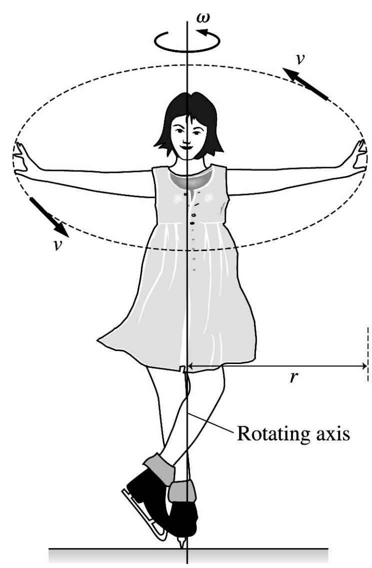
Solutions to HW20, Chapter 12

NOTE! The problems in masteringphysics.com had their numbers altered slightly for each individual student. The solutions below use the same numbers as those used in the book for that problem!

12.2. Model: A spinning skater, whose arms are outstretched, is a rigid rotating body.

Visualize:

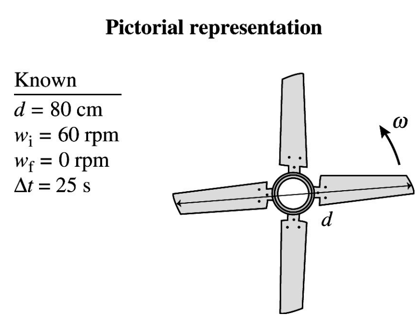


Solve: The speed $v = r\omega$, where $r = 140\text{ cm}/2 = 0.70\text{ m}$. Also, $180\text{ rpm} = (180)2\pi/60\text{ rad/s} = 6\pi\text{ rad/s}$. Thus, $v = (0.70\text{ m})(6\pi\text{ rad/s}) = 13.2\text{ m/s}$.

Assess: A speed of $13.2\text{ m/s} \approx 26\text{ mph}$ for the hands is a little high, but reasonable.

12.3. Model: Assume constant angular acceleration.

Visualize:



Solve: The initial angular velocity is $\omega_i = (60\text{ rpm})\left(\dfrac{2\pi\text{ rad}}{\text{rev}}\right)\left(\dfrac{\text{min}}{60\text{ s}}\right) = 2\pi\text{ rad/s}.$

The angular acceleration is

$$\alpha = \frac{\omega_f - \omega_i}{\Delta t} = \frac{0\text{ rad/s} - 2\pi\text{ rad/s}}{25\text{ s}} = -0.251\text{ rad/s}^2$$

The angular velocity of the fan blade after 10 s is

$$\omega_f = \omega_i + \alpha(t - t_0) = 2\pi\text{ rad/s} + (-0.251\text{ rad/s}^2)(10\text{ s} - 0\text{ s}) = 3.77\text{ rad/s}$$

The tangential speed of the tip of the fan blade is

$$v_t = r\omega = (0.40\text{ m})(3.77\text{ rad/s}) = 1.5\text{ m/s}$$

(b) $\theta_f = \theta_i + \omega_i \Delta t + \frac{1}{2}\alpha(\Delta t)^2 = 0\text{ rad} + (2\pi\text{ rad/s})(25\text{ s}) + \frac{1}{2}(-0.251\text{ rad/s}^2)(25\text{ s})^2 = 78.64\text{ rad}$

The fan turns $78.64\text{ rad} = 12.5\text{ rev} \approx 13\text{ rev}$ while coming to a stop.

12.7. The coordinates of the three masses $m_A, m_B,$ and m_C are (0 cm, 10 cm), (10 cm, 10 cm), and (10 cm, 0 cm), respectively.

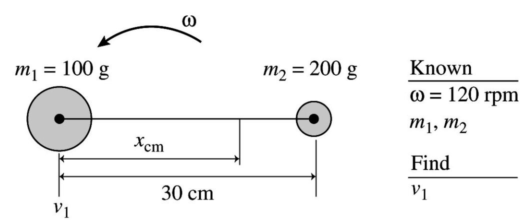
Solve: The coordinates of the center of mass are

$$x_{cm} = \frac{m_A x_A + m_B x_B + m_C x_C}{m_A + m_B + m_C} = \frac{(200\text{ g})(0\text{ cm}) + (300\text{ g})(12\text{ cm}) + (100\text{ g})(12\text{ cm})}{(200\text{ g} + 300\text{ g} + 100\text{ g})} = 8.0\text{ cm}$$

$$y_{cm} = \frac{m_A y_A + m_B y_B + m_C y_C}{m_A + m_B + m_C} = \frac{(200\text{ g})(0\text{ cm}) + (300\text{ g})(10\text{ cm}) + (100\text{ g})(0\text{ cm})}{(200\text{ g} + 300\text{ g} + 100\text{ g})} = 5.0\text{ cm}$$

12.8. Model: The balls are particles located at the ball's respective centers.

Visualize:



Solve: The center of mass of the two balls measured from the left hand ball is

$$x_{cm} = \frac{(100\text{ g})(0\text{ cm}) + (200\text{ g})(30\text{ cm})}{100\text{ g} + 200\text{ g}} = 20\text{ cm}$$

The linear speed of the 100 g ball is

$$v_1 = r\omega = x_{cm}\omega = (0.20\text{ m})(120\text{ rev/min})\left(\frac{2\pi\text{ rad}}{\text{rev}}\right)\left(\frac{\text{min}}{60\text{ s}}\right) = 2.5\text{ m/s}$$

12.15. Model: The three masses connected by massless rigid rods are a rigid body.

Solve: (a)

$$x_{cm} = \frac{\sum m_i x_i}{\sum m_i} = \frac{(0.100\text{ kg})(0\text{ m}) + (0.200\text{ kg})(0.06\text{ m}) + (0.100\text{ kg})(0.12\text{ m})}{0.100\text{ kg} + 0.200\text{ kg} + 0.100\text{ kg}} = 0.060\text{ m}$$

$$y_{cm} = \frac{\sum m_i y_i}{\sum m_i} = \frac{(0.100\text{ kg})(0\text{ m}) + (0.200\text{ kg})\left(\sqrt{(0.10\text{ m})^2 - (0.06\text{ m})^2}\right) + (0.100\text{ kg})(0\text{ m})}{0.100\text{ kg} + 0.200\text{ kg} + 0.100\text{ kg}} = 0.040\text{ m}$$

(b) The moment of inertia about an axis through A and perpendicular to the page is

$$I_A = \sum m_i r_i^2 = m_B(0.10\text{ m})^2 + m_C(0.10\text{ m})^2 = (0.100\text{ kg})[(0.10\text{ m})^2 + (0.10\text{ m})^2] = 0.0020\text{ kg m}^2$$

(c) The moment of inertia about an axis that passes through B and C is

$$I_{BC} = m_A\left(\sqrt{(0.10\text{ m})^2 - (0.06\text{ m})^2}\right)^2 = 0.00128\text{ kg m}^2 \approx 0.0013\text{ kg m}^2$$

Assess: Note that mass m_A does not contribute to I_A, and the masses m_B and m_C do not contribute to I_{BC}.