1. What is the momentum of a 540g raven traveling at 23.5 m/s?

\[ p = m \cdot v = 0.540 \text{ kg} \left( 23.5 \frac{\text{m}}{\text{s}} \right) = 12.7 \frac{\text{kg} \cdot \text{m}}{\text{s}} \]

2. An 85.0 kg astronaut in space throws a 12.0 kg oxygen tank away from himself. If the recoil speed of the astronaut is 1.82 m/s, what was the velocity given to the oxygen tank??

\[ 0 = m_1 v_1 + m_2 v_2 \quad v_1 = -\frac{m_2 v_2}{m_1} = -\frac{(85.0 \text{ kg})(1.82 \frac{\text{m}}{\text{s}})}{12.0 \text{ kg}} = -12.9 \frac{\text{m}}{\text{s}} \]

3. A 0.250 kg baseball traveling at 50.0 m/s is caught in a fielder’s mitt. If the ball takes 0.0498 seconds to come to a stop in the mitt, what average force was exerted on the ball?

\[ J = F \Delta t = \Delta p \quad F = \frac{m \Delta v}{\Delta t} = \frac{0.250 \text{ kg} \left( 50.0 \frac{\text{m}}{\text{s}} \right)}{0.0498 \text{ s}} = 251 \text{ N} \]

4. A 4.0 kg ball traveling to the right at 7.2 m/s collides with a 6.6 kg ball traveling in the opposite direction at 5.0 m/s. What is the velocity of the second ball (the 6.6 kg one) after the collision if the first ball ends up travelling at –8.9 m/s?

\[ m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2' \quad v_2' = \frac{m_1 v_1 + m_2 v_2 - m_1 v_1'}{m_2} \]

\[ v_1' = \frac{(4.0 \text{ kg})(7.2 \frac{\text{m}}{\text{s}}) + (6.6 \text{ kg})(-5.0 \frac{\text{m}}{\text{s}})}{6.6 \text{ kg}} - (4.0 \text{ kg})(-8.9 \frac{\text{m}}{\text{s}}) = 4.8 \frac{\text{m}}{\text{s}} \]

5. A planet is attracted to the sun with a certain force. If the distance from the sun to the planet is reduced by one half, what would happen to the force? It would be 4 times greater!

6. Astronauts in the space shuttle in orbit experience weightlessness. Does this mean that there is no gravity in space? Explain what is going on. They have mass the Earth has mass and there is a distance between their center of gravities, therefore we can calculate the gravity between them. However, they appear weightless because they are constantly falling, its just their tangential speed is so great that the fall and the rate the surface of the Earth is curving.

7. You weigh 625 N on earth. What would you weigh on Venus? Venus' mass is 4.88 x 10^{24} kg and it has a radius of 6.07 x 10^{6} m.

\[ w = mg \quad m = \frac{w}{g} = 625 \text{ kg} \cdot \text{m} \left( \frac{1}{9.8 \frac{\text{m}}{\text{s}^2}} \right) = 63.78 \text{ kg} \]

\[ F = G \frac{m_1 m_2}{r^2} = \left( 6.67 \times 10^{-11} \frac{\text{kg} \cdot \text{m}^2}{\text{s}^2} \right) \left( \frac{63.78 \text{ kg}}{9.8 \frac{\text{m}}{\text{s}^2}} \right) \left( 4.88 \times 10^{24} \text{ kg} \right) \left( 6.07 \times 10^{6} \text{ m} \right)^2 = 56.3 \times 10^4 = 563 \text{ N} \]

8. Neptune is 4.50 x 10^{12} m from the sun. The sun's mass is 1.99 x 10^{30} kg. Neptune’s mass is 1.03 x 10^{26} kg. (a) What is the orbital velocity of this distant planet? (b) What is its period in units of years?

\[ \frac{m_1 v^2}{r^3} = G \frac{m_1 m}{r^2} \quad v^2 = \frac{G m_1 r^3}{m_2} \left( \frac{1.99 \times 10^{30} \text{ kg}}{4.50 \times 10^{12} \text{ m}} \right) \left( \frac{1.03 \times 10^{26} \text{ kg}}{2.950 \times 10^7 \text{ m}^2/\text{s}^2} \right) \]

\[ v = \sqrt{29.50 \times 10^6 \frac{\text{m}^2}{\text{s}^2}} = 5.43 \times 10^3 \frac{\text{m}}{\text{s}} \]
9. A 126 g ball rests on the edge of a table as shown in the drawing. A second ball of the same mass attached to a piece of string swings into the first ball and collides with it head on. The second ball ends up at rest after the collision. Find: (a) the speed of the swinging ball just before it collides with the resting ball, (b) the kinetic energy of the swinging ball just before it strikes the at rest ball, (c) the time it will take the second ball to fall to the deck, (d) the distance x the second ball travels before it hits, and (e) the kinetic energy of the ball just before it hits the deck.

