Chapter 9: Momentum
9.1
Impulse and Momentum
Example: Golf Ball is a projected. What factors are important in the collision between club and ball?
Momentum

Momentum = _________________

• Momentum is ________________.
• Momentum is a __________________, the _________________ is the same as the _________________.

Momentum
Newton’s 2\textsuperscript{nd} Law Rearranged:

In football, the defensive player applies a force for a given amount of time to stop the momentum of the offensive player with the ball.
Impulse – Momentum Theorem

• The impulse on an object ________________
______________________ is equal to the
_________________________ that it causes.

• Cause –and –effect relationship: __________
is the cause and a ________________
is the effect.
Impulse

• Direction of impulse is in the ________________
  ________________________________.

• For _______________ impulses, there can be 
a  ________________________________:
  • __________ force acting over a ______ time.
  • __________ force acting over a ______ time.
Impulse Examples
Impulse Examples

https://www.youtube.com/watch?v=s6QR0KdyTFY
Units

Momentum = Mass x Velocity

Impulse = Force x Time
EX:

A 50 g golf ball on a tee is hit by a 500 g golf club. After the collision, the golf ball leaves with a velocity of 50 m/s.

a) Find the impulse imparted to the ball.

b) If the club is in contact with the ball for 0.5 ms, find the average force acting on the golf ball.
Example:

- An 2200 kg SUV traveling at 26 m/s can be stopped in 21 s by gently applying the brakes or in .22s if it hits a concrete wall. What is the average force exerted on the SUV in each case?
9.2 Momentum on Collisions

- When two objects collide, they exert ___________________________________ on each other ____________________
- These forces are applied ____________________.
- **Meaning:**
  - The ____________________ imparted by both balls are ____________________.
  - The ____________________ for each object is ____________________.
  - The momentum ____________________ by one object is equal to the momentum ____________________ by the other object.
Conservation of Momentum

Proof:
Law of Conservation of Momentum:

For a collision occurring between two objects, the momentum of the two objects is equal to the momentum of the two objects.

\[ m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f} \]

http://www.youtube.com/watch?v=4IYDb6K5UF8
Astronaut Catch
Conditions for Conservation of Momentum

1) __________________ system – a system that does not __________________________.

2) Isolated system – when the __________ __________ on a closed system is __________.
   * Meaning the only forces involved are __________________________. No forces are acting on the system by objects __________________________.
A 35.0-g bullet moving at 475 m/s strikes a 2.5-kg wooden block. The bullet passes through the block, leaving at 275 m/s. The block was at rest when it was hit. How fast is it moving when the bullet leaves?
A 75-kg fullback moving eastward with a speed of 8 m/s collides head-on with a 100-kg lineman moving westward with a speed of 4 m/s. The two players collide and *stick together*. Determine their velocities after.
Initial Momentum of Zero

- When two objects are at rest before a force is applied between them, there

  

- EX: Shooting a gun.
  
- EX: Two people on ice pushing each other.

  

- http://www.youtube.com/watch?v=KL8-PbdRYY0
EX:

An astronaut at rest in space fires a thruster pistol that expels 35 g of hot gas at 875 m/s. The combined mass of the astronaut and the pistol is 84 kg. How fast and in what direction is the astronaut moving after firing the pistol?
Two-Dimensional Collisions

- Law of ____________________________ still holds for two-dimensional collisions as long as it is a ____________________________ system.

- The momentum vectors must be broken up into components:
  - The _____ of the ________ x-components must equal the ______ of the ________ x-components.
  - The _____ of the ________ y-components must equal the ______ of the ________ y-components.
Two-Dimensional Collisions

<table>
<thead>
<tr>
<th></th>
<th>Blue Car</th>
<th>Red Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>mass (kg)</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>vel. (m/s)</td>
<td>20.0, East</td>
<td>10.0, North</td>
</tr>
<tr>
<td>mom. (kg m/s)</td>
<td>20 000, East</td>
<td>10 000, North</td>
</tr>
</tbody>
</table>
EX:

A 975 kg car moving south at 22.5 m/s collides with a 2165 kg truck moving west at 17.5 m/s. They stick together. In what direction and with what speed do they move after the collision?
A common pool shot involves hitting a ball into a pocket from an angle. In the picture, the cue ball hits a stationary ball at an angle of 45°, such that it goes into the corner pocket with a speed of 2 m/s. Both balls have a mass of 0.5 kg, and the cue ball is traveling at 4 m/s before the collision. Calculate the angle with which the cue is deflected by the collision.