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Senior High School

General Physics 1

Quarter 2 - Module 3

Periodic Moton

Department of Educaton • Republic of the Philippines

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We value your feedback and recommendations.

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Table of Contents

Module 3 Periodic Moton

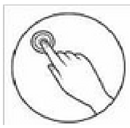
What This Module is About

This module provides you with explanation of many other phenomena in nature. We begin this new part of the text by studying a special type of motion called periodic motion or oscillation. This is a repeatiDnogw nmloaodtieod nbys aoldfr ina nal coisbo j(ealcdtri ninal cwisoh2i@chgm a given position after a fixed time interval. Many kind of motion repeat themselves over and over: the vibration of a quartz crystal in a watch, the swinging pendulum of a grandfather clock, the sound vibrations produced by a clarinet or an organ pipes, and the back-and-forth motion of the pistons in a car engine.

The lessons in this module are necessary and essential in studying other concepts in the next modules.

The following are the lessons contained in this module:

- **Lesson 1- Periodic Moton** ▯ **Lesson 2- Simple Harmonic Moton** ▯ **Lesson 3- Pendulum**
- **Lesson 4- Mechanical Wave**



What I Need to Know

In this module, you are expected to:

1.Relate the amplitude, frequency, angular frequency, period, displacement, velocity and acceleration of oscillating system **(STEM_GP12PM-IIc-24)**;

2.Recognize the necessary conditions for an object to undergo simple harmonic motion **(STEM_GP12PM-IIc-25)**;

3.Calculate the period and the frequency of spring mass, simple pendulum, and thephysical pendulum **(STEM_GP12PM-IIc-27)**;

4.Define mechanical wave, longitudinal wave, transverse wave, periodic wave, andsinusoidal wave **(STEM_GP12PM-IId-31)**; and

5.From a given sinusoidal wave function infer the speed, wavelength, frequency, period, direction, and wave number **(STEM_GP12PMIId-32).**

How to Learn from this Module

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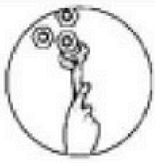
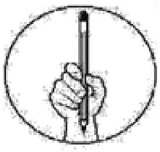
To achieve the learning competencies cited above, you are to do the following:

- Take your time reading the lessons carefully.
- Follow the directions and/or instructions in the activities and exercises diligently.
- Answer all the given tests and exercises.

Icons of this Module

	What I Need to Know	This part contains learning objectives that are set for you to learn as you go along the module.
	What I know	This is an assessment as to your level of knowledge to the subject matter at hand, meant specifically to gauge prior related knowledge
	What's In	This part connects previous lesson with that of the current one.
	What's New	An introduction of the new lesson through various activities, before it will be presented to you
	What is It	These are discussions of the activities as a way to deepen your discovery and under-standing of the concept.
	What's More	These are follow-up activities that are in-tended for you to practice further in order to master the competencies.
	What I Have Learned	Activities designed to process what you have learned from the lesson
	What I can do	These are tasks that are designed to show-case your skills and knowledge gained, and applied into real-life concerns and situations.



What I Know

MULTIPLE CHOICES. Directions**:** Read and understand each item and choose the letter of the correct answer. Write your answers on a separate sheet of paper.

1.At which position is the speed of a particle executing SHM greatest?

a.It's extreme position
b.at its equilibrium position
c.at its maximum displacement
d.somewhere between amplitude and equilibrium position

2.At which position is the acceleration of a particle executing SHM equal to zero?

a.at its extreme position
b.at its equilibrium position
c.at its maximum displacement
d.somewhere between its amplitude and equilibrium position

3.The total energy of a simple harmonic oscillator is equal to $\frac{1}{2}kx^2$. What does x represent?

a. any value
b.amplitude of the oscillator
c.equilibrium position of the oscillator
d.position between the maximum displacement and equilibrium position

4.Which type of harmonic motion refers to oscillatory motion with decreasingamplitude?

a.critically damped c. simple
b.overdamped d. under dumped

5.What does a wave carry with it as it travels through a medium?

a.energy b. matter c. water d. wind

6.In which type of wave are the particles of the medium vibrate parallel to thedirection of wave propagation?

a.Longitudinal b. mechanicalc. seismic d. transvers

7.Which of the following is an example of a longitudinal wave?

a.gamma ray b. Sound wave c. water wave d. x-ray 8. What is the highest part of the wave called?

