15. (a) The derivation of the acceleration is found in §11-4; Eq. 11-13 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 =120g, R_0 = 0.320 cm and g = 980 cm/s^2 and obtain

$$|a_{\text{com}}| = \frac{980}{1 + (950)/(120)(0.32)^2} = 12.5\ \text{cm/s}^2 \approx 13\ \text{cm/s}^2 .$$

(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_{com} = – 120 cm, and find

$$t = \sqrt{\frac{2y_{\text{com}}}{a_{\text{com}}}} = \sqrt{\frac{2(-120\,\text{cm})}{-12.5\ \text{cm/s}^2}} = 4.38\ \text{s} \approx 4.4\ \text{s}.$$

(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

$$\tfrac{1}{2} m v_{\text{com}}^2 = \tfrac{1}{2}(0.120\ \text{kg})(0.548\ \text{m/s})^2 = 1.8 \times 10^{-2}\ \text{J} .$$

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

$$\frac{1}{2} I_{\text{com}} \omega^2 = \frac{1}{2} I_{\text{com}} \frac{v_{\text{com}}^2}{R_0^2} = \frac{1}{2} \frac{(9.50 \times 10^{-5}\ \text{kg} \cdot \text{m}^2)(0.548\ \text{m/s})^2}{(3.2 \times 10^{-3}\ \text{m})^2}$$

which yields K_{rot} = 1.4 J.

(f) The angular speed is

$$\omega = |v_{\text{com}}| / R_0 = (0.548\,\text{m/s}) / (3.2 \times 10^{-3}\ \text{m}) = 1.7 \times 10^2\ \text{rad/s}\ = 27\,\text{rev/s}.$$