WEEK 7

Physics of Engineer

Chapter 7: Momentum and Collision

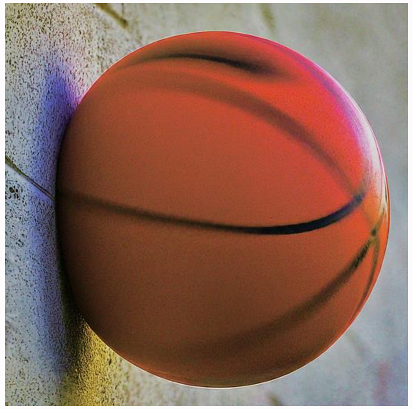
Kittipong Siengsanoh (Ph.D.Physics)

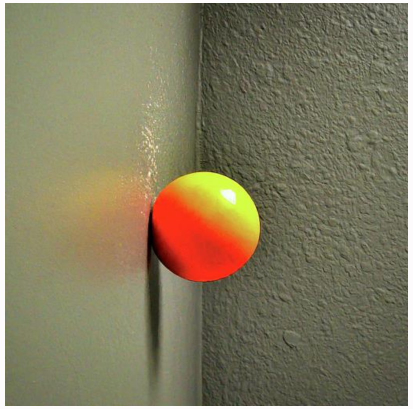
Department of Physics

Faculty of Science and Technology

Outline

- ❑ Introduction to Momentum
- ❑ Units of Momentum
- ❑ Conservation of Momentum
- ❑ Types of Collisions
- ❑ Momentum and Impulse
- ❑ Applications of Momentum in Daily Life
- ❑ Center of Mass
- ❑ Rotational Momentum
- ❑ Conservation of Rotational Momentum





NPRU

Outline

- ❑ Collisions in Two Dimensions
- ❑ Inelastic Collisions in Detail
- ❑ Explosions and Rocket Propulsion
- ❑ Momentum in Sports
- ❑ Applications and Future Directions
- ❑ Conclusion

NPRU

Introduction to Momentum

What is momentum?

- The quantity of motion of an object.
- It depends on both the object's mass and its velocity.
- It is a vector quantity, meaning it has both magnitude and direction.

Formula for momentum:

$$p = mv$$

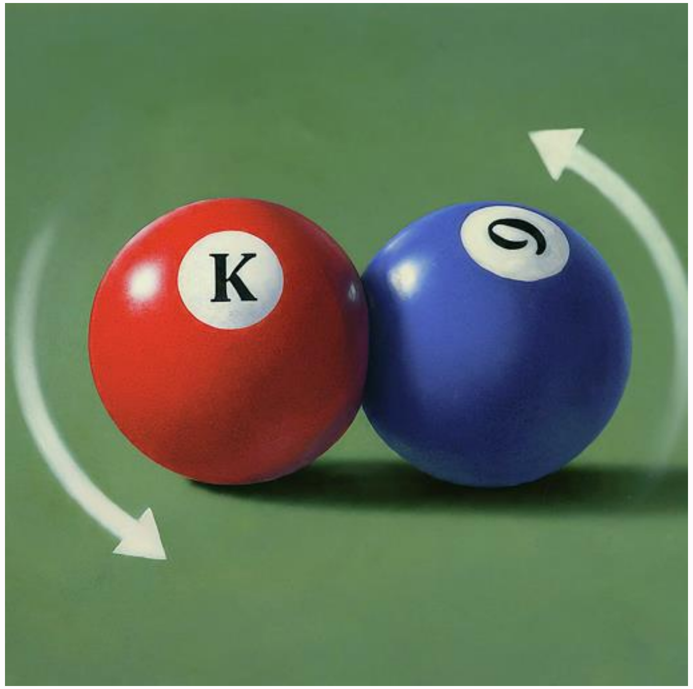
where p is momentum, m is mass, and v is velocity.