a. amplitude b. crest c. trough d. wavelength 9. Which of these is not a characteristic of a wave?

a.amplitude c. period
b.mass d. velocity

10. If a wave has a period of 0.25 seconds, what is its frequency?

a.0.25 Hz c. 4.0 Hz.
b. 1.0 Hz d. 12 Hz

Lesson 1

Periodic Moton

What's In

Many kinds of motion repeat themselves over and over – from the movement of the hands of a clock, the swinging pendulum of a grandfather clock, a rocking chair, heartbeat, the sound vibrations produced by a clarinet or an organ pipe, and the back-and-forth motion of the pistons in a car engine, and even the movement of Earth about its axis and about the sun. This kind of motion, called periodic motion or oscillations.

What I Need to Know

After this lesson, you should be able to:

1. Relate the amplitude, frequency, angular frequency, period, displacement, velocity and acceleration of oscillating system **(STEM_GP12PM-Ilc-24)**

What's New

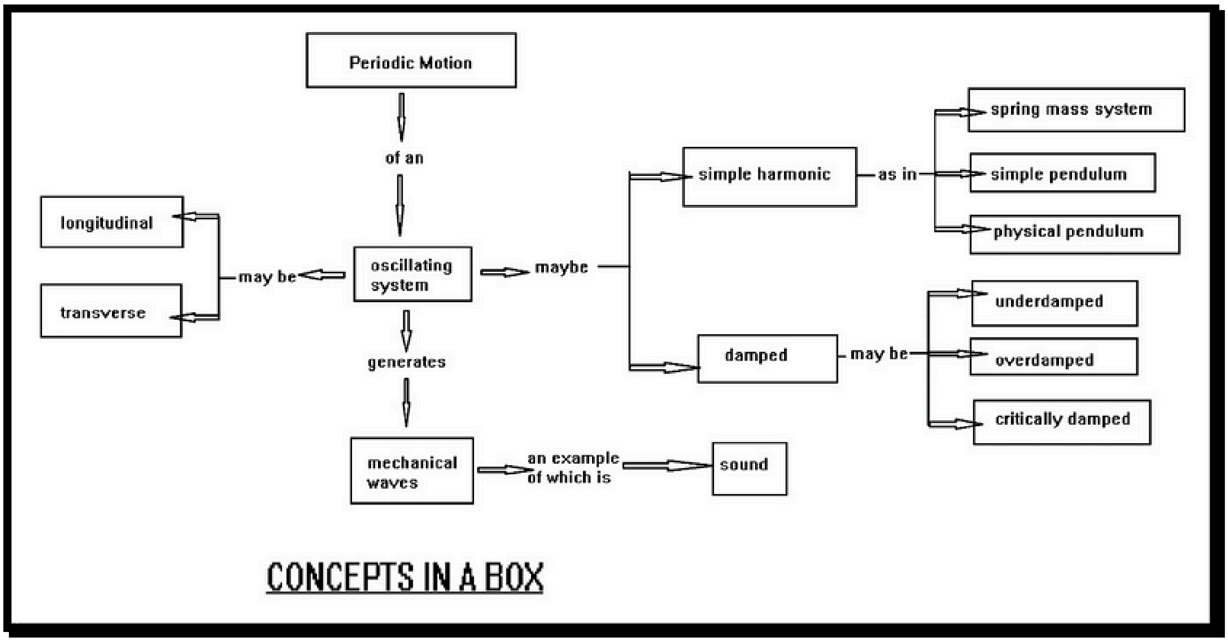
Actvity 3.1 Concepts in a Box

Directions:

1.Study Concepts in a Box for three minutes. There is no right or wrong answers for now. Take note of your answers and validate basic concepts you mentioned.

2. List down five concepts that caught your attention and explain why these concepts seem to be interesting. You may use a T-chart to organize your answer.

