1}{2} m_B v^2 + \frac{1}{2}(m_p r^2)\left(\frac{v}{r}\right)^2$

$m_B g h = \frac{1}{2} v^2 (m_B + m_p)$

$h = \frac{v^2}{2g}\left(\frac{m_B + m_p}{m_B}\right)$

Note: $v_{avg} = \frac{v_i + v_f}{2} = \frac{v}{2} = \frac{h}{t}$

Assume constant acceleration

$h = \left(\frac{2h}{t}\right)^2 \frac{1}{2g}\left(\frac{m_B + m_p}{m_B}\right)$

$$\boxed{h = \frac{1}{2} g t^2 \left(\frac{m_B}{m_B + m_p}\right)}$$

* same result