DEPED - GENERAL SANTOS CITY
SIMPLIFIED
SELF-LEARNING MODULE
(S S L M)

GENSAN's ProTUNA
General Santos City's Pro-Active Response in Turbulent, Uncertain, New and Ambiguous Environment

GENERAL PHYSICS 1 – GRADE 12

Name: _____ Date: _____

Grade: _____ Section: _____

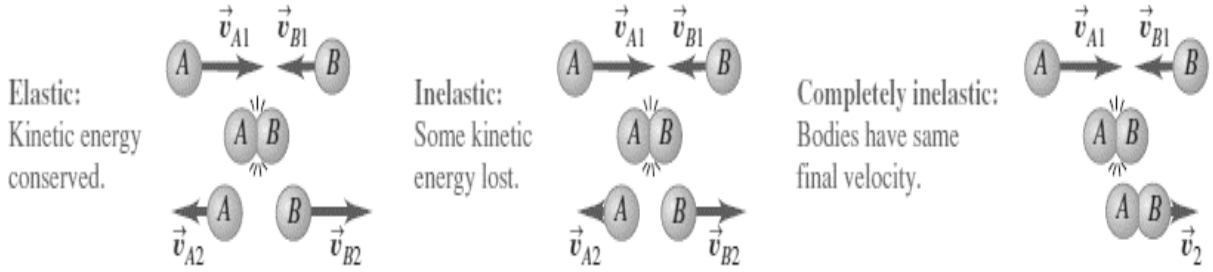
Quarter: __4__ Week: __8__ SSLM No. __8__ MELC(s): 1. Compare and contrast elastic and inelastic collisions **(STEM_GP12MMIC-Ii-60); 2.** Apply the concept of restitution coefficient in collisions **(STEM_GP12MMIC-Ii-61); 3.** Solve problems involving center of mass, impulse and momentum in contexts such as, but not limited to, rocket motion, vehicle collision **(STEM_GP12MMIC-Ii-63).**

- Objectives: 1. To compare and contrast elastic and inelastic collisions.
  2. To apply the concept of restitution coefficient in collisions.
  3. To solve problems involving center of mass, impulse and momentum in contexts such as, but not limited to, rocket motion, vehicle collision.
- **Title of Textbook/LM to Study**: University Physics with Modern Physics
- Chapter: _8_ Pages: 251-257 Topic: Momentum Conservation and Collisions

Let Us Discover

Impact occurs when two bodies collide with each other during a very short period of time, causing relatively large (impulsive) forces to be exerted between the bodies.

It's important to remember that we can classify collisions according to energy considerations. A collision in which kinetic energy is conserved is called ***elastic***. A collision in which the total kinetic energy decreases is called ***inelastic***. When the two bodies have a common final velocity, we say that the collision is ***completely inelastic***.

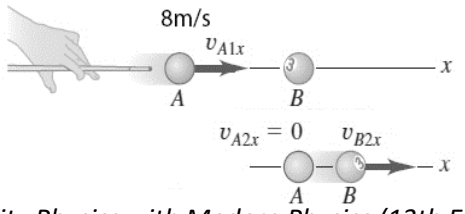


Source: University Physics with Modern Physics (13th Edition) by Young, Hugh D., Freedman (pp.254)

Elastic Collision

In an **elastic collision**, the objects separate after impact and don't lose any of their kinetic energy. Both momentum and kinetic energy are conserved in this collision.

Example: Two billiard balls collide. Ball A moves with a velocity of 8 m/s, and ball B is at rest. After the collision, ball A comes to a complete stop. What is the velocity of ball B after the collision? The mass of each ball is 0.20 kg.



Source: University Physics with Modern Physics (13th Edition) by Young, Hugh D., Freedman (pp.256)

Solution: Using Conservation of momentum given,

$$m_A(v_A)_1 + m_B(v_B)_1 = m_A(v_A)_2 + m_B(v_B)_2$$

$$(0.2)(8) + (0.2)(0) = (0.2)(0) + (0.2)(v_B)_2$$

$$\therefore (v_B)_2 = 8m/s$$

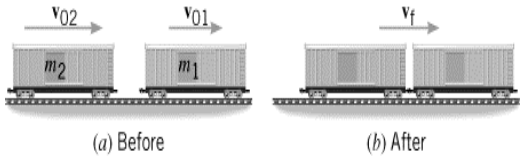
m_A= mass of 1st body
m_B= mass of 2nd body
v_{A1}= initial velocity of 1st body
v_{B1}= initial velocity of 2nd body
v_{A2}= final velocity of 1st body
v_{B2}= final velocity of 2nd body

The relative velocity of the two bodies has the same magnitude before and after the collision. Whenever this condition is satisfied, the total kinetic energy is also conserved.

Inelastic Collision

An **inelastic collision,** in contrast to an elastic collision, is a collision in which kinetic energy is not conserved due to the action of internal friction. A **completely inelastic collision** is one in which objects stick together after impact, the maximum amount of kinetic energy has been lost during this collision.

