Conservation of Momentum

Objectives

- Explain the law of conservation of momentum.

- Use conservation of momentum to solve a variety of problems.

- Explain the difference between an elastic and inelastic collision.

Conservation of Momentum

- Momentum is conserved in an isolated system.
- Total momentum of a system is constant.
- Useful for analyzing collisions and explosions.
  - A collision is an event in which two or more objects approach and interact strongly for a brief period of time.
  - An explosion results when an object is broken up into two or more fragments.
    - $P_{initial} = P_{final}$

Conservation of Momentum

- Remembering Newton's 3rd Law
  - In a collision between two objects, both objects experience forces which are equal in magnitude and opposite direction.

  This has implications when we talk about momentum too.

Momentum Tables

1. Identify all objects in the system. List them vertically down the left-hand column.
2. Determine the momenta of the objects before the event. Use variables for any unknowns.
3. Determine the momenta of the objects after the event. Use the variables for any unknowns.
4. Add up all the momenta from before the event and set them equal to the momenta after the event.
5. Solve your resulting equation for any unknowns.

Conservation of Momentum

- Each object in a collision has the same force applied on it, but in opposite directions.

- The collision time is the same for each object, so each object has the same size impulse applied to it, but in opposite directions.

- So if you add it up, the total impulse applied to both objects always equals zero

  ➢ Impulse 1 + Impulse 2 = net Impulse

  ➢ Impulse 1 = - Impulse 2 = J

  ➢ Net Impulse = J + -J = 0

Conservation of Momentum

- So in a collision the net Impulse = 0
  - This means that the change in momentum is zero
  - Or that momentum is conserved.

total P $_{before}$ collision = total P $_{after}$ collision

Conservation of Momentum

- This is similar to a money transaction
  - In the beginning I have $10 and you have $90. Together we have $_____.
  - If you give me $50, now I have $60, and you have $_____.
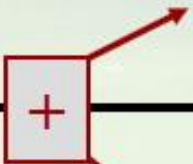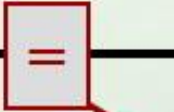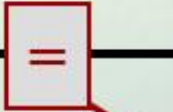 - I have more and you have less, but the total is still the same, $_____
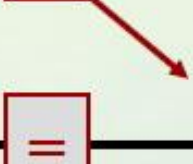
Conservation of Momentum

- In mathematical terms, this means for objects 1 and 2:
  - Total "p" before = total "p" after
  - $p1_{initial} + p2_{initial} = p1_{final} + p2_{final}$
  - $(m_{1*}v_{1i}) + (m_{2*}v_{2i}) = (m_{1*}v_{1f}) + (m_{2*}v_{2f})$

  - Advice: If you are not neat and organized, it is easy to get confused with your equation.

Table Trick

- If you don't like equations, another way to do conservation problems is to use what is called a conservation table.

- This way you write the equation in table (matrix) format, and it is easier to understand and keep track of.

- Lets take a look at the momentum practice questions.

Conservation table

	Before/Initial	After/Final
Object A		
Object B		
Total A+B		

Sample Problem 1

- A 2000-kg car traveling at 20 m/s collides with a 1000-kg car at rest at a stop sign. If the 2000-kg car has a velocity of 6.67 m/s after the collision, find the velocity of the 1000-kg car after the collision.

Sample Problem 2

- On a snow-covered road, a car with a mass of 1100 kg collides head-on with a van having a mass of 2500 kg traveling at 8 m/s. As a result of the collision, the vehicles lock together and immediately come to rest. Calculate the speed of the car immediately before the collision. [Neglect friction.]

Sample Problem 3

- A 4-kilogram rifle fires a 20-gram shell with a velocity of 300 m/s. Find the recoil velocity of the rifle.

Types of Collisions

- In an elastic collision (bouncy collision), kinetic energy is conserved.

- In a completely inelastic collision (sticky collision), the objects colliding stick together.