Things to Memorize: Impulse and Momentum

Momentum

- Momentum is a vector. It is symbolized by the letter $\vec{p}$.
- Momentum is defined as mass times velocity: $\vec{p} = m \cdot \vec{v}$
- The units for momentum are $\frac{kg \cdot m}{s}$
- The direction of the momentum is always the same as the direction of the object's velocity.
- Momentum is extremely useful for *collisions* and *explosions*.

Impulse

- Impulse is a vector. It is symbolized by the letter $\vec{J}$ or sometimes $\vec{I}$.
- Impulse is defined as force times time: $\vec{J} = \vec{F} \cdot t$
- The units for impulse are $N \cdot s$, which reduce to $\frac{kg \cdot m}{s}$.
- The direction of the impulse is always the same as the direction of the force acting on the object.
- Impulse causes an object's momentum to change.

Conservation of Momentum

- The **Law of Conservation of Momentum** states that momentum can neither be created, nor destroyed.
  - This means that whatever total momentum a system has at the beginning must equal to the total momentum the system has at the end.
  - If Impulse causes an object's momentum to change, it must be accounted for as well.
  - A basic equation for the law of conservation of momentum: $\vec{p_i} + \vec{J} = \vec{p_f}$
- To apply the law of conservation of momentum to a system:
  1. Draw the system in its *before* and *after* states.
  2. Define the positive direction and label it on your diagram. $(+\longrightarrow)$
  3. Write a momentum term for each object that is moving before and after.
  4. Determine if there is any impulse on the system.
  5. Plug in the formulas for impulse and momentum to each term.
  6. Manipulate the equation to solve for the variable you want.
  7. Substitute numbers into the equation and calculate the final answer with units.

Impulse and Momentum in 2 Dimensions

- The motion in one dimension does not effect the motion in any other dimension.
- To solve a problem in 2 Dimensions,
  1. Draw the system in its *before* and *after* states.
  2. Define the +X and +Y directions. Label them on your diagram.
  3. Concentrate on only one dimension at a time. For each dimension:
     (a) Write a momentum term for each object that is moving in that dimension before and after. (You might have to break velocities into components.)
     (b) Determine if there is any impulse on the system in that dimension.
     (c) Plug in the formulas for impulse and momentum to each term.
     (d) Manipulate the equation to solve for the variable you want.
     (e) Substitute numbers into the equation and calculate the final answer with units.
     (f) Repeat the process for the other dimension.
  4. Use the Pythagorean Theorem to combine X- and Y- variables.

Center of Mass

- An object will balance if it is supported below its center of mass.
- The motion of the center of mass of a **system** of objects is not affected by collisions or explosions, and it will continue to move along the same path as before the collision or explosion.