Module 9 Going Places



What this module is about



Loops and roller coasters are very interesting rides. Have you ever tried one? Did you experience the sudden jerks and lurks? And what about the sudden turn around the loops? Aren't they amazing? We never fall off our seats! That's Physics.

Physics is a very interesting course. It is usually described as the study of matter and energy, which includes several branches such as mechanics, thermodynamics, electricity and magnetism, waves and optics, and relativity and atomic physics. Mechanics includes the concepts about motion and its causes. Kinematics is said to be the quantitative description of the motion of the objects. Dynamics, on the other hand, includes concepts about the causes of motion. Mechanics provides explanations of many phenomena such as the motion of and why we jork when the vehicle suddenly store.

skydivers, the parachutes, and why we jerk when the vehicle suddenly stops.

In this module you will learn many things about Physics particularly about motion. This module includes four (4) lessons such as:

- Lesson 1 Describing Motion
- Lesson 2 Linear Motion
- Lesson 3 Curvilinear Motion
- Lesson 4 Physics and Transportation

Read, enjoy, and discover the secrets of Physics!



After going through the module, you are expected to:

- 1. define the fundamental principles of mechanics, specifically motion;
- 2. apply the concepts and principles in mechanics to practical situations and problems;

- 3. trace the development in transportation facilities from the animal-driven to enginepowered vehicles.
- 4. solve problems in a logical and organized manner; and,
- 5. develop appreciation of physics.



Here's a simple guide for you in going about the module.

- 1. Read and follow the instructions very carefully.
- 2. Take the pretest. It is a simple multiple-choice test provided at the start to determine how much you know about the content of this module.
- 3. Check your answers against the correct answers provided at the last page of the module.
- 4. Be very honest in taking the test so you know how much knowledge you already have about the topic.
- 5. Read the different lessons about the earth, sun and moon.
- 6. Perform all the activities, as these will help you have a better understanding of the topic.
- 7. Take the self-tests at the end of each lesson to determine how much you remember about the lesson.
- 8. Finally, take the posttest at the end of this module.

Good Luck and have fun!



Direction: Choose the letter of the best answer. Write your answer on a separate sheet of paper.

- 1. When you look at the speedometer in a moving car, you can see the car's ______.
 - a. average speed
 - b. average acceleration
 - c. instantaneous speed
 - d. instantaneous acceleration
- 2. Suppose you are in a car that is going around a curve. The speedometer reads a constant 30 km/h. Which of the following is **NOT** true?
 - a. Your speed is constant
 - b. Your velocity is constant
 - c. You and the car are accelerating.

- 3. A ball is thrown straight up. At the top of its path its acceleration is _____
 - a. 0 m/s²
 - b. about 5 m/s²
 - c. about 10 m/s²
 - d. about 20 m/s²
- 4. If you drop a feather and a coin at the same time in a tube filled with air, which will reach the bottom of the tube first?
 - a. The coin
 - b. The feather
 - c. Neither they will both reach the bottom at the same time.
- 5. At what part of a path does a projectile have minimum speed?
 - a. when it is thrown
 - b. half-way to the top
 - c. at the top of its path
 - d. when it returns to the ground
- 6. A ball is thrown straight up. What is its acceleration before it strikes the ground?
 - a. 0 m/s²
 - b. about 5 m/s²
 - c. about 10 m/s^2
 - d. about 20 m/s²
- 7. A ball is thrown straight up. After 2 seconds what is the acceleration of the ball? a. 0 m/s^2
 - b. about 5 m/s²
 - c. about 10 m/s^2
 - d. about 20 m/s²

8. In the absence of air friction, the vertical component of a projectile's velocity doesn't change as the projectile moves.

- a. always true
- b. always false
- c. sometimes true

9. If a freely falling object were somehow equipped with an speedometer, by how much would its speed reading would increase each second?

- a. about 5 m/s
- b. about 10 m/s
- c. about 15 m/s
- d. A variable amount

10. A ball is thrown vertically upward. What is its velocity at the top of its path?

- a. O
- b. 5 m/s

- c. 10 m/s
- d. 10 m/s²

11. A ball is thrown vertically upward. What is its acceleration at its maximum height?

- a. 0
- b. 5 m/s
- c. 10 m/s
- d. 10 m/s²

12. A ball is thrown vertically upward. What is its acceleration after about 1 second?

- a. 0
- b. 5 m/s
- c. 10 m/s
- d. 10 m/s²

13. A ball is thrown vertically upward, with an initial velocity of 50 m/s and caught back at the same level as when it was thrown. What is the velocity of the ball at that point?

