AP Physics - Core Concept Cheat Sheet

08: Momentum and Collisions

Key Physics Terms

- **Vector:** A quantity that represents magnitude (size) and direction. It is usually represented with an arrow to indicate the direction; arrow may be drawn to scale.
- **Vector Component:** The perpendicular parts into which a vector can be separated and that act in different directions from the vector.
- **Resultant:** The result of adding two or more vectors; vector sum.
- **Vector Addition**: The process of combining vectors; added tip to tail.
- **Force**: A vector quantity that tends to accelerate an object; a push or a pull.
- **Velocity**: The distance an object travels per unit of time including its direction of motion.
- **Momentum**: A vector quantity that is the product of mass and velocity of an item.
- **Impulse**: A change in momentum. The product of force and the time during which the force acts.
- **Conservation of Momentum**: The momentum of a system will remain constant. Momentum isn't created or destroyed unless an outside force is acting on the system.
- **Elastic Collision:** A collision where no kinetic energy is lost, momentum is still conserved; there is no deformation of the objects.
- **Inelastic Collision**: A collision where kinetic energy is lost due to heat, deformation, or other methods. However, momentum is still conserved for the system.

Variables Used

- t = time
- v = velocity
- a = acceleration
- F = force
- Δ = change in
- θ = angle
- m = mass
- P = momentum
- J = impulse
- KE = kinetic energy

Key Formulas

- $a = \Delta v / \Delta t = (v_f - v_i) / t$
- Pythagorean Theorem: $c^2 = a^2 + b^2$
- Sin θ = opp /hyp
- Cos θ = adj /hyp
- Tan θ = opp / adj
- $F_{net} = ma$
- $P = mv$
- $F\,\Delta t = m\Delta v$
- $J = Ft$
- $KE = ½\ mv^2$

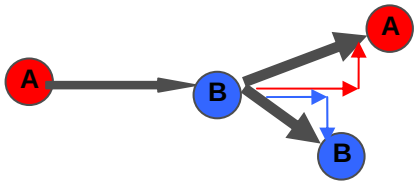
Key Metric Units

- Velocity: m/s
- Time: seconds, s
- Force: Newtons, N
- Mass: kilograms, kg
- Momentum and/or Impulse: kg•m/s

3 Types of Interactions

- **Explosion:** One object breaking into more objects.
  $0=mv+mv+\ldots$
- **Hit and stick:** One object striking and joining to another.
  $m_1v_1+m_2v_2=(m_1+m_2)v_3$
- **Hit and rebound:** one object striking and bouncing off another.
  $m_1v_1+m_2v_2=m_1v_3+m_2v_4$

Conservation of Momentum in 2D



Ball a strikes motionless ball B. After the collision they move off as shown.

Note how momentum is conserved. In the x-direction, the momenta add up to the original momentum before the collision. In the y-direction, the momenta cancel out since there was no momentum in that direction initially.

Elastic vs. Inelastic Collisions

Elastic Collisions:

- Momentum is conserved.
- The objects colliding aren't deformed or smashed.
- Thus no kinetic energy is lost; kinetic energy is conserved.
- *Ex:* billiard ball collisions

Inelastic Collisions

- Momentum is still conserved.
- Kinetic energy is lost.
- The energy may be transformed into sound, deformation of materials, flying debris, etc.
- Often objects interlock or stick together.
- Objects are also often deformed or crunched.
- *Ex:* car crash

Momentum Problem Solving Tips

These tips will make it easier to solve any physics problems:

- Thoroughly read the entire problem.
- Draw a diagram if needed. Identify all given information. Direction is especially important since momentum is a vector quantity. Be sure to make diagrams or calculations with direction in mind.
- Identify the quantity to be found.
- Select appropriate formula(s) that incorporate what you know and what you want to find.
- Convert units if needed. Use units throughout your calculations.
- Do any mathematical calculations carefully.

Typical Momentum / Impulse Problem

Example: During a car accident, a 1500 kg car may be brought to a halt in .2 s. Assuming the car was initially moving at 20 m/s, how much force was exerted on the car to stop it?

Known: m = 1500kg Δt = .2s
v_i = 20 m/s v_f = 0 m/s, stopped

Unknown: F = ? N

Define: $F\,\Delta t = m\Delta v$ Note: $v_f - v_i = \Delta v$
$F = m\Delta v / \Delta t$

Output: $F = (1500\ kg)(-20\ m/s) / .2\ s$

$F = -150{,}000\ N$

***Substantiate*:** Units are correct, sig fig correct, magnitude is reasonable

The negative sign indicates the force opposes the forward motion of the car, thus slowing it.

How to Use This Cheat Sheet: These are the keys related this topic. Try to read through it carefully twice then write it out on a blank sheet of paper. Review it again before the exams.