

## Momentum : Notes-5

**Momentum** is the quantity of motion.

The momentum of a body is equal to the mass of the body multiplied by its velocity:

$$\text{momentum} = \text{mass} \cdot \text{velocity}$$

This equation may also be written as:

$$P = m \cdot v$$

P is the symbol for momentum. Momentum is a vector.

Example: If a 0.020 kg marble rolls on the floor with a velocity of 0.85 m/s [right]. The momentum is equal to  $0.020 \times 0.85 = 0.017$  kg m/s [right].

Example: If a 650 kg car has a velocity of [2.0,-5.0] m/s, then the momentum is equal to [1300, -3300] kg m/s.

### Conservation of Momentum

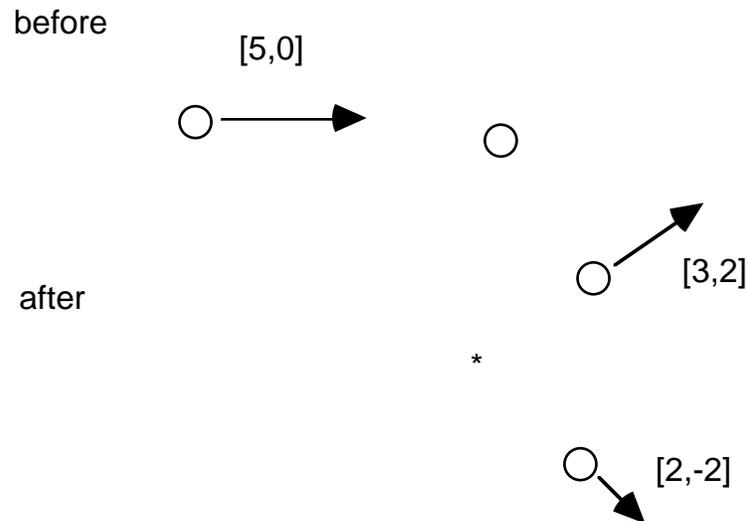
A very important law of physics is; "The Law of Conservation of Momentum". This law states that; the total momentum of a "system" does not change (external forces are assumed to be zero). This is true in all types of collisions. It is also true for explosions.

During a collision, kinetic energy may not be conserved. This is an **inelastic collision**. If the kinetic energy is conserved (doesn't change) in a collision, then it is an **elastic collision**.

Example: Suppose that a 0.60 kg object moving with a velocity of 2.1 m/s [right] collides with a 2.20 kg object moving with a velocity of 1.6 m/s [left]. They "stick together". Find the final velocity of the pair. Assume that friction is zero.

The initial momentum of the system is  $0.60 \times 2.1 + 2.20 \times (-1.6) = -2.3$ . The final momentum =  $-2.3 = M_{\text{total}} V_{\text{final}}$  (units are kg m/s). The total mass of the system after the collision is 2.80 kg. So, the final velocity is -0.81 m/s.

Example: Here is an example of a two-dimensional collision. A moving ball collides with a stationary ball. They both move off in different directions as shown. Assume that friction is zero.



The initial momentum of the system is  $[5,0]$ . The final momentum of the system is  $[3,2] + [2,-2] = [5,0]$  (units are kg m/s). In this collision, momentum is conserved. But energy is not conserved.

### Impulse

An impulse is required to change the momentum of an object.

The  $\Delta$  (delta) symbol means "change in". The impulse on an object is  $\Delta P = P_{\text{final}} - P_{\text{initial}}$ . The impulse  $\Delta P = \Delta mv = m\Delta v = m a \Delta t = F \Delta t$ . So, a force that acts on an object for a certain time, equals the change in momentum of the object.

Example: A stationary ball is hit by a force of 120 N for a time of 0.10 s. The impulse is 12 N s. The change in momentum of the ball is 12 kg m/s. The units N s = kg m/s.