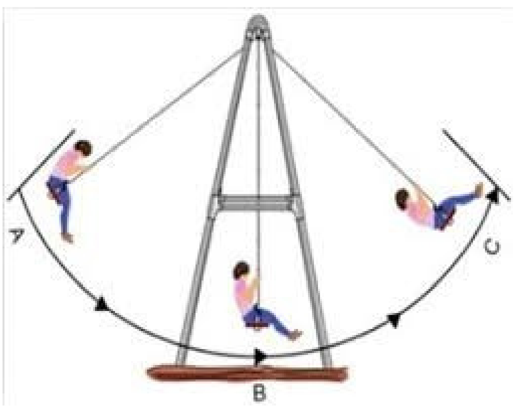
Concepts that caught my attention are…	Reason why I found it interesting…



What Is It

Periodic motion is a motion of an object that regularly repeat—the object returns to a given position after a fixed time interval. With little thought, we can identify several types of periodic motion in everyday life. Your car returns to the driveway each afternoon. You return to the dinner table every night to eat. A bumped chandelier swing back and forth, returning to the same position at a regular rate. The Earth return to same position in its orbit around the Sun each year, resulting in the variation among the four seasons. The Moon return to the same relationship with the Earth and the Sun, resulting in a full Moon approximately once a month.

Figure 3.1 The Motion of the swing is an example of periodic motion.



A body undergoing periodic motions always has a stable equilibrium position. The ***equilibrium position***, otherwise known as *resting position*, is the position assumed by the body when it is not vibrating. This equilibrium position is represented by position B of the boy in the swing and figure 3.1. When the boy is displaced from its equilibrium position to position A, a restoring force(gravity) acts on it to pull it back toward position B.

A *restoring force* is the force that tends to restore a body from its displacement to its equilibrium position. By the time the boy reaches position B, the body has gained kinetic energy, overshoots this position, moves, and stops somewhere on the other side (Position C). The body is again pulled back towards equilibrium. Vibrations about this equilibrium position results only from the action of the restoring force.

The ***amplitude (A)*** of vibration is the maximum displacement of a body from its equilibrium position. This is represented by the displacement from position B to position A or from position B to position C.

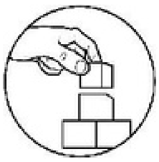
The ***period (T)*** of a body in periodic motion is the time required to make a complete to-and-fro motion. One complete to-and-fro motion is called a *cycle*. Referring to figure 3.1, the motion of the swing from position A to position C and back to position A is one cycle. Period is usually in *seconds*.

Frequency (f) is the number of the cycle per unit time. It's SI unit is the hertz, abbreviated as Hz. One (1) hertz equals one cycle per second. Frequency is the reciprocal of period.

$$f = \frac{1}{T} \qquad \text{Equation 3.1}$$

Sometimes, ***angular frequency (ω)*** is use instead of frequency. Angular frequency is commonly express in radians per second. The relationship between angular frequency and frequency is given by

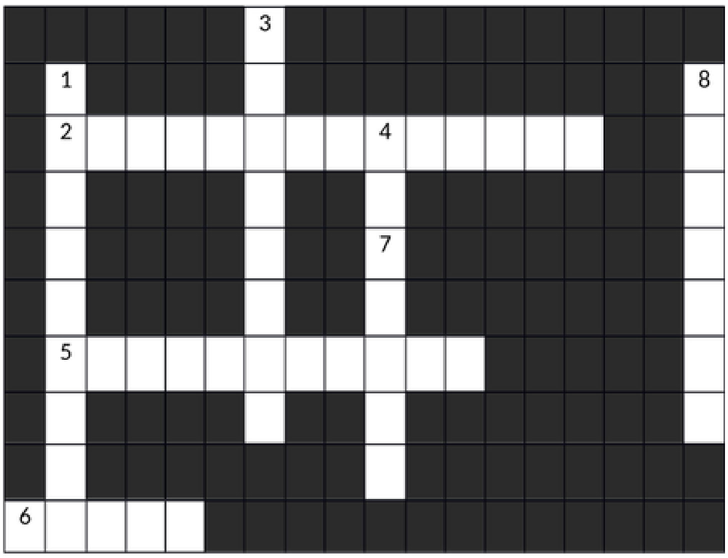
$$\omega = 2\pi f \vee \omega = \frac{2\pi}{T} \qquad \text{Equation 3.2}$$



What's More

Actvity 3.2 Completng Crossword Puzzle

Direction: Complete the crossword puzzle below.



Down

1. It is the number of cycles per unit of time from its equilibrium position.
3. It refers to motion that is repeated at regular intervals of time.
4. It's a force that causes body toaccelerate towards the earth.
8. It is the energy possessed by a body in motion.

