Momentum and Impulse Practice

1. The momentum of an object is 56 $\frac{kg \cdot m}{sec}$.

   a. What is the velocity of the object if it has mass of 2.0 kg?

$$p = mv \rightarrow \frac{p}{m} = v \rightarrow \frac{56\ kg \cdot m / sec}{2.0\ kg} = 28\ m/s$$

   b. What is the mass of the object if it has velocity of 7.0 m/s?

$$\frac{p}{v} = m \rightarrow \frac{56\ kg \cdot m/sec}{7.0\ m/s} = 8.0\ kg$$

2. A 1200 kg car is travelling at 75 **km/hr** along a highway. What is the momentum of the car? [1000 m = 1 km, 3600 sec = 1 hr]

$$75\ km/hr \times \frac{1000\ m}{1\ km} \times \frac{1\ hr}{3600\ sec} = 20.83\ m/s$$

$$p = mv = 1200\ kg \times 20.83\ m/s = 24996\ kg \cdot m/sec$$

$$= 25000\ kg \cdot m/sec$$

3. Two objects (A and B) has the some momentum, but object A is travelling twice as fast as object B. How are the masses of the objects related?

$$m_A v_A = m_B v_B \qquad v_A = 2 v_B$$

$$m_A (2 v_B) = m_B v_B$$

$$2 m_A = m_B$$

mass of B is twice mass of A

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4. A 5.5 kg object accelerates from rest at 8.3 m/s^2. What is its momentum after 3.0 seconds?

$\Delta v = at = \left(8.3\frac{m}{s^2}\right)(3.0\,sec) = 24.9\,m/s$

$p = mv = 5.5kg \times 24.9\frac{m}{s} = 136.95\,\frac{kg\cdot m}{sec}$

$= 140\,\frac{kg\cdot m}{sec}$

5. An object has 56 J of kinetic energy.
   a. What is its momentum if it has velocity of 1.0 m/s?

$56J = \frac{1}{2}mv^2$

$\frac{2\times 56J}{v^2} = m \rightarrow 112\,kg = mass$

$momentum = m \times v = 112kg \times 1.0\frac{m}{s} = 110\,\frac{kg\,m}{s}$

   b. What is its momentum if it has velocity of 2.0 m/s?

$\frac{2\times 56J}{2^2} = m \rightarrow 28\,kg = mass$

$p = mv = 28kg \times 2.0\frac{m}{s} = 56\,\frac{kg\,m}{s}$

6. An object has momentum of 650 $\frac{kg\cdot m}{sec}$. What is the kinetic energy of the object if it has mass of 25 kg?

$p = 650\,\frac{kg\,m}{s} = mv \rightarrow v = \frac{650\,\frac{kg\cdot m}{sec}}{25kg} = 26\frac{m}{s}$

$E_K = \frac{1}{2}mv^2 = \frac{1}{2}(25)(26)^2$

$= 8450J \approx 8500J$

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7. A 0.500 kg ball is thrown straight up into the air at 12.3 m/s. What is the momentum of the ball 1.0 seconds after being thrown?

$V_0 = 12.3 m/s$

$a = -9.8 m/s^2$

$V_f = ?$

$V_f = V_0 + at$

$V_f = 2.5 m/s$

$p = mv = 0.5 kg \times 2.5 m/s = 1.25 \frac{kg \cdot m}{s}$

$\simeq 1.3 \frac{kg \cdot m}{s}$

8. A 112 kg football player is running down the field at 3.6 m/s.

a) What impulse must a tackler make in order to stop the football player?

$\Delta v = -3.6 m/s$ $\quad \Delta p = m \Delta v = 112 kg \times -3.6 m/s$

$= -403.2 \frac{kg \cdot m}{s}$

$\simeq -4.0 \times 10^2 \frac{kg \cdot m}{s}$

or 4.0×10^2 N·s

b) What force must the tackler exert to stop the player in 0.20 s?