- a. 50 m/s
- b. 50 m/s, downward
- c. 9.8 m/s
- d. 9.8 m/s²

14. What force is exerted on the ball at the top of its path?

- a. 9.8 N
- b. 9.8 N
- c. Gravitational force
- d. Force exerted by the hand that threw the ball
- 15. What do you call the motion of an object with a constant acceleration?
 - a. Motion
 - b. Uniform Motion
 - c. Constant Motion
 - d. Uniformly Accelerated Motion
- 16. A ball is thrown vertically upward. What is its instantaneous speed at its maximum height?
 - a. 0
 - b. 5 m/s
 - c. 9.8 m/s
 - d. 9.8 m/s²
- 17. If you whirl a tin can on the end of a string and the string suddenly breaks, the tin can will
 - a. fly directly toward you.
 - b. fly directly away from you.
 - c. spiral away from your hand.
 - d. fly off tangent to its circular path.

- 18. Which of the following would not be considered as projectile?
 - a. A cannonball rolling down a slope.
 - b. A cannonball thrown through the air.
 - c. A cannonball rolling off the edge of a table.
 - d. All of the above.
- 19. A ladybug rests at the bottom of a tin can that is being whirled horizontally on the end of a string. Since like the tin the ladybug can moves in a circle, there must be a force on it. What exerts this force?
 - A. gravity
 - B. your hand
 - C. the tin can
 - D. the string
 - 20. Acceleration is defined as the CHANGE in _
 - a. distance divided by the time interval
 - b. velocity divided by the time interval
 - c. time it takes to move from one speed to another
 - d. time it takes to move from one place to another



Lesson 1 Describing Motion



activities of people, of vehicles in the road, in the plants that sway and even in the smallest particles – the atoms that vibrate and jostle. We can move because of the contraction and expansion of our muscles. Everything moves. Even the things that are physically at rest are in motion (jostling molecules). Like in our case, even when asleep our lungs and heart continue to vibrate and pump.

Motion is everywhere. We can see it in the everyday

Fig 1.1 The Heart

The number of times our heart beats in a minute is called our heartbeat. The normal heartbeat *is equal to or less than 100 times per minute for adults*. A heartbeat consists of 2 parts: diastole and systole. During diastole,

the heart muscle relaxes, allowing blood to flow into the atria and ventricles. During systole, the ventricles contract pumping blood to the different parts of the body. The "lub dub" sound of the heartbeat that is heard in an instrument called stethoscope is caused by the closing of

the heart valves. They move with respect to or relative to certain objects like the sun, the stars and the moon. This means that motion is relative.

Motion is very easy to recognize but has been very hard to describe. There are several physical quantities that can quantitatively describe the motion of objects. Some of them are distance and displacement.

Distance vs. Displacement

Distance is usually described as the total path length. It is the length between an identified reference point and a designated position. It is a scalar quantity, which means that distance is expressed as magnitude only. It is expressed in units such as meter, kilometer, feet and the like. However, the standard (SI) unit for distance is meter. Here are some examples of distances.

Example 1.1 The distance between the tower and the boy is 10 m. This means that the length between the reference point (the tower) and the identified position (boy) is 10 m.



Example 1.2. The distance between the house and the church is about 5 m. This means that the total path length between the reference point (the house) and the identified position (church) is the sum of the different lengths (1m, 0.5m, 2m, and 1.5m), which is equal to 5 m.





Displacement, on the other hand, is the measure of how far an object has moved in a particular direction from its original position. This is usually described as the length between the initial and the final position or the change in position including the sign of the change. Displacement is a vector quantity. This means that displacement is expressed as magnitude with the corresponding direction. It is usually

given a symbol **d**, which is a symbol for a vector quantity. It is also expressed in units such as meter, kilometer, feet and the like. However, the standard (SI) unit for displacement is meter. Here are some examples of displacements.

Example 1.3. When the boy move from point A to point B, the distance of the boy from the tower is 10 m but the boy's displacement from the tower is 10 m, W. This means that the length between the initial position of the boy (point A) and the final position of the boy (point B) is 10 m moving toward the west. In symbols;



Example 1.4. However, if the boy who started from the tower (point A) moved to point B then went back to point A (tower), then the boy's initial position is point A (tower) while his final position is still point A (tower). Then the length between the initial and the final position is 0 m. Therefore, his displacement from the tower is 0 m.



Displacement can also be described as the difference between two distances.



What you will do Activity 1.1 Measuring Displacement

Objective:

To measure and determine displacement of a 10-centavo coin or a washer

Materials: washer or 10 centavo-coin, centimeter ruler paper

Procedure:

- 1. Place a washer or a 10-centavo coin on the number line with the center of the washer or the 10-centavo coin at the position marked zero.
- 2. Draw a circle around the inside of the washer or the 10-centavo coin.
- 3. Mark the center of this circle with the letter I for the word "initial" position of the washer.
- 4. Move the center of the washer 5.0 cm to the right. Label this circle **F** for the "final" position of the washer.



Guide Questions:

- 1. What was the <u>initial position</u> of the washer?
- 2. What is the final position of the washer?
- 3. What is the distance traveled by the washer?
- 4. What is the displacement of the washer?
- 5. Which of the underlined quantities (final position, distance traveled, and <u>displacement</u>) are numerically equal?



