

# **IMPULSE AND MOMENTUM**

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## **MOST ESSENTIAL LEARNING COMPETENCIES**

Have you ever experienced riding a motorcycle or a car on a muddy road? What do you observe about the speed of the motorcycle/car? Did it slow down or speed up? In this lesson, we will know the science concepts behind it.

In this module, you will learn about the principles applied to collision of objects which includes the following lessons:

### **Lesson 1: Impulse and Momentum**

At the end of this module, you should be able to:

1. Define impulse, indicate its units and relate its significance to a situation.
2. Calculate momentum of objects in real life situations.

## INTRODUCTION

**Momentum** in a simple way is a quantity of motion. Here quantity is measurable because if an object is moving and has mass, then it has momentum. If an object does not move, then it has no momentum. However, in everyday life it has importance but many people do not recognize it.

**Impulse** is a physical phenomenon that occurs whenever two objects collide with each other or when objects come into contact. When a sepak player kicks the ball or when sublian castanets crash into each other, each object experiences an impulse. All objects in motion possess momentum.

The property of **momentum** combines an object's mass with its velocity. In fact, momentum is equal to the product of an object's mass and its velocity. So, no matter how large or massive an object is, if it is not moving, it has no momentum because its velocity equals zero. The more mass an object has, the more momentum it has.

## LESSON 1: IMPULSE AND MOMENTUM

What makes things move? Why do some objects move continuously while some moving objects stop suddenly? These might be some of the questions you had in mind but were not really answered in last year's science class.



## LET'S TRY THIS!

**Instruction:** Read the words in the WORD BOX. Can you find all the words hidden in the puzzle? Circle each word you find. You might find the words spelled across, down, and diagonally. The words might be spelled forward or backward

F	A	T	I	M	E	R	M	I
O	D	E	M	H	V	G	A	S
R	U	Z	P	O	E	L	S	T
C	A	L	U	P	T	E	S	X
E	V	E	L	O	C	I	T	Y
N	O	I	S	I	L	L	O	C
M	O	M	E	N	T	U	M	N

Velocity	Impulse	Mass	Collision
Motion	Momentum	Time	Force

## MOMENTUM

Momentum can be defined as "mass in motion." All objects have mass; so if an object is moving, then it has momentum - it has its mass in motion. The amount of momentum that an object has is dependent upon two variables: how much *stuff* is moving and how fast the *stuff* is moving. Momentum depends upon the variables mass and velocity. In terms of an equation, the momentum of an object is equal to the mass of the object times the velocity of the object.

Momentum is a commonly used term in sports. A team that has momentum is on *the move* and is going to take some effort to stop. A team that has a lot of momentum is really *on the move* and is going to be *hard to stop*. Momentum is a physics term; it refers to the quantity of motion that an object has. A sports team that is *on the move* has momentum. If an object is in motion (*on the move*) then it has momentum.

These are the things we need to consider in defining momentum:

- a. the object has mass
- b. the object is moving

Any moving object with a quantity of matter has momentum. Momentum simply means "mass in motion." It is equal to the product of mass and velocity.

Mathematically, it is expressed as

$$\mathbf{p = mv}$$

where:

p is the momentum in kilogram · meter per second (kg · m/s) m is the mass of the moving object in kilogram (kg) v refers to velocity of the moving object in meter per second (m/s).

If any object of any mass is not moving, it has **zero momentum** since its velocity is zero.

Let us first consider the situation below and try to answer the given questions.

Suppose you ride a bus from Lipa City to Batangas City. What do you think will happen to the bus after it passes along a curvy road?

- a. The bus will slow down.
- b. The bus will speed up or move faster.
- c. The velocity of the bus will not change.

After passing a curvy road, the bus travels in a straight road. How will you describe the velocity of the bus?

- a. it increases
- b. it decreases
- c. it does not change at all

There were only 25 passengers in the bus. Along the way, 5 passengers dropped off at the Main Terminal Bus stop, and another 4 passengers dropped-off at Bauan bus stop. What can you say about the mass of the bus?

- a. it increases
- b. it decreases
- c. it does not change at all

If your answer (a) the bus slows down on the first question and (a) it increases on the second, and (b) it decreases on the third question, then all your answers are correct.