$\frac{403.2 N \cdot s}{0.20 sec} = 2016 N \simeq \boxed{2.0 \times 10^3 N}$

in opposite direction to runner

c) What force must the tackler exert to stop the player in 4.0 s?

$\frac{403.2 N \cdot s}{4.0 sec} = 100.8 N \simeq \boxed{1.0 \times 10^2 N}$

in opposite direction to runner

9. A 0.20 kg ball rolls at 2.5 m/s, it hits a wall and rebounds back at 2.5 m/s. What is the impulse imparted by the wall on the ball?

Velocity changes from 2.5 m/s toward wall to 2.5 m/s away from wall,

$\Delta v = 5.0\ m/s$ away from wall

$\Delta p = m\Delta v = 0.20\ kg \times 5.0\ m/s$

$= 1.0\ \frac{kg \cdot m}{s}$ or $1.0\ N \cdot s$ away from wall

10. A puck of mass 0.20 kg is sliding along a smooth, flat section of ice at 18 m/s when it hits some snow. After 2.5 s of sliding through the snow, it returns to smooth ice travelling at 9.2 m/s.

a. What impulse is exerted on the puck by the snow?

$\Delta p = m\Delta v = 0.20\ kg\ (9.2\ m/s - 18\ m/s)$

$= -1.76\ \frac{kg \cdot m}{sec}$

$= -1.8\ N \cdot s$

b. What average force does the snow exert on the puck?

$F = \frac{\Delta p}{t} =$ [illegible] $=$

$= \frac{-1.76\ N \cdot s}{2.5\ sec} = -0.704\ N = 0.70\ N$ against direction of puck

c. What is the coefficient of friction between the snow and the puck?

$F_{Fric} = \mu F_N \rightarrow \frac{F_{Fric}}{F_N} = \mu$

$\frac{0.704}{mg} = \frac{0.704}{0.2\ kg \cdot 9.8\ m/s^2}$

$= 0.36$

11. A 56 kg person jumps from a height of 1.3 m, when they land they bend their knees, taking 0.24 seconds to slow to a stop. What is the force acting on them while they slow to a stop?

Part 1: Find velocity it hits the ground at

Use $V_f^2 = V_0^2 + 2ad$

to find V_f

$V_f = -5.048\ m/s$

↑ negative because it is moving down

$V_0 = 0$

$d = -1.3m$

$a = -9.8\ m/s^2$

$V_f = ?$

Part 2: Find Force during stop

$\Delta p = m\Delta v$

$= 56(0 - (-5.048\ m/s))$

$= 282.688\ N \cdot s$ up

$F = \frac{\Delta p}{t} = \frac{282.688}{0.24} = 1177.87\ N$

$\approx (1200\ N)$

12. The terminal velocity of a falling human is about 55 m/s. If a 65 kg sky driver were falling at that speed, and hit a net which slows them to a stop in 2.0 seconds, how much force would they experience?

Velocity changes from 55 m/s down to 0

so change is 55 m/s upwards

$\Delta p = m\Delta v = 65kg \times 55 m/s$

$= 3575\ \frac{kg \cdot m}{sec}$

$F = \frac{\Delta p}{t} = \frac{3575\ \frac{kg \cdot m}{sec}}{2.0 sec} = 1787.5\ N$

$= (1800\ N)$

13. A baseball player can hit a ball with about 3.0×10^4 N of force. This changes the ball from travelling 35 m/s towards the player to 45 m/s away from the player. How long was the ball in contact with the bat?

$\Delta v =$ from 35 m/s towards to 45 m/s away

$= 80$ m/s away

$\Delta p = mv = 0.142\text{ kg} \times 80\text{ m/s}$

$= 11.36\text{ N}\cdot\text{s}$

$\Delta p = Ft$

$\frac{\Delta p}{F} = t \rightarrow \frac{11.36\text{ N}\cdot\text{s}}{3.0\times10^4\text{ N}} = 0.00038\text{ sec}$

$= 3.8\times10^{-4}\text{ sec}$