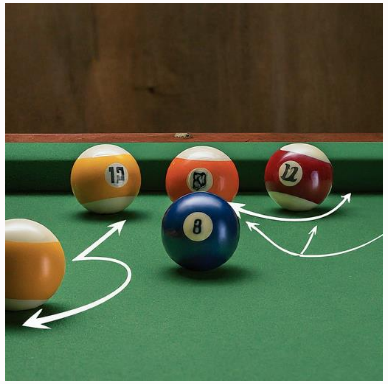
Units of Momentum

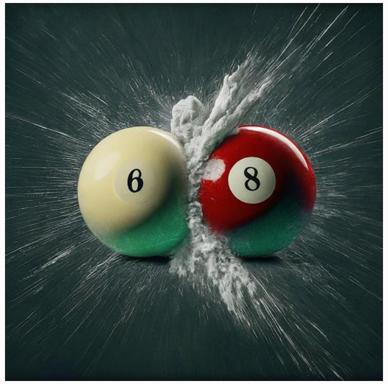
Unit	SI Equivalent	Conversion Factor to kg m/s	Example
Kilogram meter per second (kg m/s)	**SI Base Unit**	1	Base unit, no conversion needed
Gram meter per second (g m/s)	0.001 kg m/s	Divide by 1000	100 g m/s = 0.1 kg m/s
Pound-force second (lb·s)	4.4482216 N·s	Divide by 4.4482216	1 lb·s ≈ 0.453592 N·s ≈ 0.453592 kg m/s
Pound-mass foot per second (lbm·ft/s)	1.3558179 N·s	Divide by 1.3558179	1 lbm·ft/s ≈ 0.453592 kg ≈ 0.3048 m ≈ 0.453592 kg m/s
Slug foot per second	4.7880259 N·s	Divide by 4.7880259	1 slug·ft/s ≈ 14.5939 kg ≈ 0.3048 m ≈ 4.4482216 N·s ≈ 4.4482216 kg m/s

- The SI unit of momentum is kilogram meter per second (kg m/s).
- Other common units include gram centimeter per second (g cm/s) and pound foot per second (lb ft/s).

Conservation of Momentum







- In an isolated system, the total momentum before a collision is equal to the total momentum after the collision.
- This is a fundamental law of physics that applies to all types of collisions.

NPRU

Types of Collisions

Elastic collisions:

- No loss of kinetic energy during the collision.
- Both objects retain their original shapes.
- Example: Billiard balls colliding.

Inelastic collisions:

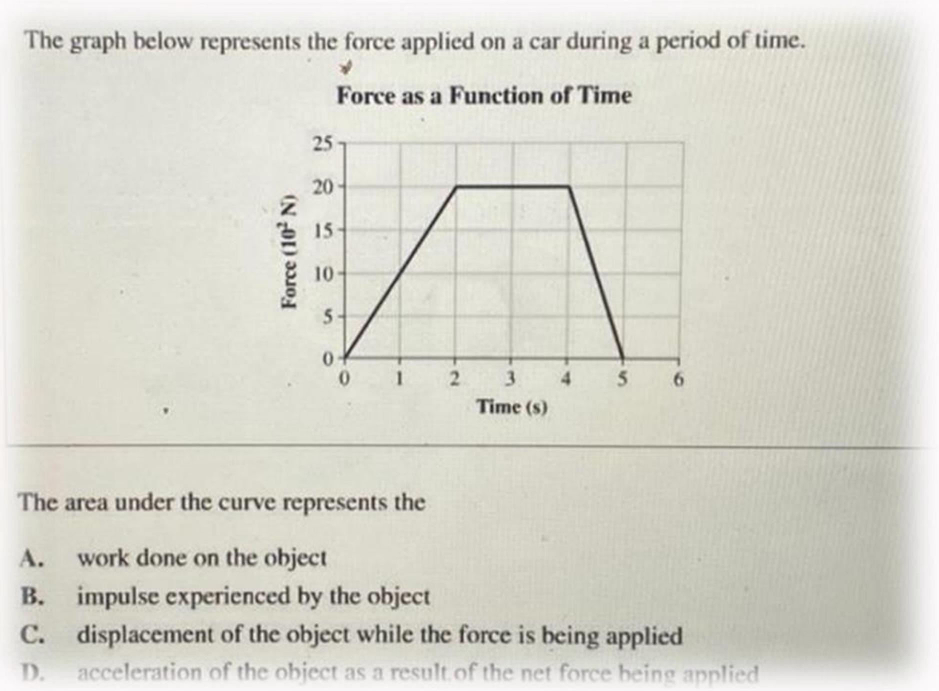
- Some kinetic energy is lost during the collision.
- Objects may deform or stick together.
- Example: Clay balls colliding.