Key to answers on page 32

Speed and Velocity

The idea of rate is also a good tool in the description of motion. A rate is a quantity divided by time. It tells how fast something happens, how much something changes in certain amount of time. Speed is one example of a rate. It is a measure of how fast something is moving. It is also known as the rate at which distance is covered. In symbols;

$$v = \frac{d}{t}$$

where:

v = speed d = distance covered t = time of travel

The SI units used for speed is m/s, km/h, m/min, etc.



Here's a good way of remembering this equation and all other equations that can be derived from the given equation. If you need an equation for distance then cover distance and write the symbol d in your paper. In such a case, v and t are adjacent thus they are expressed as products.

Hence,

d = vt

If you want to have an equation for t, then cover t on the triangle and write the symbol t in your paper, then since d is written above v, then they appear as quotient. Thus, d and v must be written as ratio. In symbols,

t = d/v

Are you now ready to take a look at the example below and see how we can use the different equations?

Example 1.5

Elma Muros, the fastest female sprinter in the South East Asia can run along a 200-m distance in 24.42 seconds. What is Elma's speed?

| Given: | d | = | 200 m |
|--------|---|---|---------|
| | t | = | 24.42 s |
| RTF: | V | | |

| | ν | = | 9.53 m/s |
|-----------|---|---|-----------------|
| | v | _ | 10.49 <i>s</i> |
| | V | = | 100 <i>m</i> |
| | | | t |
| Solution: | ν | = | \underline{d} |

Instantaneous Speed and Average Speed

Take a look at the dashboard of car or a jeep when you ride in one of them. The circular gauge encircled in figure 1.2 is called a speedometer. A **speedometer** is an instrument that determines the instantaneous speed of a vehicle. Does the **speedometer** always register the same speed? At a red light, the car has a 0 km/h speed, and along the highway, its speed is probably 80 km/h. These individual speeds are known as instantaneous speeds. **Instantaneous speed** is the speed of an object at an instant.







Fig 1.3 Car Dashboard

Average speed, on the other hand, is the total distance covered by an object in a certain period of time. It is the representative speed of the whole course of travel. Using the sample of instantaneous speeds above, the average speed can be computed by getting the sum of all the individual speeds and dividing the sum by the number of instantaneous speeds. In the case above, the average speed is about (80 km/h + 0 km/h)/ 2, 40 km/h. On the other hand, a much easier way of determining the average speed is to look at the odometer. An odometer like the one encircled in figure 1.3 is an instrument that informs the total distance traveled by the vehicle. Average speed is the ratio of the total distance traveled and the total time of travel. In symbols,

$$r = \frac{dT}{tT}$$

where:

| Vave | = | average speed |
|-------|---|-------------------------|
| d_T | = | total distance traveled |
| t⊤ | = | total time of travel |

Our blood, which flows from one part of the body to another, has an average speed of about 0.6 m/s

Velocity

In everyday situations, speed and velocity are just the same. They only describe how fast an object moves. In physics, however, they are a lot different. Velocity is a speed in a given direction. It is known as the distance traveled in a particular direction in a given time interval. In symbols,

(3) $v = \frac{d, dir}{t_{\text{int}}}$

where:

v = velocity d, dir = distance in a given direction t_{int} = time interval

ν

More often than not, d + dir which means distance in a given direction is also called **displacement**. Both speed and velocity are expressed in units such as m/s, km/h, m/min, etc. Thus,

$$=$$
 $\frac{d}{t \text{ int}}$

where:

Example 1.6.

Karen drove to the city to pick up a friend. She went 280 km east in about 9.6 hours. Calculate her velocity.

Solution:

| 1. Given | Required to Find |
|-------------------------|------------------|
| d = 280 km, E | Vave |
| t _t = 9.6 hr | |

- 1. Equation: $\mathbf{v}_{ave} = \frac{d}{t_{int}}$
- 2. Solution: $\mathbf{v}_{ave} = \frac{d}{t_{int}}$ 280km, E

$$\mathbf{v}_{\text{ave}} = \frac{280 \text{km}, I}{9.6 \text{hr}}$$



What you will do Activity 1.2 Determining Average Speed and Average Velocity

Objective:

- A. To determine the average speed and the average velocity of a skier
- B. To differentiate average speed and average velocity

Procedure:

1. Below is a diagram of a man who is skiing. Ski is a sport that is done on places where we have snow.

Use the diagram to determine the average speed and the average velocity of the skier during these three minutes.