Therefore, when the object slows down or moves faster, its velocity decreases or increases. If there is a change in the velocity or the mass of an object, there is also a change in momentum. That change of momentum is called Impulse.

### **Impulse = Change in Momentum**

What do you think of the impulse of an object moving with constant momentum?

**Constant** means there is no change.

Therefore, there is no impulse or zero impulse for objects moving with constant momentum.

Example:

If a 6.0 kg rattan ball is kicked through the air at a velocity of 3.5 m/s, what is the momentum of the ball?

Given:

$$m = 6.0 \text{ kg}$$

$$v = 3.5 \text{ m/s}$$

Find:  $p = ?$

Solution: Formula for momentum is

$$p = mv$$

Then, substitute the given values to the equation

$$p = (6.0 \text{ kg}) (3.5 \text{ m/s})$$

$$p = 21 \text{ kg.m/s}$$

### **PRACTICE TEST**

Enumerate at least 3 activities in real life situations which involve the concepts of momentum and impulse.

**Example:** Bird flying, driving a motorcycle along a muddy road

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

## IMPULSE

**Impulse** is a term that quantifies the overall effect of force acting over time. It is conventionally given the symbol  $I$ , and expressed in Newton-seconds (N.s). For a constant force,  **$I = F \cdot \Delta t$** .

Do you still remember Newton's Second Law of Motion? It states that the net force is directly proportional to the mass of a body and its acceleration. In equation form,

$$F = ma$$

Since  $a = \frac{v_f - v_i}{t}$ , then

$$F = m (v_f - v_i) / t$$

Rearranging the equation will give you

$$Ft = mv_f - mv_i$$

Since  $p = mv$ . Then

$$Ft = p_f - p_i \text{ or } \mathbf{Ft = \Delta p}$$

## LET'S TRY THIS!

Tiger Woods hits a 0.02 kg golf ball, giving it a speed of 25 m/s. What impulse does he impart to the ball?

**Given:**

$$m = 0.02 \text{ kg}$$

$$\Delta v = 25 \text{ m/s} - 0 = 25 \text{ m/s}$$

**Find:  $I$**

**Solution:**

Since the golf ball is initially at rest, the initial velocity is equal to zero

Thus,

$$= (0.02 \text{ kg})(25 \text{ m/s})$$

$$\mathbf{= 0.50 \text{ kg m/s or } 0.50 \text{ Ns}}$$

One of the reasons why impulse is important and useful is that in the real world, forces are often not constant. Forces due to things like people and engines tend to build up from zero over time and may vary depending on many factors. Working out the overall effect of all these forces directly would be quite difficult.

## **ASSESSMENT**

**A. MULTIPLE CHOICE:** Choose the letter of the best answer.

1. Which of the following describes momentum?
  - a. Mass times its velocity.
  - b. Force times the time interval.
  - c. Force times its acceleration.
  - d. Mass times its acceleration.
2. Which of the following would describe momentum?
  - a.  $p=mv$
  - b.  $p=m/v$
  - c.  $p=v/t$
  - d.  $p=F/t$
3. Which of these is the quantity of matter in an object?
  - a. force
  - b. mass
  - c. motion
  - d. time
4. What is impulse?
  - a. the change in volume of an object.
  - b. the change in momentum of an object
  - c. the original momentum of the object.
  - d. a force applied to an object for a period of time.
5. What is the impulse of an object moving with constant momentum?
  - a. 0
  - b. 1
  - c. the same with momentum
  - d. none of these

**B. Modified True or False.** Write true on the space provided before the number if the statement is correct, but if it is false, change the underlined word or group of words to make the whole statement true.

\_\_\_\_\_1. A moving object has momentum.

\_\_\_\_\_2. When the object slows down, the velocity increases.

\_\_\_\_\_3. An object with zero velocity has zero momentum.

\_\_\_\_\_4. An object moving with constant momentum has impulse.

\_\_\_\_\_5. If there is no change in momentum, there would be no impulse.



## ANSWER KEYS

ASSESSMENT  
1. A  
2. A  
3. B  
4. B  
5. A

B.

1. True

2. Decreases

3. True

4. has no impulse

5. True