Across

2. It is a force that tends to restore a body.
5.It refers to the position assumed by the body when it is not vibrating
6.It refers to one complete to-and-from motion
7.It is the maximum displaDcoewmnloeandetd o bfy balodrdiny a flcriosom (a lidtrsin ealqciusoi2li@brgimu

Lesson 2 Simple Harmonic Moton (SHM)

What's In

In the previous lesson, we learned that a body undergoes periodic motion always has a stable equilibrium position. When it is moved away from this position and released, a force comes into play to pull it back toward equilibrium. By the time it gets there, it picked up some kinetic energy, so it overshoots, stopping somewhere on the other side, and is again pulled back toward equilibrium. For this lesson, we will recognize the necessary conditions for necessary condition for a periodic motion to be classified as a simple harmonic motion.

What I Need to Know

After this lesson, you should be able to:

1. Recognize the necessary conditions for an object to undergo simple harmonic motion **(STEM_GP12PM-IIc-25)**
2. Calculate the period and the frequency of spring mass, simple pendulum and physical pendulum **(STEM_GP12PM-IIc-27)**

What's New

ACTIVITY 3.3 SHM Actvity

Direction: Place a raisin or marshmallow on the end of a stick of spaghetti. Shake your hands back and forth to make the pasta/raisin system oscillate.

Materials: Pasta and Raisins/Marshmallows

A. Does the period depend on the mass?

____

____

B. Does the period depend on the length?

____

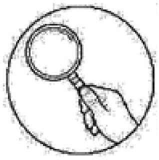
____

Answer the following questions on a separate paper.

a) Do you think this system motion would fall under the classification of *simple harmonic motion?* Provide as much evidences as you can for your answer.

b) Do your answers to A and B above matches a spring/mass system or a pendulum? How so?

c) Do you think this system can be modeled as pendulum, spring, or neither? What are your reasons for each?



What Is It

4

A very common type of periodic motion is what we called **simple harmonic moton (SHM)**. It is a type of periodic motion where the restoring force is proportional to the displacement of the body from its equilibrium position. This restoring force act in a direction opposite that of the displacement.

In equation, $F_s = -kx$ Equation 3.3

where, F_s is the restoring force or spring force x is the displacement from the equilibrium position k is a proportionality constant

The negative sign simply means that the restoring force and displacement are oppositely directed. We call this restoring force because it is always directed toward the equilibrium position and therefore opposite the displacement from equilibrium.

A system that oscillate with SHM is called **simple harmonic oscillator**. The simplest form of a simple harmonic oscillator is a body of mass *m* oscillating on one end of an elastic spring also known as the *mass-spring system.*

In the model for simple harmonic motion, consider a block of mass m attached to the end of a spring, with the block free to move on a horizontal, frictionless surface Figure 3.2.

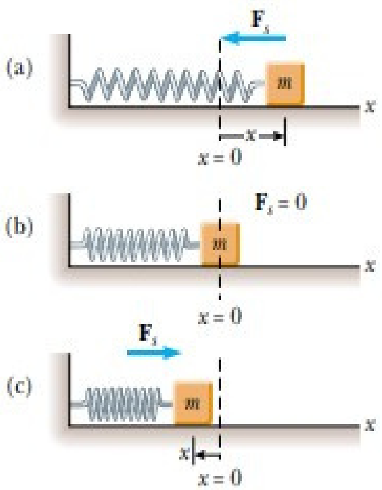


Figure 3.2. A block attached to a spring moving on a frictionless surface.

(a)Stretched spring. When the block is displaced tothe right of equilibrium (x > 0), the force exerted by the spring acts to the left.

(b)When the block is at its equilibrium position (x = 0), the force exerted by the spring is zero.

(c)Compressed spring. When the block is displacedto the left of equilibrium (x < 0), the force exerted by the spring acts to the right.

Note that the amount of the spring is negligible to the amount of stretching for compressing force.

An external force can cause object, like spring, to stretch or compressed by a certain displacement x (figure 3.2). This force is numerically equal to the restoring force but opposite in direction. Thus,

$$F = kx \qquad \text{Equation 3.4}$$

The proportionality constant (*k)* is what we called the *force constant* of the spring. It is the force needed to produce a unit of elongation or compression of the spring and has the unit of *N/m.*

The *force constant k* is measure of the stiffness of the spring. A small value of *k* indicates that the spring can be easily stretched or compressed. In other words, springs with lesser spring constants will have greater displacements than those with larger spring constants for the same amount of force applied.