Results:

| Distance (0-1) min | Distance (1-2) min | Distance (2-3) min | Total Distance | Total Time | Average Speed |
|--------------------------|--------------------------|--------------------------|-------------------|---------------|------------------|
| | | 100 m | | 3 min | |

| Initial | Final | Displacement | Total | Average |
|----------|----------|--------------|-------|----------|
| Position | Position | (0-3) min | Time | Velocity |
| A | D | | 3 min | |

Guide Question:

1. Differentiate average speed and average velocity.



Acceleration

Imagine yourself driving your bicycle along the road when suddenly a man crosses the road. What would you do? Definitely you step on the brake! What happens to the bicycle as you step on the brake? When an object changes its velocity the object is said to accelerate. **Acceleration** is a measure of how fast the velocity changes with respect to time. This means that a body accelerates whenever there is a *change in speed*; a *change in direction*, or a *change in both the speed and direction*. Acceleration is expressed in units such as m/s², km/h², m/min², etc. Blood flow also exhibits acceleration. When the heart pumps the blood is pushed away from the heart. The sudden surge or push to the blood makes the flow of the blood change in speed or direction.

 $\frac{\Delta v}{t}$ int

a where: a = acceleration

a = acceleration $\Delta \mathbf{v}$ = change in velocity t_{int} = time interval

or

| а | = | $V_f - V_i$ |
|---|---|-------------|
| u | _ | t int |

where:

 $\mathbf{v}_{f} = final velocity$ $\mathbf{v}_{i} = initial velocity$



Oops! Before you go on, try this one!

A. Direction: Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

- 1 Which of the following is an example of acceleration?
 - A. 5 m/s
 - B. 5m/s²
 - C. 5 km/h
 - D. 5 m/min
- 2. Suppose you are in a car that is going around a curve the speedometer reads a constant
- 30 km/h. Which of the following is NOT true?
 - A. Your speed is constant
 - B. Your velocity is constant.
 - C. You and the car are accelerating
- 3. Which of the following exhibits acceleration?
 - A. A body at rest
 - B. A body at uniform speed
 - C. A body with uniform velocity
 - D. A body moving with constant speed in a circle
- 4. Which of the following instruments measures the distance traveled by a vehicle?
 - A. Odometer
 - B. Manometer
 - C. Speedometer
 - D. Anemometer
- 5. Which among the following is an example of velocity?
 - A. 50 km/h
 - B. 40 km/h
 - C. 50 mi/h
 - D. 40 mi/h, E

B. Direction: Write "A" if the situation shows an accelerated motion and write "B" if the situation shows that the motion of the object is not accelerated.

- 1. The initial velocity of a boy in a bike is about 5 km/h E while his final velocity is about 7 km/h E.
- 2. A boy on his bike moves around a curve with a constant speed of 5 km/h.
- 3. A man initially running at **7 km/h E**, moves west at the same speed of 7 km/h.

- 4. A boy initially running at around 3 km/h suddenly stops because of a truck.
- 5. A girl initially sitting on a bench stood up and started running.



Lesson 2 Linear Motion



Fig 2.1. Parachuters

Take a look at the parachuters. Are they falling? Are they moving horizontally? Motion comes in 2 forms: linear motion and curvilinear motion. **Linear motion** refers to the movement of an object along a straight path. Examples of these are vehicles and other objects with a constant acceleration and freefall. **Curvilinear motion** is the motion of bodies along curved paths. Projectile and object moving along circular paths are some examples.

Uniformly Accelerated Motion

If a vehicle maintains a constant or a uniform change in its velocity in a given time interval along a straight line, then the vehicle is said to have a constant acceleration. Its motion is known as **uniformly accelerated motion**. This constant acceleration could be derived using the equation:

a =
$$\frac{v_f - v_i}{t_{\text{int}}}$$

Free Fall



Fig 2.2 Water falls

Are there waterfalls in your vicinity? How would you describe them? The water is usually called a freely falling body. Its motion is known as free fall. **Freefall** is an example of a **uniformly accelerated motion**. In such a motion, the only force acting on the body is the **gravitational pull of the earth** which is also called the **earth's gravity**. For an object in freefall, the acceleration is a constant popularly known as **gravitational acceleration** or **acceleration due**

to gravity also directed downward (-g). On the earth's surface at sea level the exact magnitude is **9.8 m/s²**. Ten

(10 m/s²) is used, however, for easier analysis of motion. This means that the velocity of an object in freefall changes by 9.8 m/s or 10 m/s every second of fall.

If an object is dropped a certain distance from the ground, then its motion is also known as freefall. In such a case the initial velocity of the object dropped with respect to the vertical axis is zero (0). $v_i = 0$

Did you know that the concept of freefall helps determine our reaction time? Reaction time is the time it takes for the information sent to the brain to travel to the different parts of the body for execution. Here's one way of determining your reaction time



Here's a great task that you can do.