Example: A freight train is being assembled in a switching yard, figure shows two boxcars. Car 1 has a mass of m=100kg and moves a velocity of 2m/s. Car 2 with a mass of 250kg and a velocity of of 3.5 m/s, overtake car 1 and couples to it Neglecting friction, find the common velocity of the cars after they become coupled.



Source: https://tinyurl.com/inelastic-sample

Solution: Using Conservation of momentum given,

$$m_A(v_A)_1 + m_B(v_B)_1 = m_A(v_A)_2 + m_B(v_B)_2$$

$$(v_A)_2 = (v_B)_2 = v_f$$

m_A= mass of 1st body
m_B= mass of 2nd body
v_{A1}= initial velocity of 1st body
v_{B1}= initial velocity of 2nd body
v_{A2}= final velocity of 1st body
v_{B2}= final velocity of 2nd body

When two objects collide under inelastic condition, the final velocity with which the object moves are given by,

$$m_A(v_A)_1 + m_B(v_B)_1 = v_f(m_A + m_B)$$

$$(100kg)(2m/s) + (250kg)(3.5m/s) = v_f(100kg + 250kg)$$

$$v_f = 3.07\ m/s \qquad \boldsymbol{Ans.}$$

Therefore, the common velocity of the cars after they become coupled is 3.07 m/s.

Coefficient of Restitution

The formula to calculate the coefficient of restitution is defined as a ratio of the final to the initial relative velocity between two objects after their collision, it can be mathematically represented as follows:

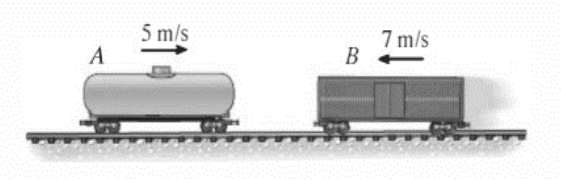
$$\text{Coeffiecient of Restitution (e)} = \frac{Relative\ velocity\ after\ collision}{Relative\ velocity\ before\ collison} = \frac{(v_B)_2 - (v_A)_2}{(v_A)_1 - (v_B)_1}$$

Elastic Impact (e = 1). If the collision between the two particles is perfectly elastic, the initial kinetic energy before impact is equals to the final kinetic energy after impact. Although in reality this can never be achieved, e = 1 for an elastic collision.

Completely Inelastic Impact (e=0). The impact is said to be completely inelastic or plastic when e=0. In this case the relative velocity after collision is equals to zero. So that after collision both particles couple or stick together and move with a common velocity.

Example:

The 15-Mg tank car A and 25-Mg freight car B travel towards each other with the velocities shown. If the coefficient of restitution between the bumpers is e = 0.6, determine the velocity of each car just after the collision.



Source: Engineering Mechanics: Dynamics (12th Edition) by Hibbeler, Russell (pp.251)

Solution:

Given: $m_A = 15{,}000kg$; $m_B = 25{,}000kg$; $v_{A1} = 5m/s$; $v_{B1} = -7m/s$; $e = 0.6$

The direction and sense of the particle's initial and final velocities should be established. Apply the Conservation of linear momentum in the appropriate directions.

$$\binom{+}{\rightarrow} \quad m_A(v_A)_1 + m_B(v_B)_1 = m_A(v_A)_2 + m_B(v_B)_2$$

$$15{,}000(5m/s) + 25{,}000(-7m/s) = 15{,}000(v_A)_2 + 25{,}000(v_B)_2$$

$$\mathbf{15}(\boldsymbol{v_A})_2 + \mathbf{25}(\boldsymbol{v_B})_2 = -\mathbf{100} \qquad \boldsymbol{eq}\ (\mathbf{1})$$

Using the coefficient of restitution,

$$(\mathrm{e}) = \frac{(v_B)_2 - (v_A)_2}{(v_A)_1 - (v_B)_1}$$

$$0.6 = \frac{(v_B)_2 - (v_A)_2}{(5m/s) - (-7m/s)}$$

$$(\boldsymbol{v_B})_2 - (\boldsymbol{v_A})_2 = \mathbf{7.2} \qquad \boldsymbol{eq}\ (\mathbf{2})$$

Solving eq (1) and eq (2),

$$(\boldsymbol{v_B})_2 = \mathbf{0.2}\ \boldsymbol{m/s} \rightarrow \qquad \boldsymbol{Ans.}$$

$$(\boldsymbol{v_A})_2 = -\mathbf{7}\boldsymbol{m/s}\ \textbf{or}\ \mathbf{7}\ \boldsymbol{m/s} \leftarrow \qquad \boldsymbol{Ans.}$$

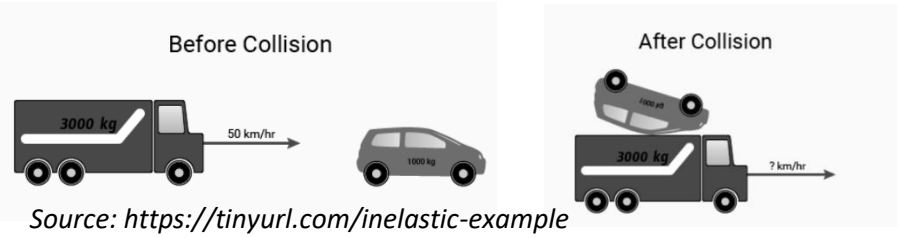
Therefore, the velocity of Car A is 7m/s to the left and Car B is 0.2 m/s to the right after collision.

