Unit 7: Forces and Motion
Content Outline: Momentum & Collisions (7.5)

I. **Vector Quantities** (Think direction related… "vector" means "direction of movement")
- A. These are quantities associated with *magnitude* (numbers) but *also direction*.
- B. The can be positive – moving forward or upward.
- C. The can be negative – moving in reverse or downward.
- D. Vectors are usually drawn with arrows →, ←, 🡻, 🡹
  For example, a train is moving north at a rate of 550 m/hour. Direction is given.

II. **Scaler Quantities** (Think scales… scales measure quantities (numbers)
- A. These are quantities associate with just *numbers.*
- B. These can also be positive or negative values.
  For example the Cheetah can run 70 mph. No indication of direction is given.

III. **Momentum (P)**
- A. This term refers to *quantity of motion* within an object.
- B. It is essentially the *product* (multiply) of mass x velocity of an object
- C. There are 2 types of Momentum:
  1. **Linear Momentum**
     - a. This movement along a "straight line" ("linear" means "line")
     - b. The formula for calculating momentum is **P=m x v**
       For example, it will take a much larger engine to move a semi vs. an engine to move a smart car. Just the same, it will take much stronger breaks to stop the semi, versus brakes for the smart car.
     - c. It is measured in kg m/s OR Ns
     - d. This is considered a *conserved* quantity, if in a *closed system*.
       - i. This is the **Law of Conservation of Momentum**.
       - ii. This is related to Newton's 2nd Law of Motion.
       - iii. **Closed system** – could be a lab, could be a vacuum, or outer space; but no *resistance* is present.
  2. **Angular Momentum (A.K.A. Rotational Momentum)**
     - a. This is the movement/rotation in a *circular path.*
       - i. It is highly influenced by *mass, speed, and shape of the orbit.*
     - b. The object in motion rotates around a *fixed point* referred to as **Axis of symmetry.**
       For example, a tire is attached to an axel (bar). The tire rotates around the axel.
     - c. The formula for angular momentum is: **L =r x mv**
       - i. L = angular momentum
       - ii. r = radius (distance from center →orbit of object)
       - iii. m = mass
       - iv. v = velocity = distance x time
     - d. Measured in n·m·s OR $kg{\cdot}m^2/s$

IV. **Collisions** (two objects running into each other) & Momentum
- A. Energy in the form of momentum is *transferred between objects.*
  1. Mass and velocity are *important values* here.
- B. This centers around Newton's 3rd Law of Motion.
- C. There are 2 types of Collisions that involve momentum:
  1. **Elastic Collisions**
     a. This is a collision where *Kinetic Energy* is *conserved, but transferred*.

For example, you are playing pool. You hit the cue ball (solid white ball) with your pool stick. The white ball is now moving with momentum. It *hits* another stationary (not moving) pool ball. The result is now *both* balls are moving, but each slower than the original cue before the hit. The energy was *partially* transferred from one object to another object or objects…such as at the start (break) of a pool game.

b. Momentum is calculated by *adding* the momentums of the objects.

For example, $P_{total} = P_1 + P_2$ OR $P_{total} = (m_1v_1) + (m_2v_2)$

Remember, you can *substitute* variables if they are *equal.*

c. If the collision is linear, the objects move in a straight line.

d. If the collision is at an angle, both objects will move in *different & opposite directions.*

2. **Inelastic Collisions**
   a. This is a collision where *Kinetic Energy* is *lost* due to *heat, sound, or destruction of shape.*

For example, you see two cars collide. There is a loss of Kinetic energy for both cars. *Both* cars stop eventually, but the one moving fastest keeps moving where the slower stops immediately. All the energy was transferred to sound energy, heat energy, and destruction of the cars. Another example, your in a moving car and a bug hits the windshield. The bug splatters, but the larger car keeps going on its course. The bug lost its Kinetic energy. It was transferred into the splatter. Mass and velocity is important remember. What would happen between a semi going 75 mph and a smart car going 25mph?

b. Inelastic collisions tend to leave the greater force object still moving after the collision; the lesser not moving after the collision.