- 1. Ask a friend to help you.
- 2. Have a 12-in ruler and let your friend hold its tip for you.
- 3. Position your hand on the zero-mark of the ruler but take extra care not to touch the ruler.
- 4. When your friend releases the ruler, catch it with your fingers initially positioned at the zero-mark.
- 5. Note the distance covered from the zero mark to where your fingers are when you caught the ruler. This represents the distance covered.
- 6. Determine your reaction time using the equation:

$$t = \sqrt{(2d)/g}$$

where: t_r = reaction time

- d = distance covered
- g = acceleration due to gravity (9.8 m/s²)

Another example of a freely falling body is an object thrown vertically downward. For convention, the initial velocity of such case is always expressed as a negative value (downward, -vi). $v_i = -v$

Objects thrown vertically upward are also considered freely falling bodies. Whether the *object goes up or goes down* the only force acting is the pull of **earth's gravity**. The initial velocity of the object is only a result of the initial force exerted by the launcher.



Answer the following very carefully. Write your answers on a separate sheet.

A ball is thrown vertically upward.

- a. What is the acceleration of the ball after 1 s?
- b. What is the acceleration of the ball at its maximum height?
- c. What is the velocity of the ball at the top of its path?
- d. If the ball is thrown with an initial velocity of 50 m/s, what is the final velocity of the ball at a point at the same level as when it was thrown?
- e. What force was exerted on the ball 1 second after it was thrown?
- f. What exerts this force?
- g. What is the acceleration of the ball 10 seconds after being thrown up?
- h. If the ball took 5 s to reach its maximum height, how long will the ball go back to where it was initially launched?
- i. What is the acceleration of the ball at the top of its path?
- j. What is the speed of the ball at the top of its path?



Lesson 3 Curvilinear Motion

Projectile Motion



When the player hits the "Sepak", the motion of the "Sepak" is called **projectile motion**. The "Sepak" itself is called **projectile**. The "Sepak" will follow a parabolic path called **trajectory** especially if air resistance is negligible. Two coordinates are usually used to describe projectile motion: horizontal and vertical axes. The horizontal distance traveled by the projectile is called the **range**. While the vertical distance, that is, the distance from where it was launched to the top most point of its path is called its **height**.

Fig 3.1 Sepak Takraw Players

Examples of projectiles are cannon ball launched by a cannon, golf ball hit by a golfer, and an ice skater jumping over some barrels. Usually, a strong, abrupt force initiates the motion of a projectile. Following this force, the projectile moves through the air and is influenced only by the *earth's gravitational force* pulling it down and by air resistance. If the effect of air resistance is ignored, equations in free fall are

readily used to analyze the motion of a projectile – how high it will travel, how far it will go and so on.

A remarkable thing to note is that the same **range** is obtained from two different projection angles – complementary angles. An object thrown into the air at an angle of **75°**, for example, will have the **same range** as if it were thrown at the same speed at an angle of **15°**. An object thrown at **60°** will have the same range as when the object is launched at **30°**. As you can see, when we get the sum of **75°** angle and **15°** angle, **60°** angle and **30°**



Fig 2.4 Angle of Projection vs. Range

angle, in both sets we would obtain a 90° angle. This means that 75° angle and 15° angle are called **complementary angles**. Similarly, 60° angle and 30° angle are also **complementary angles**. Thus, complementary angles (*angles whose sum is equal to 90*°) would result to equivalent range. For smaller angles, object remains in the air for a shorter time. A **maximum range** is attained when an object is launched **45°** from the horizontal.



Projectile motion is a very helpful and practical concept in Physics. For example, if there are floods and rescuers could not reach the place, a rescue plane is usually used to drop a package of emergency rations to the victims

Fig 3.2 Plane to the rescue

Circular Motion



Have you experienced riding the merry-go-round? Which moves faster – the horse near the outside rail or the horse near the inside rail? Have you tried swinging a tin can overhead? When the string breaks, how does the can move? Does it move directly outward or does it move tangent to the circle?

Fig 3.3 Merry-go-round

You and your friends would probably answer the questions differently. Some may chose the horse near the inside rail, while others the horse near the outside rail. That's

because some of you maybe are thinking about linear speed while others rotational speed.

All objects that turn around on axis located within the object is said to be **rotating**. When an object turns about an external axis the rotational motion is called **revolution**.

Linear speed is what we have been calling simply "speed" – the distance traveled per unit of time. A point outside the merry-go-round moves a greater distance in one complete rotation than a point inside it. Linear speed is thus greater on the outside of a rotating object than closer to the axis.

Rotational speed (angular speed/velocity) refers to the number of rotations or revolutions per unit of time. All parts of a rotating object share the same rate of rotation. This rate of rotation is usually expressed in revolutions per minute (RPM). A common phonograph record, for example, rotates at 33.33 RPM.

However, linear and rotational speeds are related. Linear speed is directly proportional to rotational speed. This relationship is expressed in an equation as

where:

= rω

| ν | = | linear speed |
|---|---|-----------------------------|
| r | = | radius of the circular path |
| ω | = | angular/rotational speed |

In any rigid rotating system, all parts have the same rotational speed. Linear speed varies as. it depends on the rotational speed and the distance from the axis of rotation. From the equation above, we note that linear speed also depends on the distance from the center. The greater the radius the greater the linear speed if the rotational speed is kept constant. At the very center (the axis of the rotating object) you have no linear speed but you still rotate.



