3. (10 pts) A light string wrapped around a solid cylinder of mass M and radius R is pulled vertically upward to prevent the cylinder from falling as the string unwinds. (In other words, the spool would unwind and drop to the floor if the hand were not pulling up. As a result of the hand pulling up, the center of mass of the cylinder does not move.) If the cylinder is initially at rest, how much string is unwound after time t?

(a) tR^2/gM.

(b) R^2/t.

**(c) gt^2.

(d) $\frac{1}{2}gt^2$.

Net Force on cylinder $= 0$ (doesn't drop or rise)

$= T - Mg$

or $T = Mg$.

Net torque about the c.m $= TR = I_{cm}\alpha$

or $\alpha = \frac{TR}{I_{cm}} = \frac{MgR}{\frac{1}{2}MR^2} = 2\frac{g}{R}$.

Connect to rate at which angle changes:

$\theta = \theta_0^{\,0} + \omega_0^{\,0} t + \frac{1}{2}\alpha t^2 = \frac{1}{2}\cdot\left(2\frac{g}{R}\right)t^2 = \frac{gt^2}{R}$

But linear amount of string pulled off is θR,

or gt^2