Sample Problem 3.1

1. An oscillating body takes 0.8 seconds to complete four cycles. What is the (a)period, (b)frequency, and (c)angular frequency of the body?

Solution:

a.We are asked to determine the time taken to complete one cycle.

$$T=\frac{time}{number of cycles}=\frac{0.8\,s}{4}=0.2s$$

b. Substituting the value of *T* in Equation (3.1), $f=\frac{1}{T}=\frac{1}{0.2\,s}=5.0\,s^{-1}\vee 5.0\,Hz$

$$\omega = 2\pi f = 2(3.14 radians)(5.0s^{-1}) = 31.4\ radians/s$$

Sample Problem 3.2

2. A force of 3.0N elongates a spring by 6.0 cm. (a) What is the force constant of spring? (b) How much force is needed to elongate spring an additional 6.0 cm?

Solution:

Using Equation 3.4 and substituting values,

a. $k=\frac{F}{x}=\frac{3.0\,N}{0.06m}=\frac{50\,N}{m}$

b. $F=kx=\left(\frac{50\,N}{m}\right)(0.12m)=6.0\,N$

What's More

Actvity 3.4: Simple Harmonic Moton Problems

Direction: Solve the following problems. Show your complete solutions legibly and concisely in a separate sheet of paper.

1. It takes 365.25 days for the Earth to complete one revolution around the sun. Calculate the (a) period, (b) frequency, and (c)angular frequency of Earth as it revolves around the sun.

What I Have Learned 6

Actvity 3.5: Self-check Questons

1.What is the necessary condition for a periodic motion to be classified as a simple harmonic motion?

____

____

2.What is the physical meaning of the force constant of a spring?

____

____

3.When are maximum acceleration and maximum velocity achieved in a simple harmonic oscillator?

____

____

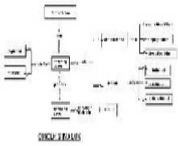
What I Can Do

Actvity 3.6: Create Your Own Problem

Make **your own** word problem. One problem calculating the period and the frequency of spring mass. Show your complete solutions to the problems. Be sure that the problems are not taken from the internet and that they are realistic.

Lesson 3

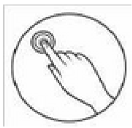
Pendulum



What's In

In the previous lesson, we recognized the necessary conditions for a periodic motion to be classified as a simple harmonic motion. In this lesson, will learn the concept of simple pendulum and physical pendulum as well as how to calculate the period and the frequency of simple and physical pendulum.

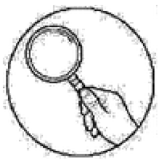
A pendulum is any object which can swing freely from a pivot point under the influence of gravity.



What I Need to Know

After this lesson, you should be able to:

1. Calculate the period and the frequency of spring mass, simple pendulum and physical pendulum **(STEM_GP12PM-Ilc-27)**



What Is It

The **simple pendulum** is another mechanical

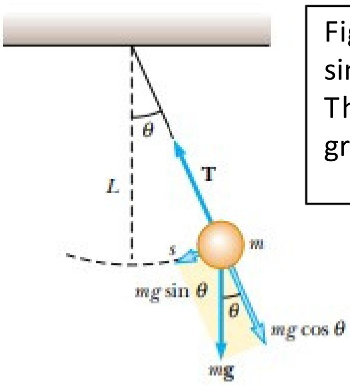


Figure 3.3 When is small, a simple pendulum oscillatesϴ in simple harmonic motion about the equilibrium position. ϴ = 0. The restoring force is –mg sin , the component ofϴ the gravitational force tangent to the arc

system that exhibit periodic motion. It consists of a particle-like bob of mass *m* suspended by a light string of length *L* that is fixed at the upper end, as shown in Figure 3.3.

The motion occurs in the vertical plane and it is drivenby the gravitational force. We shall show that,provided the angle. is small (less than about10°), the motion is very close to that of simpleharmonic oscillator.

The forces acting on the bob are the force *T* exerted by the string and the gravitational force *mg*. The tangential c

Θ=0, opposite the displacement of the bob from the lowest position. Therefore, the tangential component is a restoring force, and we can apply Newton's second law for motion in the tangential direction:

$$F_t = -mg\sin\Theta = m\frac{d^2s}{dt^2} \qquad 8$$

where *s* is the bob's position measured along the arc and the negative sign indicates that the tangential force acts toward the equilibrium (vertical) position.

