# Lesson 5 More C of M

May 10, 2020 11:30 AM

Physics 11 Unit 6 Momentum Name: _____

**Lesson 5 More C of M**

## C of M = Conservation of Momentum

Types of Collisions:

1. Objects bounce off of each other after the collision (i.e. curling rocks, billiard balls, baseball and bat, some car crashes, etc.)

Fancy Physics Word: Elastic

2. Objects stick together after the collision (i.e. football player tackling and holding on to ball carrier, dart hitting dart board, some car crashes, bullet entering and sticking inside a target, etc.)

Fancy Physics Word: Inelastic

Ex. 1) A $1.5 \times 10^3$ kg car travelling 44 m/s collides 'head-on' with a $1.0 \times 10^3$ kg car travelling 22 m/s in the opposite direction. (If the cars stick together on impact, what is the velocity of the wreckage immediately after impact?

A + B

$\vec{p} = m\vec{v}$

$\sum \vec{p}_i = \sum \vec{p}_f$

$\vec{p}_{A_i} + \vec{p}_{B_i} = \vec{p}_{both_f}$

$m_A \vec{v}_{A_i} + m_B \vec{v}_{B_i} = (m_A + m_b)\vec{v}_f$

$$\vec{v}_f = \frac{m_A \vec{v}_{A_i} + m_B \vec{v}_{B_i}}{m_A + m_b} = \frac{(1.5 \times 10^3)(44) + (1 \times 10^3)(-22)}{1.5 \times 10^3 + 1 \times 10^3}$$

$\vec{v}_f = +17.6$ m/s

Is this collision elastic or inelastic?

A B

Ex. 2) An 18 kg curling stone is travelling due East at 2.6 m/s. It strikes a 12.5 kg curling stone that is moving East at 1.2 m/s. After the collision, the first stone is moving East at 0.65 m/s. What is the final velocity (magnitude and direction) of the second stone?

$$\Sigma \vec{p}_i = \Sigma \vec{p}_f$$

$$m_A \vec{v}_{A_i} + m_B \vec{v}_{B_i} = m_A \vec{v}_{A_f} + m_B \vec{v}_{B_f}$$

$$\vec{v}_{B_f} = \frac{m_A \vec{v}_{A_i} + m_B \vec{v}_{B_i} - m_A \vec{v}_{A_f}}{m_B} = \frac{18(2.6) + 12.5(1.2) - 18(.65)}{12.5}$$

$$\vec{v}_{B_f} = 4.01 \text{ m/s @ East}$$

Is this collision elastic or inelastic?

Physics 11 Unit 6 Momentum Name: _____

Ex. 3) A ~~550 g~~ .55 kg can of soda is thrown due east at 25 m/s. A ~~12 g~~ .012 kg bullet traveling west at 250 m/s strikes the can, passing through it. Afterwards the bullet continues west at 55 m/s. What is the final velocity of the can (magnitude and direction)?

$$\Sigma \vec{p}_i = \Sigma \vec{p}_f$$

$$m_A \vec{v}_{A_i} + m_B \vec{v}_{B_i} = m_A \vec{v}_{A_f} + m_B \vec{v}_{B_f}$$

$$\vec{v}_{A_f} = \frac{m_A \vec{v}_{A_i} + m_B \vec{v}_{B_i} - m_B \vec{v}_{B_f}}{m_A} =$$

$$\vec{v}_{A_f} = \frac{(.55)(25) + (.012)(-250) - (.012)(-55)}{.55} = 20.7 \text{ m/s @ East}$$

Is this collision elastic or inelastic?

**Lesson 5 Homework:**

1) A 50 kg object initially traveling at 30 m/s North is decelerated to 10 m/s North during a time interval of 5 ms (milliseconds).

a) What is the initial linear momentum of the object?

b) What is final momentum of the object?

c) What is the impulse exerted on the object?

d) What is the average force exerted on the object?

e) If the deceleration had occurred over a time interval of 5 sec, what would be the average force exerted on the object?

f) How far does the object travel during the 5 ms deceleration?

(1500 kgm/s North, 500 kgm/s North, 1000 kgm/s South, $2 \times 10^5$ N, 200 N, 0.1 m)

2) An 100 kg object traveling at 50 m/s collides inelastically with a 25 kg object initially at rest. What is the speed of the objects following the collision? (40. m/s)

3) A metal sphere with a mass of 95 g rolls along a frictionless surface at 20.0 m/s due north and strikes a stationary sphere having a mass of 300 g. The first sphere stops completely. At what velocity (**magnitude and direction**) does the second sphere move away after impact? (6.33 m/s North)

4) An arrow of mass 25 g traveling at 80.0 m/s due south is shot into a stationary target hanging from a rope. The target has a mass of 2.4 kg and the arrow sticks into the target. (a) Is this collision elastic or inelastic? (b) Calculate the velocity (**magnitude and direction**) of the target with the arrow immediately after the arrow strikes. (ans: inelastic, 0.825 m/s South)

5. An arrow of mass 45 g traveling north is shot into a target hanging from a rope. The target has a mass of 1.2 kg and the arrow sticks into the target. After the impact, both masses move off due north at 5.6 m/s.Calculate the incoming velocity (**magnitude and direction**) of the arrow before impact. (155 m/s north)

6. A 2.50 kg ball moving at 7.50 m/s is caught by a 70.0 kg man while the man is standing on ice. How fast will the man / ball combination be moving after the ball is caught by the man? (0.26 m/s)

7. A 1200 kg car traveling North at 20.0 m/s collides with a 1400 kg car traveling South at 22.0 m/s. The two cars collide and entangle. What is the resulting velocity of the wreckage? (2.6 m/s South)

8. A 5.00 kg ball hits a 75.0 kg man standing at rest on ice. The man catches the ball. How fast does the ball need to be moving in order to send the man off at a speed of 3.00 m/s? (48 m/s)

9. A $1.50 \times 10^3$ kg car traveling at 39 m/s South collides with a $1.20 \times 10^3$ kg car traveling North at 10 m/s. The heavier car continues to move South after the collision, but slows to 15 m/s. How fast is the lighter car moving after the collision? (20 m/s South)

10. A 109 kg running back is trying to score a touchdown. Just before the goal line he is moving South at 8.5 m/s. He collides head-on and sticks together with a 159 kg defensive player moving towards him at 5.9 m/s North.

a) Will the running back score a touchdown? Justify your answer with calculations. (Ans: No, the running back won't score --his final velocity is 0.043 m/s backwards)

b) How fast (magnitude and direction) does the running back's initial velocity need to be if he wants to keep moving forwards after the collision with a velocity of 0.20 m/s South? (ans: 9.1 m/s South)