Momentum and Impulse

Momentum (p): The quantity of motion of an object, measured in kilogram meter per second (kg m/s).

- It is a vector quantity, meaning it has both magnitude and direction.
- It is calculated as the product of mass (m) and velocity (v):

$$p = mv.$$



The graph below represents the force applied on a car during a period of time.

The area under the curve represents the

A. work done on the object
B. impulse experienced by the object
C. displacement of the object while the force is being applied
D. acceleration of the object as a result of the net force being applied

Momentum and Impulse

Impulse (J): The change in momentum of an object caused by a force acting on it for a certain amount of time.

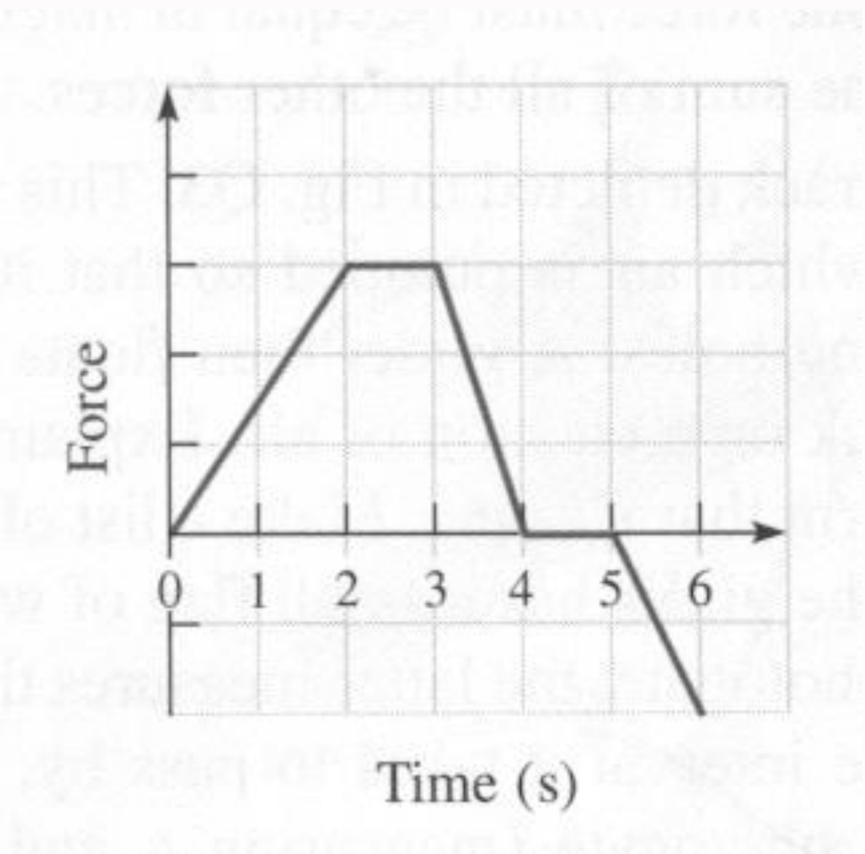
- It is measured in newton seconds (N s).
- It is calculated as the product of force (F) and the time interval (Δt) during which the force acts:

$$J = F\Delta t.$$

Where;

Force (F): The push or pull acting on an object, measured in newtons (N). It can cause the object to change its speed, direction, or both.