(a) \( \frac{1}{2}m v^2 = mgh \) \( \frac{1}{2}v^2 = g(l-\cos \theta) \) \( v = \sqrt{2g(l-\cos \theta)} \)

\[ v = \sqrt{2 \left( 9.8 \frac{m}{s^2} \right) \left( 0.75 m - (0.75 m) \cos 12^\circ \right) } = 0.567 \frac{m}{s} \]

(b) \( K = \frac{1}{2}mv^2 = \frac{1}{2} \left( 0.125 \text{ kg} \right) \left( 0.567 \frac{m}{s} \right)^2 = 0.0201 \text{ J} \)

(c) \( y = \frac{1}{2}at^2 \) \( t = \sqrt{\frac{2y}{a}} = \sqrt{2 \left( \frac{0.95 \text{ m}}{9.8 \frac{m}{s^2}} \right) } = 0.440 \text{ s} \)

(d) \( m_2v_2 = m_1v_1' \) \( v_1' = \frac{m_2v_2}{m_1} \) \( m_1 = m_2 \) so \( v_1' = v_2 \)

\[ x = vt = 0.567 \frac{m}{s} \left( 0.44 \text{ s} \right) = 0.249 \text{ m} \]

(e) \( K_{bot} = U_{top} + K_{top} = mgh + K_{top} \)

\[ K_{bot} = \left( 0.125 \text{ kg} \right) \left( 9.8 \frac{m}{s^2} \right) \left( 0.95 m \right) + 0.0201 \text{ J} = 1.18 \text{ J} \]

10. A 1.2 kg stone is attached to a 1.1 m line and swung in a circle. If it has a linear speed of 13 m/s, what is the centripetal force?

\[ a_c = \frac{v^2}{r} \] \( F = ma \) \( F_c = \frac{mv^2}{r} = \frac{1.2 \text{ kg} \left( 13 \frac{m}{s} \right)^2}{1.1 \text{ m}} = 180 \text{ N} \]
11. A space station is designed to simulate gravity by spinning at a constant angular velocity. The plan is for the thing to simulate half of the earth’s gravitational force by spinning at 5.0 rpm. What radius does the station need to have?

\[ a_c = \frac{1}{2} g \quad \text{and} \quad a_c = \frac{v^2}{r} \quad \Rightarrow \quad v = \frac{x}{t} = \frac{5}{t} (2\pi r) \quad \text{so} \quad a_c = \frac{\left( \frac{5}{t} (2\pi r) \right)^2}{r} = \frac{25}{t^2} \left( 4\pi^2 r^2 x \right) \left( \frac{1}{x} \right) = 100 \frac{\pi^2 r^2}{t^2} \]

\[ \frac{1}{2} g = 100 \frac{\pi^2 r^2}{t^2} \quad \Rightarrow \quad r = \frac{gt^2}{2(100)\pi^2} = \frac{9.8 \frac{m}{s^2}}{2(100)\pi^2} \left( \frac{60 \frac{s}{1 \text{ min}}}{} \right)^2 = 18 \text{ m} \]

12. A 1250 kg car is traveling at a constant speed and makes a turn with a radius of 350.0 m. Its speed is 45.0 m/s. Find the minimum coefficient of friction needed to keep the car traveling along the path.

\[ a_c = \frac{v^2}{r} \quad F = ma \quad F_c = \frac{mv^2}{r} = \frac{1250 \text{ kg} \left( \frac{45 \text{ m}}{s} \right)^2}{350 \text{ m}} = 7232 \text{ N} \]

\[ f = \mu n \quad \mu = \frac{f}{n} = \frac{7232 \text{ N}}{1250 \text{ kg} \left( 9.8 \frac{m}{s^2} \right)} = \frac{7232 \text{ N}}{12250 \text{ N}} = \boxed{0.590} \]

\[ a_c = \frac{v^2}{r} \quad F = ma \quad F_c = \frac{mv^2}{r} \quad f = \mu n = \mu mg = \frac{mv^2}{r} \quad \mu = \frac{v^2}{rg} = \frac{\left( \frac{45 \text{ m}}{\text{ s}} \right)^2}{350 \text{ m} \left( 9.8 \frac{\text{ m}}{\text{ s}^2} \right)} = \boxed{0.590} \]