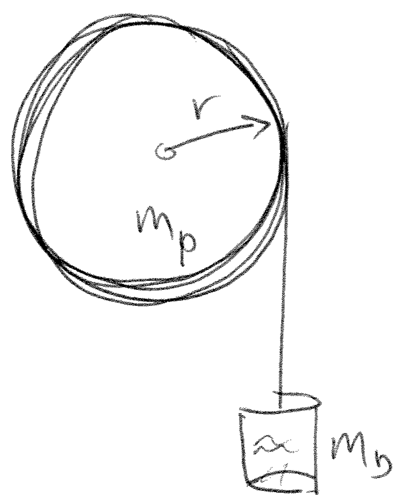
While watching the local TV news show, you see a report about ground water contamination and how it effects farms which get their water from wells. For dramatic effect, the reporter stands next to an old style well which still works by lowering a bucket at the end of a rope into a deep hole in the ground to get water. At the top of the well a single vertical pulley is mounted to help raise and lower the bucket. The thin rope passes over the large pulley which is essentially a heavy steel ring supported by light spokes. To demonstrate the depth of the well, the reporter completely wraps the rope around the pulley and suspends the bucket from one end. She then releases the bucket, at rest near the pulley, and it descends to the bottom of the well unwinding the rope from the pulley as it falls. It takes 9.1 seconds. She doesn't tell you the depth of the well so you decide to calculate it. You estimate that the pulley has a diameter four times the height of the bucket and has a mass that is three times more than the bucket. You also assume that the mass of the rope and any friction can be neglected.



$3m_b = m_p \qquad I_p = m_p r^2 \qquad \omega = \frac{v}{r}$

USE ENERGY CONSERVATION

$m_b g h = \frac{1}{2} m_b v^2 + \frac{1}{2} I_p \omega^2$

$(m_p r^2)\left(\frac{v}{r}\right)^2$

$m_b g h = \frac{1}{2} m_b v^2 + \frac{1}{2} m_p v^2$

Units ☑

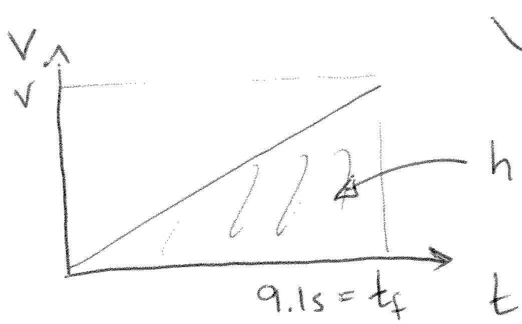
$v\uparrow \quad h\uparrow$ ✓

$m_b \gg m_p \quad h = \frac{v^2}{2g}$ ✓ "free fall"

$m_b \ll m_p \quad h\uparrow$ for same v ✓

$\rightarrow \quad h = \frac{v^2}{g2}\left(\frac{m_b + m_p}{m_b}\right) = \frac{2v^2}{g}$

$3m_b = m_p$



$h = \frac{1}{2} v t$

NOTE: $V_{AVG} = \frac{h}{t}$

[Alternate methods] $V_{AVG} = \frac{1}{2} V$

$h = \Delta x = \frac{1}{2} a t^2$

$a = \frac{v}{t}$

$\frac{2h}{t} = v$

$h = \frac{2}{g}\left(\frac{2h}{t}\right)^2 = \frac{8h^2}{gt^2}$

$h = \frac{gt^2}{8} = \frac{(9.8\frac{m}{s^2})(9.1s)^2}{8}$

$h = 101$ m