Section 11.8
Conservation of Momentum / Elastic and Inelastic Collisions

Conservation of Momentum

The total momentum in any closed system will remain constant.

When two or more objects collide, the collision does not change the total momentum of the two objects.

Whatever momentum is lost by one object in the collision is gained by the other. The total momentum of the system is conserved.

Newton's Cradle!!

https://www.youtube.com/watch?v=4IYDb6K5UF8

Conservation of Momentum

Formula

- $p_{system} = m_1v_1 + m_2v_2$
- **The total momentum of the system before the collision equals the total momentum of the system after the collision. Thus,**

$$p_{system} = p'_{system}$$

Collisions

There are three types of collisions:

1. **Elastic**
2. **Completely Inelastic ***
3. **Inelastic ****

**** We will deal with this situation***
***** We will NOT deal with this situation***

Elastic Collisions

- When an object hits another object and bounce off each other, the collision would be Elastic.

Formula

- $m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$

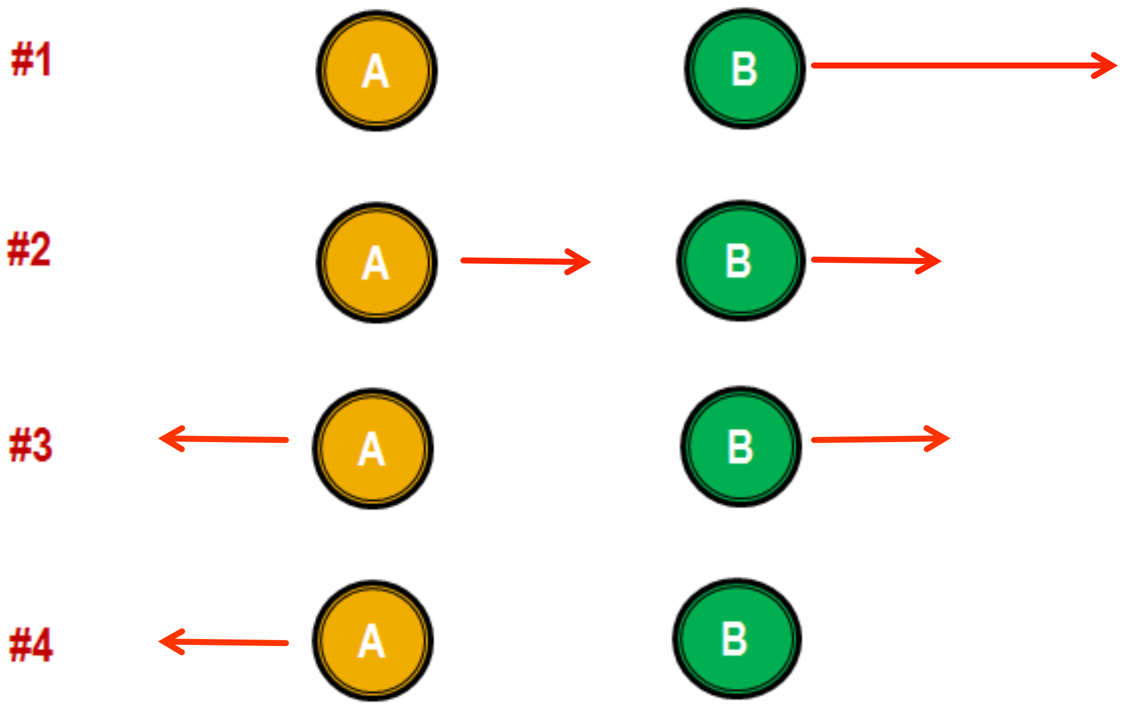
- *Where v is the velocity before the collision and v' is the velocities after the collision.*

Elastic Collision Examples

Examples

1. Pools Balls
2. Car wreck when cars hit and bounce away from each other
3. Baseball and bat collision

Elastic Collision Possibilities



How will you know which situation occurred? If direction changes, velocity will be negative

Totally Inelastic Collisions

- When an object hits another object and **sticks together**, the collision would be totally inelastic.

- Since the objects stick together, they have the same **final velocity**.

Formula

- $m_1v_1 + m_2v_2 = (m_1 + m_2)v_F$

- *Where v (v_1 and v_2) is the initial velocity of the objects and v_F is the final velocity of the objects stuck together.*

Totally Inelastic Collisions Examples

1. Box cars coupling together
2. Tackling a football player
3. Car wreck in which the cars become stuck

Inelastic Collisions

- The total momentum of the system after the collision is not equal to the total momentum of the system before the collision

- Energy is lost to heat and sound during the collision. Most real life collisions are Inelastic.