Time interval (Δt): The amount of time the force acts on the object, measured in seconds (s).

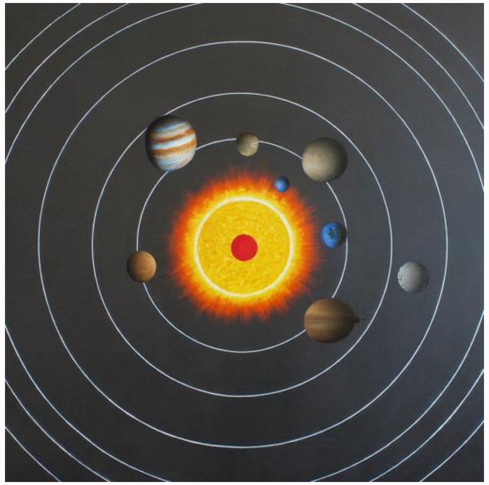


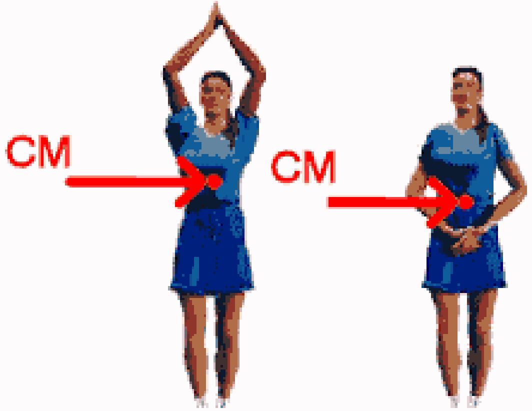
Applications of Momentum in Daily Life

- **Car airbags:** Designed to absorb the momentum of passengers during a collision, reducing the force and potential injuries.
- **Rocket propulsion:** The force exerted by the hot gases leaving a rocket engine creates a change in momentum, propelling the rocket forward.
- **Sports:** Used to analyze the motion of athletes and objects in various sports, such as baseball throws and football tackles.

Center of Mass

- **Definition:** The average location of all the mass in an object or system.
- **Importance:** Helps analyze the motion of complex objects as if they were a single point mass.
- **Formula:** Calculated by weighting the position of each particle by its mass and summing over all particles.





Rotational Momentum

- **Definition:** The angular equivalent of linear momentum.
- **Formula:**

$$L = I\omega$$

where L is angular momentum, I is moment of inertia, and **ω** is angular velocity.