Let Us Try

Activity 1:

Directions: Analyze and solve the following problems below. Write your answers on a separate sheet of paper

Question 1: A 3000 kg truck travelling at 50 km/hr strikes a stationary 1000 kg car, locking the two vehicles together.



Source: https://tinyurl.com/inelastic-example

A) What is the momentum of the truck before collision?

B) What is the momentum of the car before collision?

C) After Collision Truck Speed increases or decreases?

D) After Collision Car Speed increases or decreases?

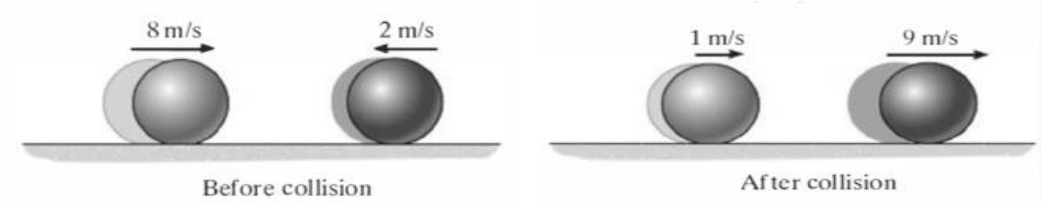
E) After Collison the total mass of Truck and Car is____.

F) After Collision the total momentum of Truck and Car is_____.

G) How much of the initial Kinetic energy is lost to the collision? Divide KE after by KE before to find the ratio between the values.

H) Use the conservation of momentum law to find the speed of Truck and Car together after collision. Show your work in your answer sheet.

Question 2: The velocities of Ball A and B before and after the collision are shown. Both have the same mass.



Source: Engineering Mechanics: Dynamics (12th Edition) by Hibbeler, Russell (pp.251)

A) After Collision, what is the relative velocity between Ball A and B?

B) Before Collision, what is the relative velocity between Ball A and B?

C) What is the coefficient of restitution e between ball A and ball B?

D) Was the collision elastic, inelastic or completely inelastic?

Let Us Do

Activity 2

A. Directions: Tell whether the following statements is TRUE or FALSE. Put check (√) if the statement is true and if it is false, change the underlined word/phrase to make it true.

_____1. Momentum is conserved in any collision, elastic or inelastic. This means that any momentum lost by one object must be gained by the other.

_____2. Momentum and kinetic energy are both conserved in an inelastic collision, inelastic refers to a collision where some or all kinetic energy is lost.

_____3. If two objects undergo a completely inelastic collision, they stick together after the collision.

_____4. In an inelastic collision, the final kinetic energy is always less than the initial kinetic energy of the system

_____5. The Momentum of an object depends upon the object's mass and energy.

B. Direction: Answer the following problems, show your complete solution in your answer sheet.

1. Suppose that you have a mass of 50 kg and are standing on frictionless roller skates. Someone then throws you a 5 kg mass with a velocity of 14.5 m/s and you catch it. What will be your resultant velocity?

2. A 1300 kg car is moving down the highway with a velocity of 35.0 m/s when it bumps into the car ahead of it which has a mass of 885 kg and a velocity of 26.0 m/s. After the collision, the two cars stick together. What will be the resulting velocity of the two cars together?

3. A toy 25-kg fire truck is rolling at 15 m/s when it hits a parked 1-kg toy car. After the collision, the car rolls at 5 m/s. What is the velocity of the fire truck?

4. The 2-kg ball is thrown at the 20-kg block with a velocity of 4 m/s. If the coefficient of restitution between the ball and the block is e=0.8, determine the velocity of ball and the block after collision.

5. A 13,500 kg railroad freight car travels on a level track at a speed of 4.5 m/s. It collides and couples with a 25,000 kg second car, initially at rest and with brakes released. What is the speed of the two cars after collision?

Let Us Apply

All of the sports associations have hired you to develop the next big sport. They want you, as an engineer, to develop a sport that includes components of other sports. Describe your new sport, including what type of ball and surface will be used and why. Remember to discuss momentum and elasticity.

Rubrics

Excellent (10)	Good (8-9)	Satisfactory (6-7)	Needs Work (0-5)
Ideas are thoroughly explained, highly coherent writing, almost no grammatical errors	Ideas are explained, coherent writing, few grammatical errors	Ideas are partially explained, somewhat coherent writing, several grammatical errors.	Ideas are poorly explained, incoherent writing, many grammatical errors

References

Hibeller, R. C. 2010. *Engineering Mechanics Dynamics 12th Edition.* New Jersey: Pearson Education, Inc.

Young, Hugh D. 2012. *University Physics with Modern Physics 13th edition.* San Francisco: Addison-Wesley.

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