Linear Momentum and Impulse

SYLL. STATEMENTS 2.2.10-2.2.13
DUE WEDNESDAY

Linear Momentum

- "Quantity of Motion"
- Defined mathematically as "the product of an object's mass and its velocity

$$p = m \cdot v$$

- Momentum is a vector quantity
- Units = $kg \cdot m \cdot s^{-1}$

Practice problem #1

- A 50.0 g bullet is fired with a velocity of 100.0 m/s. What is the momentum of the bullet?

$$p = m \cdot v$$

$$p = (0.0500 kg)(100.0\ \mathrm{m} \cdot \mathrm{s}^{-1})$$

$$p = 5.00\ \mathrm{kg} \cdot \mathrm{m} \cdot \mathrm{s}^{-1}$$

In terms of Newton's 2nd law:

- Newton's 2nd law explains how a net force causes an object to accelerate
- By definition, acceleration is: $a = \frac{\Delta v}{t}$
- So Newton's 2nd law becomes:

$$F_{net} = ma = m\frac{\Delta v}{t}$$

$$F_{net} = \frac{m \cdot \Delta v}{t}$$

In terms of Newton's 2nd Law:

- Since we know, from the definition of momentum, that a change in momentum can be written as: $\Delta p = m \cdot \Delta v$
- Newton's 2nd law becomes:

$$F_{net} = \frac{m \cdot \Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$$

- OR:

$$\Delta p = F_{net} \cdot \Delta t$$

Impulse-Momentum Theorem

$$\Delta p = F_{net} \cdot \Delta t$$

- The right-hand side of this equation (F·t) is known as **IMPULSE**
- The **<u>Impulse-Momentum Theorem</u>** states that an object's momentum can change if a force is applied through a period of time

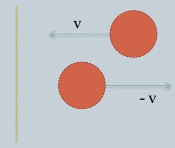
Impulse Example:

- Assume that an object's change in momentum is kept constant
  - If the force causing the change in momentum increases, then the time required for the change in momentum will decrease:

  - **Force** and the **time** the force is applied are **inversely proportional** to each other when the momentum change is kept constant.

Sample problem #2

- A 0.125 kg ball moving at 5.00 m·s^{-1} bounces off a vertical wall without a change in its speed. If the collision with the wall lasted for 0.111 s, what force was exerted by the wall to rebound the ball?



$$F_{net} \cdot \Delta t = \Delta p$$

$$F_{net} = \frac{\Delta p}{\Delta t} = \frac{m\Delta v}{\Delta t}$$

$$F_{net} = \frac{(0.125kg)(-5.00m \cdot s^{-1} - 5.00m \cdot s^{-1})}{0.111s}$$

$$F_{net} = -11.3N$$

Impulse…a graphing technique

- Impulse, or a change in momentum, can be determined by interpreting a Force vs. Time graph:
- The **area under the curve** is equal to the impulse, or change in momentum, of the object