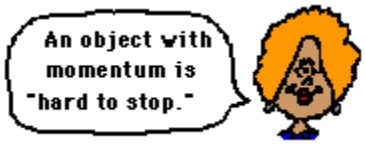
NAME:_____

U3:L2 Impulse and Momentum



Momentum is a commonly used term in sports. When a sports announcer says that a team has the momentum they mean that the team is *really on the move* and is going to be hard to stop

Momentum can be defined as "mass in Motion."

All objects have mass; so if an object is moving, then it has momentum - it has its mass in motion.

The amount of momentum that an object has is dependent upon two variables: how much stuff is moving and how fast the *stuff* is moving.

"Speed with direction"

Momentum depends upon the variables MASS and VELOCITY

In terms of an equation, the momentum of an object is equal to the mass of the object times the velocity of the object.

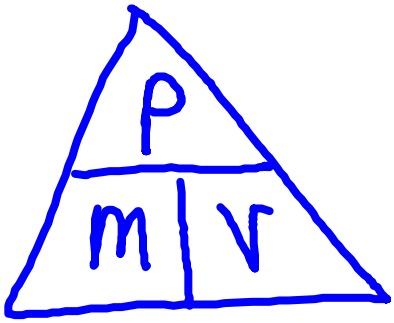
$$\text{momentum} = \text{mass} \times \text{velocity}$$

In physics, the symbol for the quantity momentum is the lower case p. Thus, the above equation can be rewritten as

$$p = m \times v$$

The equation illustrates that momentum is directly proportional to an object's mass and directly proportional to the object's velocity.

This means...



$$p = m \times v$$

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

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

The term *momentum* is a physics concept. Any object with momentum is going to be hard to stop.

To stop such an object, it is necessary to apply a FORCE *against* its motion for a given period of time.

The more momentum that an object has, the harder that it is to stop.

It would require a greater amount of force or a longer amount of time (or both!) to bring such an object to a halt.

As the force acts upon the object for a given amount of time, the object's velocity is changed; and hence, the object's momentum is changed.

$$F=ma \quad \text{AND} \quad F=m\frac{v}{t}$$

If both sides of the above equation are multiplied by the quantity t, a new equation results.

$$F \times t = m \times v$$ momentum

In physics, the quantity $F \times t$ is known as IMPULSE

And since the quantity m•v is the momentum, the quantity $m \times v$ must be the change in momentum

The equation really says that the:

Impulse = Change in Momentum

In a collision, objects experience an impulse; the impulse causes and is equal to the change in momentum.

Consider a football halfback running down the football field and encountering a collision with a defensive back. The collision would change the halfback's speed and thus his momentum.

Examples:

1. A 0.50-kg cart (#1) is pulled with a 1.0-N force for 1 second; another 0.50 kg cart (#2) is pulled with a 2.0 N-force for 0.50 seconds.

a) Which cart (#1 or #2) has the greatest acceleration? Explain.

① $m = 0.5\,kg$, $F = 1\,N$, $t = 1\,s$

$F = m \times a$

$a = \frac{F}{m} = \frac{1\,N}{0.5\,kg}$

$a = 2\,m/s^2$

② $m = 0.5\,kg$, $F = 2\,N$, $t = 0.5\,s$

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

$a = \frac{2\,N}{0.5\,kg}$

$a = 4\,m/s^2$

b) Which cart (#1 or #2) has the greatest impulse? Explain.

Fxt

① $1N \times 1s$

$1\,N \cdot s$

② $2N \times 0.5s$

$1\,N \cdot s$

c) Which cart (#1 or #2) has the greatest change in momentum? Explain.

Both the same

2. A hockey player applies an average force of 80.0 N to a 0.25 kg hockey puck for a time of 0.10 seconds. Determine the impulse experienced by the hockey puck.

Fxt

$80.0N \times 0.10s = 8\,N \cdot s$

3. If a 5-kg object experiences a 10-N force for a duration of 0.10-second, then what is the momentum change of the object?

$m = 5kg$

$F = 10N$

$t = 0.1s$

Fxt

$10N \times 0.1s$

$1\,N \cdot s$

momentum = m x v

4. What is the momentum of Patrick Mahomes (104 kg) running at 6.98 m/s?

p = m x v

p = 104 kg x 6.98 m/s

p = 725.92 N·s

5. What is the momentum of Travis Kelce (118 kg) running at 9.21 m/s?

p = m x v

p = 118 kg x 9.21 m/s

p = 1086.78 N·s

6. What is the momentum of Tom Brady (102 kg) hitting someone at 7.14 m/s?

p = m x v p = 102 kg • 7.14 m/s

p = 728.28 N·s

7. What is the momentum of a punch thrown by MMA fighter Kabib Nurmagomedov (78 kg) at 19.2 m/s?

p = 78 kg x 19.2 m/s

p = 1497.6 N·s

8. What is the momentum of Connor McDavid (88 kg) hitting the boards at 8 m/s ?

p = m x v

p = 88 kg • 8 m/s

p = 704 N·s

9. What is the momentum of Sidney Crosby (91 kg) hitting Connor McDavid at 5.6 m/s?

p = m x v

p = 91 kg x 5.6 m/s

p = 509.6 N·s