- **Relationship to linear momentum**

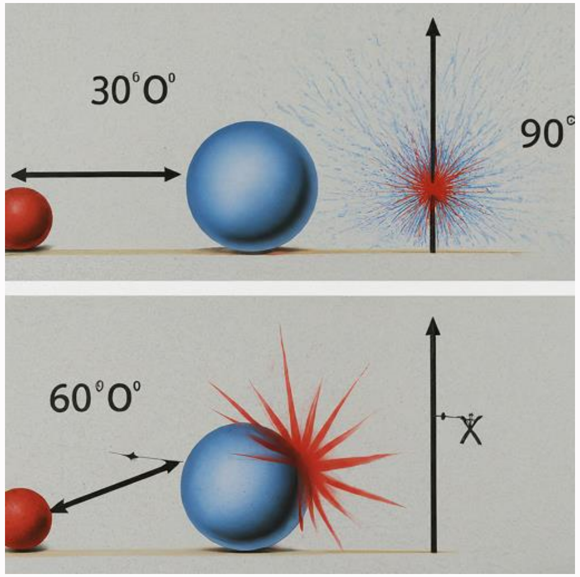
$$L = p * r$$

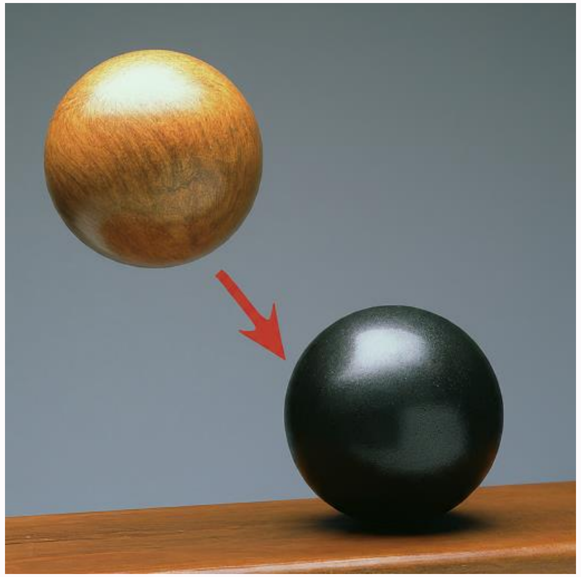
where p is linear momentum and r is the distance from the rotation axis.

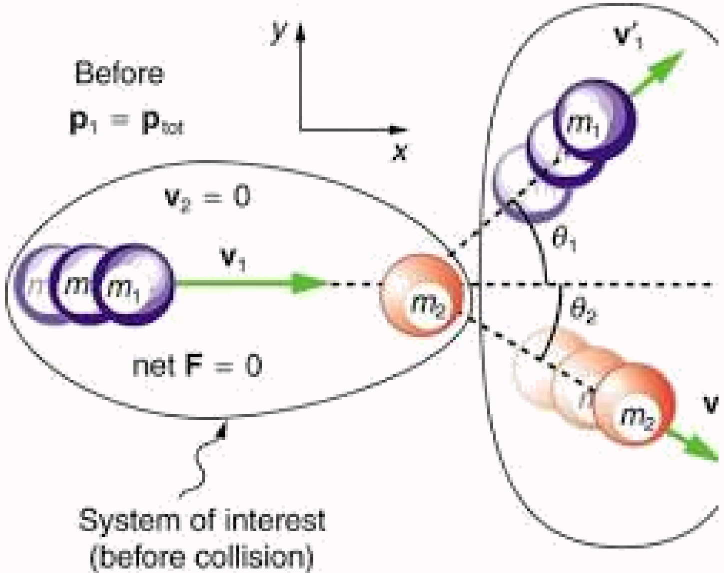
Conservation of Rotational Momentum

- Similar to linear momentum, rotational momentum is conserved in an isolated system.
- Applications in:
  - Ice skaters changing their spin speed by pulling in or out their arms.
  - Planets orbiting the sun.

