**Chapter 6 Summary of terms**

**Momentum**

* It is inertia in motion
* Momentum = mass x velocity
  + Momentum = mv
* It is a vector quantity, it has both magnitude and direction
* If direction is not important, Momentum = mass x speed
* A moving object can have a large momentum, if either its
  + mass is large
  + or velocity is large
  + or, if both mass and velocity is large
* Example:
  + Massive truck rolling down a steep hill with no brakes has huge momentum.
  + Same truck at rest has no momentum at all.

**Impulse**

* It is a vector quantity
* If momentum of an object changes,
  + then either the mass changes
  + or its velocity changes
  + or both mass and velocity changes
* Mass of an object remains unchanged mostly,
  + then momentum changes if velocity changes
  + when velocity changes, acceleration occurs
  + when acceleration changes, there is a force acting on the object
  + therefore, the greater the force acting on an object
    - the greater is its change in velocity
    - hence, the greater is its change in momentum
* Another important parameter in changing momentum is Time
* Impulse = Quantity Force x Time Interval
  + Impulse = Ft
  + For a fixed time, t
    - if F increases to 2F, impulse is larger
    - if F decreases to F**/**2, impulse is smaller

For a fixed force, F

* if time increase to 2t, impulse is larger
* if t decreases to t**/**2, impulse is smaller

If time increases to 2t and force decreases to F**/**2, impulse remains constant

If time decreases to t**/**2 and force decreases to 2F, impulse remains constant

**Check Point**

1. Which has more momentum, a 1-ton car moving at 100km/h or a 2 ton truck moving at 50 km/h?
2. Does a moving object have momentum?
3. For the same force, which cannon imparts a greater impulse to a cannonball- a long cannon or a short one?

**Impulse Changes Momentum**

* The greater the impulse exerted on something,
* The greater will be the change in momentum:
  + Impulse = Change in Momentum
  + Ft = change in (mv)
* Sometimes, the impulse causes a change of momentum
* Sometimes, the change of momentum causes impulse
* Most important: impulse and change of momentum are always linked
* Case 1: Impulse related to increasing momentum
  + Apply greatest force possible for as long as possible; impulse constant
* Case 2: Impulse related to decreasing momentum over a long time
  + Apply minimum force by increasing the time during which momentum is brought to zero; impulse constant

* Case 3: Impulse related to decreasing momentum over a short time
  + Short time of contact and impact forces are large; impulse constant

**Check Point page 88**-

Q1 If the boxer is able to increase the duration of impact 3 times, as long by riding with the punch, by how much will the force of impact be reduced?

Q2 If the boxer moves into the punch so as to decrease the duration of impact by half, by how much will the force of impact be increased?

Q4 When does impulse equal momentum?

**Bouncing –**

* Impulses are greater when an object bounces back,
* than when,
* impulse is only required to bring the object to a stop

**Check Point page 89**

Q1 A karate expert can split a stack of bricks with a blow of her bare hand. She brings her arms and swiftly against the bricks with considerable momentum. This momentum is quickly reduced when she delivers an impulse to the bricks. How does the force she exerts on the bricks compare with the force exerted on her hand?

Q2 How will the impulse resulting from the impact differ if her hand bounces back upon striking the bricks?

**Law of Conservation of Momentum-**

* If we need to change the momentum of the object,

we need to exert an external (to the system) impulse on it.

* Internal forces and impulses come in balanced pairs that cancel to zero within the object.
* If no external force is present,

then no external impulse is present,

and thereby no change in momentum is possible

**Example:**

* Cannon being fired from cannonball
* The force on the cannonball inside the cannon barrel is equal and opposite to the force causing the cannon to recoil.
* Since these forces act for the same time, the impulses are also equal and opposite
* Newton’s third law that applies to action and reaction forces, it applies to the impulses too.
* These impulses are internal to the system comprising cannon and the cannonball. Therefore they don’t change the momentum of cannon-cannonball system.
* Before the firing,
* The system is at rest and the momentum is zero
* After the firing,
* The cannonball gains momentum when fired
* Recoiling cannon gains equal momentum but in opposite direction
* There is no net gain of momentum in the cannon-cannonball system

**In the absence of an external force,**

**the momentum of a system remains unchanged**

**Check Point page 90**

Q1 Newton’s second law states that, if no net force is exerted on a system, no acceleration occurs. Does it follow that no change in momentum occurs?

Q2 Newton’s third law states that the force, a cannon exerts on a cannonball is equal and opposite to the force the cannonball exerts on the cannon. Does it follow that the impulse the cannon exerts on the cannonball is equal and opposite to the impulse the cannonball exerts on the cannon?

**Collisions**

* **Net momentum before collision = Net momentum after collision**
* Because the forces that act during the collision are internal forces
* Forces acting and reacting within the system itself
* There is only redistribution of momentum that exists before the collision

**Elastic Collision**

* Ideally, the colliding objects rebound without lasting deformation or the generation of heat

**For Example**

* When a moving billiard ball makes a head on collision with another identical billiard ball at rest
* The moving ball comes to rest and the resting ball moves with the speed of the colliding ball
* But momentum is conserved even when the colliding objects become entangled during the collision

**Inelastic Collision**

This is characterized by deformation or generation of heat or both

In perfectly inelastic collision, both objects stick together

**For Example**-

#1 A freight car moving at 10 m**/**s along a track and colliding with another freight car at rest If the cars are of equal mass, m and are coupled by the collision, then the velocity of the coupled cars after impact is 5m/s

#2 If two trucks A and B are moving with equal momentum, mv in opposite directions; they have a head on collision and their momenta algebraically (vector sum) add to zero. After collision, the coupled wreck remains at the point of impact, with zero momentum.

#3 If two trucks A and B are moving in the same direction (A catching up with B), the net momentum is simply the addition of their individual momenta

**Exercises**

3. In terms of impulse and momentum, why do air bags in cars reduce the chances of injury in accidents?

5. In terms of impulse and momentum, why are nylon ropes, which stretch considerably under tension, favored by mountain climbers?

7. When jumping from a significant height, why is it advantageous to land with your knees bent?

15. Why is it difficult for a firefighter to hold a hose that ejects large amounts of water at a high speed?

17. Why are the impulses that colliding objects exert on each other equal and opposite?

19. When an apple falls from a tree and strikes the ground without bouncing, what becomes of its momentum?

21. Why do 8-ounce boxing gloves hit harder than 16-ounce gloves?

27. A fully dressed person is at rest in the middle of a pond on a perfectly frictionless ice and must get to shore. How can this be accomplished?

37. The momentum of an apple falling to the ground is not conserved because the external force of gravity acts on it. But momentum is conserved in a larger system. Explain

41. Which exerts the greater impulse on a steel plate - machine gun bullets that bounce from the plate, or the same bullets squashing and sticking to the plate?

47. If a tennis ball and a bowling ball collide in mid-air, does each undergo the same amount of momentum change? Defend your answer?