10-63

\[ \vec{V}_{ic} \rightarrow \quad \theta \]
\[ \vec{V} = 2.0 \]
\[ \vec{V} = 3.5 \]

\[ P_{xi} = P_{xf} \]
\[ m_i V_{ic} = m_z (2.0) \cos \theta + m_i (3.5) \cos (22^\circ) \]
\[ V_{ic} = 2 \cos \theta + 3.5 \cos (22^\circ) \]

\[ P_{yi} = P_{yf} \]
\[ 0 = m_z (2.0) \sin \theta - m_i (3.5) \sin (22^\circ) \]
\[ 2 \sin \theta = 3.5 \sin (22^\circ) \]

solve to get \( \theta = 41^\circ \) and \( V_{ic} = 4.8 \text{ m/s} \)

\[ k_i = \frac{1}{2} m (4.8)^2 \]
\[ k_f = \frac{1}{2} m (2)^2 + (3.5)^2 \]

K.E. not conserved

10-67

\[ \vec{B}_i \rightarrow \vec{A}_i \]
\[ \vec{B}_f \]
\[ \sqrt{2} \]

\[ \vec{P}_{Ai} + \vec{P}_{Bi} = \vec{P}_{Af} + \vec{P}_{Bf} \]
\[ \vec{P}_{Af} = \vec{P}_{Bi} - \vec{P}_{Bf} \]
use the usual Cartesian system:

\[ \vec{P}_{A_f} = (mv, 0) - (0, -\frac{mv}{2}) = mv(1, 0.5) \]

a) Angle of \( \vec{P}_{A_f} \) wrt x-axis is \( \tan^{-1}(\frac{0.5}{1}) = 26.6^\circ \)

b) No. If A is very much more massive than B, then it will have a low final velocity.

The impulses are directed as shown. Because triangle is equilateral, impulses make 30° angle with \( \vec{V}_0 \).

By symmetry considerations, \( \vec{V}_{1f} \) will be parallel or antiparallel to \( \vec{V}_0 \).

\[ P_{ix} = P_{fx} \Rightarrow mv_0 = mv_{1f} + mv_{2f} \cos(30^\circ) \]
\[ + mv_{3f} \cos(30^\circ) \]

By symmetry \( V_{2f} = V_{3f} \)

10 = \( V_{1f} + 2V_{2f} \cos(30^\circ) \)

Cons. of K.E.

100 = \( V_{1f}^2 + 2V_{2f}^2 \)

Solve to get:

\[ V_{1f} = -2.0 \text{ m/s} \text{ (bounces back)} \]

\[ V_{2f} = V_{3f} = 6.93 \text{ m/s } \text{(\( \vec{V}_f \) directed along J's)} \]
11-10 Arrow must be fast enough so it moves 20 cm in a time = \( \frac{T}{8} \) where \( T \) is the time that it takes for the wheel to make 1 rev. It doesn't matter where you aim.

\[ V_{min} = \frac{20 \text{ cm}}{(T/8)} \quad T = \frac{1}{2.5} \text{ sec} \quad V_{min} = 4 \text{ m/s} \]

11-21 \( \Delta \theta = 40 \text{ rev} = 251 \text{ rad} \)
\( \omega_0 = 1.5 \text{ rad/s} \quad \text{and} \quad \omega = 0 \)

(a+b) First find \( \alpha \):

\[ w^2 = \omega_0^2 + 2 \alpha \Delta \theta \]
\[ \alpha = -4.5 \times 10^{-3} \text{ rad/s}^2 \]

Next \( t \):

\[ w = \omega_0 + \alpha t \]
\[ t = 340 \text{ s} \]

(c) Use \( w^2 = \omega_0^2 + 2 \alpha \Delta \theta \) with \( \Delta \theta = 126 \) rad
Get \( w = 1.06 \text{ rad/s} \)

\[ t = (w - \omega_0)/\alpha = 98 \text{ s} \]

(11-42 see below)

11-44 Let \( f \) = # of rev. per sec.
\[ w = \text{# of rad. per sec.} \]

Then \( f = \frac{1}{T} \) also \( f = \frac{w}{2\pi} \)
Thus \( w = \frac{2\pi}{T} \)

(a) \[ \alpha = \frac{dw}{dt} = 2\pi \frac{d(1/T)}{dt} = -2\pi T^{-2} \frac{dT}{dt} \]

\[ = -0.073 \text{ s}^{-2} \left( \frac{s}{y} \right) = -2.3 \times 10^{-9} \text{ rad/s}^2 \]
6. Use \( w = w_0 + \alpha t \) with \( w_0 = \frac{2\pi}{T_0} = \frac{2\pi}{0.033 \text{ s}} \)
get \( t = 26.00 \text{ y} \)

(c) Let \( t = 0 \) now. Want \( w \) for \( t = -9.42 \text{ y} \)
or \( t = -3.0 \times 10^{10} \text{ s} \)
\( w = w_0 - \alpha t \) gives \( w = 259 \text{ s}^{-1} \) or \( T = 0.024 \text{ s} \)

11.42

(a) \( V_1 = wR = w_0 r_A = 150 \text{ cm/s} \)
(b) \( w_B = \frac{V}{r_B} = 15 \text{ rad/s} \)
(c) \( w_B' = w_B = 15 \text{ rad/s} \)
(d) \( V_2 = w_B' r_B' = 75 \text{ cm/s} \)
(e) \( \omega_c = \frac{V_2}{r_c} = 3 \text{ rad/s} \)

11.56
See table 11-2
\[ I_{cm} = \frac{1}{2} M (a^2 + b^2) \]
\[ h = \sqrt{(a/2)^2 + (b/2)^2} \]
\[ I = I_{cm} + M h^2 = \frac{1}{3} M (a^2 + b^2) \]

11.70
\( M = 44,000 \text{ kg} \)
\( I = 8.7 \times 10^4 \text{ kg m}^2 \)
\( R = 2.4 \text{ m} \)
\( \Delta \theta = \frac{\pi}{2} \)
\( t = 30 \text{ sec} \)

\[ T = I \alpha \]
\[ FR = I \alpha \]
\[ \Delta \theta = w_0 t + \frac{1}{2} \alpha t^2 \]
\[ \alpha = \frac{2 \Delta \theta}{t} \]

\[ F = \frac{I\alpha}{R} = \frac{2 I \Delta \theta}{R t^2} = 130 \text{ N} \]

11-76

\( a_t \) of a point on outer edge of pulley = \( \alpha \)

So \( \alpha = \frac{a_t}{R} = \frac{\alpha}{R} = \text{constant} \)

(a) \( \alpha = \frac{2 \theta}{t^2} \) because \( W_o = 0 \)

(b) \( a = R \alpha = \frac{2 \theta R}{t^2} \)

(c) \( T = I \alpha \)

\[ T_1 R - T_2 R = I \alpha \]

Free-body dia. for lower M gives

\[ T_1 - Mg = -Ma \]

\( \theta, a \) are known (see above) so solve 2 eq. for \( T_1, T_2 \) to get:

\[ T_1 = M \left( g - \frac{2 \theta R}{t^2} \right) \]

\[ T_2 = Mg - \frac{2 \theta}{t^2} (RM + \frac{I}{R}) \]