Objective:

To observe circular motion.

Materials: tin can, string, cutter or scissors

Procedure:

- 1. Tie a long string to a tin can.
- 2. Whirl the tin can at the end of the string above your head until you are able to make horizontal circles.
- 3. Observe how the tin can moves while traveling along the circular path.
- 4. Observe how your hand holding the string tied to the tin can behave.

What do you notice? Did you notice that you kept on pulling the string to maintain its circular motion? This force that causes the tin can to follow a circular path is called centripetal force. **Centripetal force** means "**center-seeking**" or **towards the center**. In the case of the can your hand exerts the centripetal force.



Gravitational force is the centripetal force exerted on moon by earth to maintain an almost circular path. The same centripetal force (gravitational force) is responsible for keeping the planets in their orbit about the sun. And in an atom, the electron orbits the nucleus because of the electrical force between them.

Centripetal force depends on the mass (m), the tangential speed (v), and the radius of curvature (r) of the circularly moving object. In symbols;

$$F_c = \frac{mv^2}{r}$$

where:

Fig 3.4 (upper) Solar System (lower) Atom

 F_c = centripetal force m = mass r = radius of curvature v = tangential speed



Objective: To observe circular motion.

Materials: tin can, string cutter or scissors

Procedure:

- 1. While whirling the tin can, cut the string.
- 2. Observe the motion of the can while it moves away from the circular path.

If the string breaks how does the tin can move? In the early years people thought that a "center-fleeing" force counteracts the centripetal force. This is known as centrifugal force. It is believed that centrifugal force pulls the can from its circular path. But the fact is that when the string breaks, the can goes off in a *tangent, straight-line path because no force acts on it*! Similarly, if you are in a car that rounds a sharp corner to the left, you tend to pitch outward to the right – not because of an outward force but because of the absence of centripetal force holding you in circular motion (as a seatbelt provides).

Lesson 4 Physics and Transportation



Which among the following vehicles do you often use? Does it make traveling more convenient or it is better to travel on foot. Which do you prefer?



Have you ever tried riding on one of the following forms of transportation? Do you have any idea what forms of transportation were used by your ancestors like your grandmother or great grandmother?

Brief Account of Transportation

No one basically knows when humankind first tamed the ox, the burro, the horse and the carabao. All we know is that we do move from one place to another to trade using our **feet.** American Indians shipped copper, iron oxide and other valuables from Minnesota to Alabama on foot over "forest highways" or downriver.



The principal innovation on land transportation was the construction of roads where **horses** and riders could keep a **message** moving at the speed of about two hundred miles a day. **Freight was carried by a camel**, **an elephant**, **a burro or an ox. Human porters**, on the other hand, carried cargos in China. In the Philippines, the most famous animal is the **carabao (kalabaw)**. It carries freight for its owner who is usually a farmer. Later, carriages were connected to these animals to improve the transport of goods and people..

In the Philippines, we call a horse-driven carriage as "**kalesa**". The **kalesa** or **karitela** was introduced during the 18th century. Spanish officials and nobles used it as a chief means of transportation. The illustrados, the rich Filipinos who had their own businesses, used the kalesa not only for traveling but as a means of transporting their goods.





In 1867, the **motorcycle** was first invented. By the 1880's inventors tried very hard to make cars that would run well enough to use everyday. Since the cars replaced the horses and they ran on steam, they were called "Iron Horses" (steam-powered cars). By 1890's Europeans were buying and driving cars by Benz.



In the United States, automotive progress was exemplified by the Old Motor Works, which mass produced 425 cars in 1901. In 1908-1927 Henry Ford made the **Ford Model T**, which was **ran by gasoline** but costs much less than other cars. It ran well on dirty and bumpy roads. During this era, the Wright brothers invented the first heavier-thanair flight.



By the 1930's transoceanic "flying boats" were plying the ocean of the world at speeds greater than 150 miles an hour. Aircraft played a dominant role in World War II. In the Philippines, the exotic **jeepney** is a post-war creation inspired by the GI jeeps that the American soldiers brought to the country in 1940's. Enterprising Filipino salvaged the surplus engines and came out with a unique vehicle of art.



Then the jet passenger aircraft came. These were followed by supersonic transport. Not long after, the aerospace planes and spaceships came.



In land transportation, one of the fastest vehicles is the **bullet train** or the **MagLev** (**Magnetically Levitated**) **Trains.** These are run by electricity, which also creates magnetism on both the rails and the road. Since both (rail and road) are like poles they then repel each other causing the train to be levitated or to be at a vertical distance (floating) from the road. In such a case, friction is decreased and the velocity of the train is increased.



Today, there are many modes of transportation available in the Philippines. There are buses, taxi, jeepneys, the LRT (Light Rail Transit) and MRT (Metro Rail Transit).





Objective: To be able to complete the timeline below.

