15. (a) The derivation of the acceleration is found in §12-4; Eq. 12-13 gives

$$a_{\text{com}} = -\frac{g}{1 + I_{\text{com}}/MR_0^2}$$

where the positive direction is upward. We use $I_{\text{com}} = 950\,\text{g}\cdot\text{cm}^2$, $M = 120\,\text{g}$, $R_0 = 0.32\,\text{cm}$ and $g = 980\,\text{cm/s}^2$ and obtain

$$|a_{\text{com}}| = \frac{980}{1 + (950)/(120)(0.32)^2} = 12.5\ \text{cm/s}^2\ .$$

(b) Taking the coordinate origin at the initial position, Eq. 2-15 leads to $y_{\text{com}} = \frac{1}{2}a_{\text{com}}t^2$. Thus, we set $y_{\text{com}} = -120\,\text{cm}$, and find

$$t = \sqrt{\frac{2y_{\text{com}}}{a_{\text{com}}}} = \sqrt{\frac{2(-120\,\text{cm})}{-12.5\,\text{cm/s}^2}} = 4.38\ \text{s}\ .$$

(c) As it reaches the end of the string, its center of mass velocity is given by Eq. 2-11: $v_{\text{com}} = a_{\text{com}}t = (-12.5\,\text{cm/s}^2)(4.38\,\text{s}) = -54.8\,\text{cm/s}$, so its linear speed then is approximately 55 cm/s.

(d) The translational kinetic energy is $\frac{1}{2}mv_{\text{com}}^2 = \frac{1}{2}(0.120\,\text{kg})(0.548\,\text{m/s})^2 = 1.8\times10^{-2}\,\text{J}$.

(e) The angular velocity is given by $\omega = -v_{\text{com}}/R_0$ and the rotational kinetic energy is

$$\frac{1}{2}I_{\text{com}}\omega^2 = \frac{1}{2}I_{\text{com}}\frac{v_{\text{com}}^2}{R_0^2} = \frac{1}{2}\frac{(9.50\times10^{-5}\,\text{kg}\cdot\text{m}^2)(0.548\,\text{m/s})^2}{(3.2\times10^{-3}\,\text{m})^2}$$

which yields $K_{\text{rot}} = 1.4$ J.

(f) The angular speed is $\omega = |v_{\text{com}}|/R_0 = (0.548\,\text{m/s})/(3.2\times10^{-3}\,\text{m}) = 1.7\times10^2\,\text{rad/s} = 27\,\text{rev/s}$.