

## Momentum and Collisions (Chp. 6)

### *Momentum and Impulse (Sec 1)*

**Momentum** ( $p$ ) – a quantity defined as the product of an object's mass and velocity. (Velocity is a vector and mass is a scalar, momentum must be a vector and have direction)

$$p = m \cdot v$$

The SI unit for momentum is  $\text{kg} \cdot \text{m/s}$

Ex || Usain Bolt has a weight of 650 N and a top speed of 12 m/s. What is the magnitude of his momentum at this top speed?

Practice A – Answers: (1) 2500  $\text{kg} \cdot \text{m/s}$  to the south (2) a) 120  $\text{kg} \cdot \text{m/s}$  NW b) 94  $\text{kg} \cdot \text{m/s}$  NW c) 27  $\text{kg} \cdot \text{m/s}$  NW

**Impulse** ( $J$ ) – the product of the force and the time over which that force acts on an object.

$$J = F \cdot \Delta t$$

The SI unit for Impulse is  $\text{kg} \cdot \text{m/s}$  (spoiler alert: same as momentum)

Ex || A baseball is given an impulse of 200  $\text{kg} \cdot \text{m/s}$ . If the ball was in contact with the bat for 0.025 seconds, then what force was the bat exerting on the ball?

**Impulse – Momentum Theorem** – The change in momentum of an object is equal to the impulse it undergoes during the same time interval.

$$J = \Delta p \quad \text{or} \quad F \cdot \Delta t = \Delta p$$

Ex || From the previous example, if the ball was thrown at 30 m/s, then what was the speed after it was hit by the bat?

Practice B – Answers: (1) 380 N left (2) 1100 N upward (3) 16 kg·m/s south (4) a) 9.0 m/s right b) 15 m/s left

Practice C – Answers: (1) 5.33 s; 53.3 m west (2) a) 14 m/s north b) 42 m north c) 8.0 s (3) a)  $1.22 \times 10^4$  N east  
b) 53.3 m west

### *Conservation of Momentum (Sec 2)*

**Conservation of Momentum** – The total momentum of all objects interacting with one another remains constant regardless of the nature of the forces between the objects.

$$p_i = p_f$$

Ex || You (60 kg) and your friend (90 kg) are out at the ice skating rink. You push off of each other. If your friend travels backwards at 3 m/s, how fast are you traveling?

Practice D – Answers: (1) 1.90 m/s (2) 1.66 m/s W (3) a) 12.0 m/s b) 9.6 m/s (4) 38 kg

***Elastic and Inelastic Collisions (Sec 3)***

**Inelastic Collision** – A collision in which two objects stick together after colliding. Kinetic Energy is *not conserved* in inelastic collisions.

Ex || A block of mass 15 kg sliding at a constant speed of 8 m/s. It collides and sticks with another block of equal mass. What is the speed of the two blocks stuck together after the collision?

Practice F – Answers: (1) 3.8 m/s south (2) 1.8 m/s (3) 4.25 m/s north (4) 4.2 m/s (5) a) 3.0 kg b) 5.32 m/s

**Elastic Collisions** - a collision in which the total momentum and the total kinetic energy *are conserved*.

Ex || Ball A (mass 3 kg) is rolling across a table at 2 m/s and strike Ball B (mass 5 kg) which was initially at rest. If Ball A bounces off ball B at 1.2 m/s, then what is the velocity of Ball B after the collision?

Practice G – Answers: a) 22.5 cm/s right b)  $6.2 \times 10^{-4}$  J 2) a) 14.1 m/s right b)  $3.04 \times 10^3$  J 3) a) 8.0 m/s b) 130 J  
4) a) 2.0 m/s b) 382 J