Materials: worksheet, pencil

Procedure:

Complete the timeline illustrated below. You may do this by illustrating or identifying the means or form of transportation according to the passage **Brief Account of Transportation.**





Answer the following very carefully. Write your answers on a separate sheet.



С

Which among the sets of vehicles would your prefer? Cite the advantages and disadvantages of your choice.



D



Objective: To identify basic physics principles that are related to transportation.

Materials: worksheet, pencil

Procedure:

1. Below is a picture of a vehicular accident. Identify as many physics concepts related to the accident as you can.



| Physics concepts: | |
|-------------------|--|
| | |
| | |
| | |
| | |
| | |



Understanding transportation accidents requires knowledge of the physics of moving bodies. Although these physical laws were discovered largely by Galileo and by Sir Isaac Newton in the 1600's, they were not always clearly understood. However, they really are very simple, and depend only on a few key principles, which are familiar to you **Newton's laws of motion**. Newton correctly explained the behavior of most objects. Transportation problems require the application of **Newton's Second Law**, which states that the acceleration of a body is proportional to the force applied and inversely proportional to the body's mass.

Acceleration is not just "gaining speed." Gaining speed is only one form of acceleration. Braking or losing speed is another form, and it is usually expressed as negative acceleration. Regardless of its type, acceleration requires force and is resisted by mass.

The law of friction states that the frictional force between two surfaces is proportional to the "normal" force between them times the coefficient of friction. The normal force is the force tending to press the surfaces together. In automotive situations, the normal force is the weight of the car on the tires. In normal operation, the frictional forces of the tires are the main acceleration and braking forces on an automobile, and those forces limit the acceleration, braking and cornering ability of the automobile. With these ideas and concepts it is possible to predict the braking distance of an automobile when the speed and coefficient of friction with the road are known.

Clearly, researches in physics brought about many inventions such as airbags, computerized fuel injection, electric sensors, General Pocket Radio Service (GPRS) and the likes which are very helpful in upgrading both the efficiency of the engine and the safety of the passengers. Physics has helped transportation a lot.



- 1. Distance is usually described as the total path length. It is the length between an identified reference point and a designated position
- 2. Displacement is the length between the initial and the final position.
- 3. Motion is relative. It is easy to recognize but hard to describe.
- 4. Rate, which describes motion, is a quantity per unit time.
- 5. Speed determines how fast an object moves. It is the ratio of the distance traveled and unit time.
- 6. Velocity describes how fast an object moves in a given time in a particular direction.
- 7. Acceleration is the change in velocity that happened in a period of time.
- 8. The two types of motion are linear motion and curvilinear motion
- 9. Uniformly accelerated motion and freefall are examples of linear motion.
- 10. Projectile and circular motions are examples of curvilinear motion.
- 11. A body is said to be moving in a uniformly accelerated motion when it maintains a constant acceleration throughout the motion.
- 12. The motion of a body on which the only force acting on it is the gravitational pull of the earth is known as freefall.
- 13. Projectile is a motion of an object when the only force acting on it is gravity. It includes both horizontal and vertical components of motion.
- 14. Circular motion occurs when there is a force exerted on an object that is directed towards the center. This force is known as centripetal force.
- 15. Linear speed is what we have been calling simply as "speed" the distance traveled per unit of time.
- 16. Physics plays an important role in the advancement of transportation.



Direction: Choose the letter of the best answer. Write your answer on a separate sheet of paper

- 1. Which statement is true?
 - A. Speed indicates the direction of motion.
 - B. Velocity indicates the direction of motion.
 - C. Velocity measures the rate of motion only.
 - D. The magnitudes of velocity and speed are always equal.

2. A projectile is thrown 30° above the horizontal. What happens to its acceleration as it moves upward?

- A. It decreases because its velocity is directed upward
- B. It increases because its velocity is directed upward
- C. It decreases because its velocity is decreasing
- D. It remains the same
- 3. Which of the following is an example of acceleration?
 - A. 5 m/s
 - B. $5m/s^2$
 - C. 5 km/h
 - D. 5 m/min

4. Suppose you are in a car that is going around a curve and the speedometer reads a constant 30 km/h. Which of the following is **not** true?

- A. Your speed is constant.
- B. Your velocity is constant.
- C. You and the car are accelerating.
- 5. Which of the following exhibits acceleration?
 - A. A body at rest
 - B. A body at uniform speed
 - C. A body with uniform velocity
 - D. A body moving with constant speed in a circle
- 6. Which of the following instruments measures the distance traveled by a vehicle?
 - A. Odometer
 - B. Speedometer
 - C. Anemometer
 - D. Manometer

- 7. When you throw a ball directly upward, it is accelerated ______.
 - A. at all times
 - B. only as it falls
 - C. during the instantaneous stop and during fall
- 8. Which of the following instruments measures the instantaneous speed of a vehicle?
 - A. Odometer
 - B. Speedometer
 - C. Anemometer
 - D. Manometer

