Science 20 Unit B - Physics

Momentum

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POS Checklist:

- ☐ define momentum as a vector quantity equal to the product of the mass and velocity of an object ($p = mv$).

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what does it mean to be

conserved?

defn: Things that are conserved cannot be created or destroyed.

things that are conserved:

- Energy
- matter
- momentum!

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what do you

know about momentum?

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Momentum

"Is the product of mass and velocity."

$$\vec{p} = m\vec{v}$$

where:

m = mass (kg)
$\vec{v}$ = velocity (m/s)
$\vec{p}$ = momentum (kgm/s)

All objects in motion have momentum.

Momentum is a vector quantity.

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Practice Problems (From Handout):

1. While stepping off a skateboard, the rider propels the skateboard with a velocity of 2.50 m/s [N]. If the mass of the skateboard is 2.2 kg, calculate the momentum of the skateboard.

$\vec{p} = m\vec{v}$ $\vec{p} = (2.2\,kg)(2.5\,\frac{m}{s}) = 5.5\,kgm/s$

2. A 900 kg car has a momentum of 1.35 x 10^4 kgm/s [E]. Calculate the velocity of the vehicle.

$\vec{p} = m\vec{v}$ $1.35 \times 10^4\,kg\frac{m}{s} = (900\,kg)\vec{v}$ $\vec{v} = 15\,m/s$

3. A ball thrown with a velocity of 32.0 m/s [W] has a momentum of 4.5 kgm/s [W]. What is the mass of the ball?

$\vec{p} = m\vec{v}$ $-4.5\,kg\frac{m}{s} = m(-32\,m/s)$ $m = 0.141\,kg$

West = negative!

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Momentum and Newton's Second Law

Our old friend Newton had momentum in mind when he penned his famous second law:

$$\vec{F} = m\vec{a}$$

"a net force causes acceleration"

Newton found a way to connect forces to momentum.

$$\vec{F} = m\vec{a}$$

"a net force causes acceleration"

some math

$$\vec{F} = \frac{\Delta \vec{p}}{\Delta t}$$

This means that any change in momentum causes a change in force, or vice-versa.

We now have two equations to calculate momentum:

$$\vec{p} = m\vec{v}$$

or

$$\vec{p} = \vec{F}\Delta t$$

4. A water balloon with a mass of 4.00 kg is dropped from a window. The balloon reaches a velocity of 31.3 m/s just before striking the ground.

a) Determine the momentum of the balloon just before it strikes the ground.

$\vec{p} = m\vec{v}$ $\vec{p} = (4\,kg)(-31.3\,m/s) = -125\,kg\frac{m}{s}$

b) If the velocity of the balloon is 0 upon striking the ground, determine the change in momentum of the balloon.

$\Delta\vec{p} = \vec{p}_F - \vec{p}_i = -125\,kg\frac{m}{s} - 0\,kg\,m/s = -125\,kg\frac{m}{s}$

c) If the impact with the ground took 0.011 s, calculate the force exerted by the ground on the balloon.

$\Delta\vec{p} = \vec{F}\Delta t$ $-125\,kg\frac{m}{s} = \vec{F}(0.011\,s)$

$\vec{F} = 11363\,N$

$= 1.14 \times 10^4\,N$

5. A 2000 kg car traveling 25 m/s strikes a tree and comes to rest. If the impact took 0.23 s, determine the force exerted on the car.

step 1: $\vec{p} = m\vec{v}$

$= (2000\,kg)(25\,m/s)$

$= 50000\,kg\,m/s$

step 2: $\Delta\vec{p} = \vec{F}\Delta t$

$50000\,kg\,m/s = \vec{F}(0.23\,s)$

$\vec{F} = 2.2 \times 10^5\,N$

6. A 500 g rubber ball is thrown at a velocity of 5.00 m/s and strikes a wall. After only 0.25 s, the ball rebounds straight back with a velocity of -4.50 m/s. Calculate the force exerted on the ball.

Omit during covid-19!

Next: Impulse