Inelastic Collisions

Totally Inelastic Collison Problems

Totally Inelastic Collisions

Example #1

A toy freight train car of mass 50 kg collides with a stationary empty car of mass 15 kg while moving 5 m/s. At the collision the cars couple together. What is the final velocity of the moving pair?

$v_F = 3.85$ m/s

Totally Inelastic Collisions

Example #2

Batman (91 kg) is standing on a bridge and then jumps straight down from the bridge into a boat (510 kg) in which the Joker is fleeing. The velocity of the boat is initially 11 m/s. What is the velocity of the boat after Batman lands in it?

$v_F = 9.33$ m/s

Totally Inelastic Collisions

Example #3

A 20 g bullet moving horizontally at 50 m/s strikes a 7 kg block resting on a table. The bullet embeds in the block after collision. Find the speed of the block after collision.

$v_F = 0.142$ m/s

Totally Inelastic Collisions

Example #4

A 0.34 kg glider on a track is moving at 1.5 m/s collides with a 0.51 kg glider that is initially at rest. They collide and stick together. How fast are the two gliders traveling after the collision?

$v_F = 0.60$ m/s

Totally Inelastic Collisions

Example #5

A 3 kg bullet moving at 2 km/s strikes an 8 kg wooden block at rest on frictionless table. The bullet lodges in the wooden block. How fast does the block move across the table after being struck?

$v_F = 545.45$ m/s

Elastic Collisions

Elastic Collison Problems

Elastic Collision Problems

Example #6

A carriage of mass 0.150 kg moving with a velocity of 1.2 m/s collides with a 0.30 kg carriage that is stationary on an air track. The second carriage moves at 0.8 m/s after the collision. Calculate the velocity after the collision of the first carriage if the collision is perfectly elastic.

$v_1' = -0.40$ m/s

Elastic Collision Problems

Example #7

A 3 kg steel ball moving at 8 m/s collides with a stationary steel ball of mass 2 kg. After the collision, both balls move in the same direction. The velocity of the 3 kg ball is 4 m/s after the collision. What is the velocity of the 2 kg ball after the collision?

$v_2' = 6$ m/s

Elastic Collision Problems

Example #8

A cart with mass 0.340 kg moving on a track at 1.2 m/s strikes a stationary second cart with a mass of 0.987 kg. After the collision, the first cart continues in its original direction at 0.66 m/s. What is the velocity of the second cart after impact?

$v_2' = 0.188$ m/s

Elastic Collision Problems

Example #9

A 112 g billiard ball moving at 1.54 m/s strikes a second billiard ball of the same mass moving in the opposite direction at 0.46 m/s. The second billiard ball rebounds and travels at 0.72 m/s after the head-on collision. Determine the velocity of the first billiard ball after the collision

$v_1' = 0.36$ m/s

Elastic Collision Problems

Example #10

A 4.88 kg bowling ball moving east at 2.41 m/s strikes a stationary 0.95 kg bowling pin. Immediately after the head-on collision, the pin is moving east at 5.19 m/s. Determine the velocity of the bowling ball after the collision.

$v_1' = 1.40$ m/s

Collision Problems

<u>Conservation of Momentum Problems</u>

The additional problems can elastic or inelastic.
The answers are provided in your packet

Collision Problems

Example #11

A 98 kg fullback is running along at 8.6 m/s when a 76 kg defensive back running the direction at 9.8 m/s jumps on his back. What is the post-collision speed of the two players after the tackle?

$v_F = 9.12$ m/s

Collision Problems

Example #12

A 2 kg blob of putty moving at 4 m/s slams into a 6 kg blob of putty at rest. What is the speed of the two stuck-together blobs immediately after colliding?

v_F = 1.00 m/s

Collision Problems

Example #13

A football player runs at 8 m/s and plows into an 80 kg referee standing on the field. The player hits the referee and stops moving while the referee flies forward at 5 m/s. What is the mass of football player?

$m_1 = 50$ kg

Collision Problems

Example #14

A 3,000 kg truck moving rightward with a speed of 5 m/s collides head-on with a 1,000 kg car moving leftward with a speed of 10 m/s. The two vehicles stick together and move with the same velocity after the collision. Determine the post-collision speed of the car and truck.

$v_F = 1.25$ m/s

Collision Problems

Example #15 - Challenge!!!

An artillery shell of mass 30 kg has a velocity of 250 m/s vertically upward. The shell explodes into two pieces; immediately after the explosion a fragment of mass 10 kg has a velocity of 120 m/s straight downward. How high above the point of the explosion does the larger fragment rise?

d = 4,644.49 m