9. Suppose an object is in freefall. The object falls each second ______.

- A. with the same average speed
- B. with the same change in velocity
- C. with the same instantaneous speed
- D. with the same distance as in the second

10. If you drop a feather and a coin at the same time in a vacuum tube, which will reach the bottom of the tube first?

- A. The coin
- B. The feather
- C. Both will reach the bottom at the same time

For Nos. 11-16 the choices are:

- A. 0 m/s^2
- B. 9.8 m/s
- C. 9.8 m/s²
- D. -50 m/s

11. A ball is thrown vertically upward. At the top of its path what is its velocity?

- 12. A ball is thrown vertically upward. At the top of its path what is its acceleration?
- 13. A ball is thrown vertically upward, with an initial velocity of 50 m/s and caught back at the same level as when it was thrown. What is the velocity of the ball at that point?
- 14. A ball is thrown vertically upward. What is its instantaneous speed at its maximum height?
- 15. A ball is dropped from a cliff. What is the acceleration of the ball before it touches the ground?
- 16. A ball is thrown vertically upward. What is the change in velocity of the ball after 1 second?

- 17. The positions of two blocks at successive 0.20-second time intervals are represented by the numbered squares in the figure below. The blocks are moving toward the right. Do the blocks ever have the same speed?
 - A. No.
 - B. Yes, at instant 2.
 - C. Yes, at instant 5.D. Yes, at instants 2 and 5.



- E. Yes, at some time during the interval 3 to 4
- 18. A steel ball is attached to a string and is swung in a circular path in a horizontal plane as illustrated in the accompanying figure. At the point P indicated in the figure, the string suddenly breaks near the ball. If these events are observed from directly above as in the figure, which path would the ball most closely follow after the string breaks?
- 19. A bowling ball accidentally falls out of the cargo bay of an airliner as it flies along in a horizontal direction. As observed by a person standing on the ground and viewing the plane as in the figure at right, which path would the bowling ball most closely follow after leaving the airplane?
- 20. If you whirl a tin can on the end of a string and the string suddenly breaks, the tin can will
 - A. fly directly away from you.
 - B. fly off tangent to its circular path.
 - C. fly directly toward you.
 - D. spiral away from your hand.









Pretest

| 1. | C | 11.D |
|----|----|-------|
| 2. | В | 12. D |
| 3. | С | 13.B |
| 4. | A | 14.C |
| 5. | С | 15.D |
| 6. | С | 16.A |
| 7. | С | 17.D |
| 8. | В | 18.D |
| 9. | В | 19.B |
| 10 | .A | 20.C |

Lesson 1

Activity 1.1

- 1. 0 cm-mark
- 2. 5 cm-mark
- 3. 5 cm
- 4. 5 cm, right
- 5. distance and displacement

Activity 1.2

| Distance (0-1) min | Distance (1-2) min | Distance (2-3) min | Total Distance | Total Time | Average Speed |
|--------------------------|--------------------------|--------------------------|-------------------|---------------|------------------|
| 180 m | 140 m | 100 m | 420 m | 3 min | 140.00 m/min |

| Initial | Final | Displacement | Total | Average |
|----------|----------|--------------|-------|--------------------------|
| Position | Position | (0-3) min | Time | Velocity |
| A | D | 140 m | 3 min | 46.67 m/min, right |

* Velocity is the rate of displacement while speed is the rate of distance.

Self-Test 1.1

- Α.
- 1. 2.
- 2. B 3. D

В

- 4. A
- 5. D

Lesson 2

Self-Test 2.1

- a. 9.8 m/s²
- b. 9.8 m/s²
- c. 0
- d. –50 m/s

Lesson 4

Self-Test 4.1

Choice A

- Advantages
 - no use of fuel or gasoline
 - lesser accidents
- Disadvantages
 - slow
 - tiring

Choice B

Advantages

- no use of fuel or
 - gasoline
- lesser accidents
- faster than on foot
- Disadvantages
 - slow
 - tiring

Choice C

Advantages

- faster than animal driven
- much more convenient
- carry more load and passengers
- Disadvantages
 - use fuel and gasoline
 - pollutes air

Choice D

- Advantages
 - very fast
 - very convenient
 - carry lots of load and passengers
- Disadvantages
 - high use of fuel
 - pollution

f. Earth g. 9.8 m/s²

e. Gravity

- h. 5 s
- i. 9.8 m/s²
- j. O

Β.

1. B

2. A

3. A

4. A

5. A



Activity 4.2

- 1. Newton's Laws
- 2. Friction
- 3. Momentum
- 4. Impulse
- 5. Energy

Posttest

| 1. B | 11.A |
|------|-------|
| 2. D | 12.C |
| 3. B | 13.D |
| 4. B | 14.A |
| 5. D | 15.C |
| 6. A | 16.B |
| 7. A | 17.A |
| 8. B | 18.B |
| 9. B | 19. D |
| 10.C | 20.B |

-End of Module-

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