Collisions in Two Dimensions

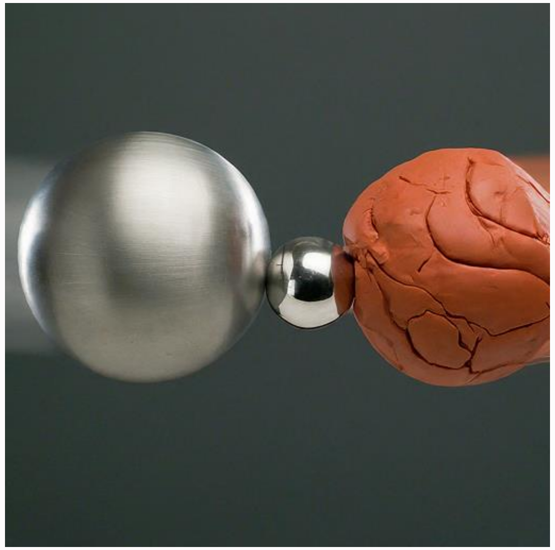


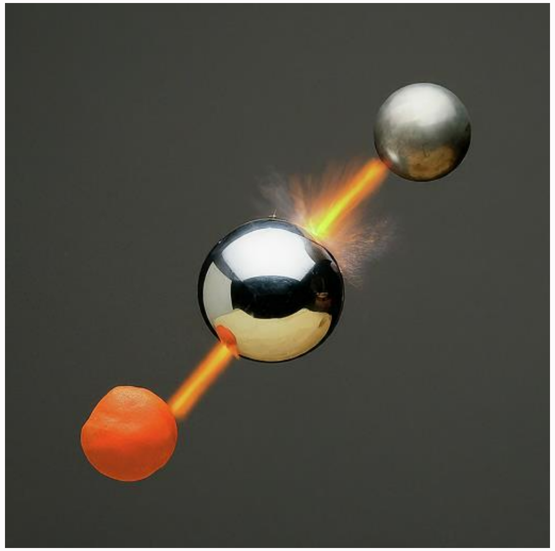


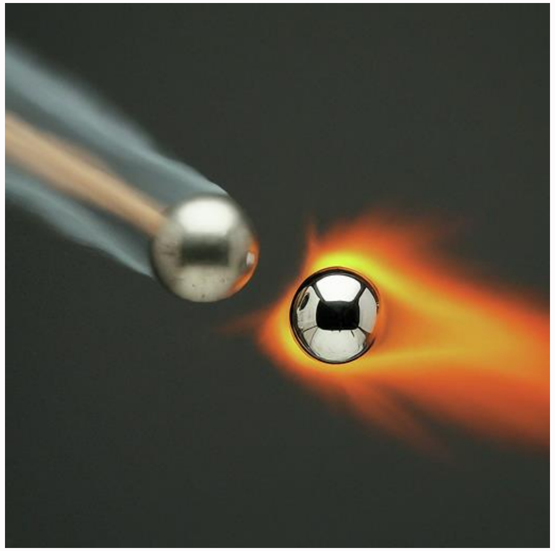


- Collisions can occur in two dimensions, requiring vector analysis to solve.
- Components of momentum in x and y directions are conserved separately.

Inelastic Collisions in Detail







- Explore different types of inelastic collisions:
  - Perfectly inelastic (objects stick together).
  - Partially inelastic (some kinetic energy lost as heat or sound).

Explosions and Rocket Propulsion

- Apply momentum principles to understand explosions and rocket propulsion.
- Explosions: Rapid release of energy, causing fragments to fly outwards with equal and opposite momenta.
- Rockets: Burning fuel creates a force that propels the rocket forward due to momentum conservation.

NPRU

Momentum in Sports

- Analyze various sports actions using momentum principles:
    - Tennis serves and returns.
    - Baseball pitching and hitting.
    - Football tackles and throws.

Applications and Future Directions

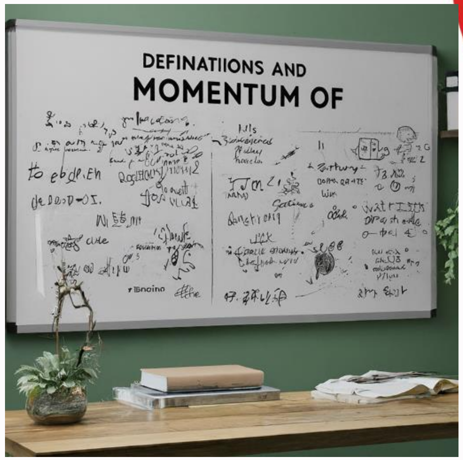


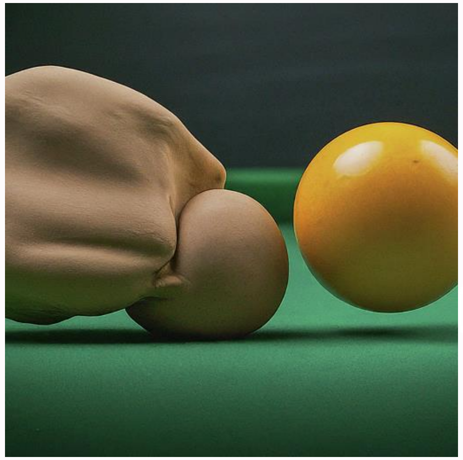

- Discuss potential applications of momentum in various fields:
  - Engineering (designing safer vehicles)
  - Astrophysics (understanding stellar collisions)
  - Particle physics (analyzing subatomic particles)

