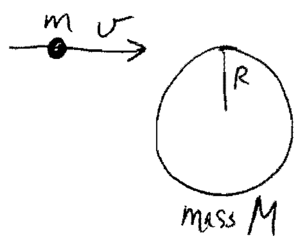
(41) (a)



$L_i = mvR$

$L_f = I\omega \qquad I = \frac{1}{2}MR^2 + mR^2$

$$L_i = L_f \Rightarrow mvR = \left(\frac{1}{2}MR^2 + mR^2\right)\omega$$

$$\omega = \frac{mvR}{\frac{1}{2}MR^2 + mR^2} = \frac{mv}{\frac{1}{2}MR + mR}$$

(b) Work necessary to slow down child when child jumps on to disk; goes into internal energy of disk + child.

(c) Disk doesn't change location (its center of mass doesn't move) so it doesn't contribute to the linear momentum.

For the child, $v_f = \omega R = \frac{mv}{\frac{1}{2}M + m}$

$$\Delta p = p_f - p_i = mv_f - mv = m\left[\frac{mv}{\frac{1}{2}M + m} - v\right] = mv\left(\frac{-\frac{1}{2}M}{\frac{1}{2}M + m}\right)$$

Force exerted on disk by axle changes the linear momentum.

(d) $L_i = I_i\omega_i = \left(\frac{1}{2}MR^2 + mR^2\right)\omega_i$

$L_f = I_f\omega_f = \left(\frac{1}{2}MR^2 + m\left(\frac{R}{2}\right)^2\right)\omega_f$

$$L_i = L_f \Rightarrow \omega_f = \omega_i \frac{\frac{1}{2}MR^2 + mR^2}{\frac{1}{2}MR^2 + m\left(\frac{R}{2}\right)^2} = \omega_i \frac{\frac{1}{2}M + m}{\frac{1}{2}M + \frac{1}{4}m}$$

(e) Child must expend internal energy (chemical energy) to walk inward

(f) Estimate: $R = 1.5\,m$

Suppose the disk is made of steel and is 1cm thick.

$V = \pi R^2 t = \pi(1.5m)^2(.01m) = 0.0707\,m^3$

density of steel $= 8\times10^3\,kg/m^3 \Rightarrow M = 560\,kg$

mass of child ~ 30kg v of child ~ 4 m/s

$$\omega = \frac{(30\,kg)(4\,m/s)}{\left[\frac{1}{2}(560\,kg) + 30\,kg\right]1.5\,m} = 0.25\,\frac{rad}{s} = 0.04\,rev/s$$

(about 25s for 1 revolution - seems about right)

(42)

torque $= rF = (0.2m)(25N) = 5.0\,m\cdot N$

$$\omega = \omega_0 + \frac{\tau}{I}\Delta t$$

$$= 2\,\frac{rad}{s} + \frac{5.0\,m\cdot N}{1.5\,kg\cdot m^2}(0.1\,s)$$

$$= 2.3\ rad/s$$