NPRU

Conclusion

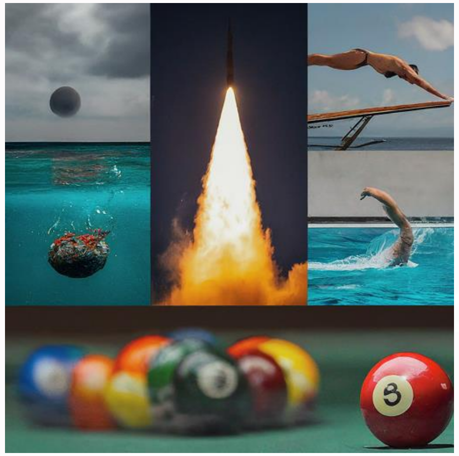
- **Recap the key takeaways:** Briefly summarize the core concepts covered in the presentation, including:
  - Definition and properties of momentum.
  - Types of collisions (elastic and inelastic) and the concept of impulse.
  - Applications of momentum in various fields, from daily life to advanced physics.





Conclusion

- **Emphasize the significance:** Highlight the importance of understanding momentum in:
  - Analyzing motion and interactions in the real world.
  - Comprehending various scientific phenomena across disciplines.
  - Appreciating the interconnectedness of physical principles.



Conclusion

- **Encourage further exploration:** Invite students to:
    - Ask questions and discuss any remaining uncertainties.
    - Explore additional resources to deepen their understanding.
    - Apply the learned concepts to analyze real-world scenarios.

04

NPRU

Exploring Resources and References

Textbooks:

- A comprehensive resource covering momentum and collisions in detail, offering explanations and practice problems. Consider:
  - "Physics for Scientists and Engineers" by Raymond A. Serway and John W. Jewett Jr.
  - "Fundamentals of Physics" by Halliday, Resnick, and Krane
- An alternative perspective on the topic, potentially offering additional insights and approaches. Consider:
  - "University Physics" by Hugh D. Young and Roger A. Freedman
  - "Classical Mechanics" by Herbert Goldstein, Charles P. Poole, and John L. Safko

Online Resources:

- Allows you to experiment with different scenarios involving momentum and collisions. Consider:
  - "Phet Interactive Simulations: Momentum and Collisions" (https://phet.colorado.edu/sims/html/collision-lab/latest/collision-lab_en.html)
- Provides a clear and concise explanation of momentum. Consider:
  - "Khan Academy: Momentum and Collisions" (https://www.khanacademy.org/science/hs-physics/x215e29cb31244fa1:forces-and-motion/x215e29cb31244fa1:introduction-to-momentum/v/newton-s-third-law-of-motion)

Exploring Resources and References

Articles and Documentaries:

- Showcases real-world applications of momentum in various fields. Consider:
  - "How Does a Rocket Work? Understanding Momentum and Newton's Laws" (https://ca01001129.schoolwires.net/cms/lib/CA01001129/Centricity/Domain/958/Newtons%20Laws.pdf)
- Explores various physics concepts, including momentum, in a visually engaging way. Consider:
  - "Cosmos: A Spacetime Odyssey" by Neil deGrasse Tyson
  - "NOVA: The Elegant Universe"

WEEK 7

Physics of Engineer

Chapter 7: Momentum and Collision

Kittipong Siengsanoh (Ph.D.Physics)

Department of Physics

Faculty of Science and Technology