The period of the motion is $T = 2\pi\sqrt{\frac{L}{g}}$ Equation 3.5

In other words, the period and frequency of a simple pendulum depends only on the length of the string and the acceleration due to gravity. The simple pendulum can be used as timekeeper because its period depends only on its length and the local value of g. It is also a convenient device for making precise measurements of the freefall acceleration. Such measurements are important because variation in local values of g can provide information on the location of oil and of other valuable underground resources.

Based on the equation, the period of a simple pendulum is governed by the following laws.

1. The period of simple pendulum is directly proportional to square root of its length.
2. The period is inversely proportional to square root of the acceleration due to gravity.
3. The period is not dependent of the mass of the bob.
4. The period is independent of the angular amplitude if angular displacement is small, say less than or equal to 100 .

Sample Problem 3.3

A simple pendulum of length 50.0 cm takes 5s to make 10 complete backand-forth motion. (a) Find its period. (b) What will be its period when its length is increased to 200cm?

Solution:

a. $T = \frac{time}{numberof\ cycles} = \frac{5\,s}{10} = 0.5s$

b. Based on the laws governing the period of simple pendulum, T

$$\frac{T_1}{T_2} = \frac{\sqrt{L_1}}{\sqrt{L_2}}$$

Using this equation and substituting values,

$$\frac{T_1}{T_2}=\frac{\sqrt{L_1}}{\sqrt{L_2}} \longrightarrow \frac{0.5s}{T_2}=\frac{\sqrt{50.0\,cm}}{\sqrt{200cm}} \longrightarrow T_2 = 1.0s$$

Physical Pendulum 9

Suppose you balance a wire coat hanger so that the hook is supported by your extended index finger. When you give the hanger a small angular displacement (with your other hand) and then release it, it oscillates. If a hanging objects oscillates about a fixed axis that does not pass through its center of mass and the object cannot be approximated as a point mass, we cannot treat the system as a simple pendulum. In this case the system is called a ***physical pendulum***.

Consider a rigid object pivoted at a point O that is a distance d from the center of mass (Figure 3.4).

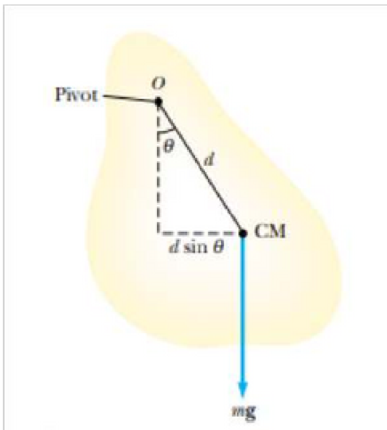


Figure 3.4 A physical pendulum pivoted at O

The gravitational force provides a force about an axis through O, and the magnitude of that torque is *mgd sin*ϴ., where ϴ is as shown in Figure3.4. Using the rotational form of Newton's second law ∑ where *I* is the moment of inertia about the axis through O, we obtain

$$-mgd\sin\vartheta = I\frac{d^2\vartheta}{dt^2}$$

The negative sign indicates that the torque about O tends to decrease ϑ .. That is, the gravitational force produces a restoring torque.

The period of the motion is $$T = 2\pi\sqrt{mgL}$$ Equation 3.6

One can use this result to measure the moment of inertia of a flat rigid object. If the location of the center of *mass*—and hence the value of *d*—is known, the moment of inertia can be obtained by measuring the period. Finally, note that Equation 3.6 reduces to the period of a simple pendulum (Equation 3.5) when $I=md^2$ – that is, when all the mass is concentrated at the center of mass.

Sample Problem 3.4

A 1.5kg uniform meter stick pivoted at one end oscillates as a physical pendulum with a period of 1.25s. Find its moment of inertia with respect to the pivot point.

Solution:

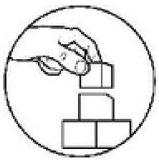
Manipulating equation 3.5 to solve for *I* and substituting values,

$$\frac{(¿¿2)(1.5\,kg)(9.8\,m/s\,2)(0.5\,m)}{4(3.14)^2}$$

1.25 =0.29$kg.m$2

$$I = \frac{T2mgL}{4\pi} 2 = ¿$$

10



What's More

Actvity 3.7

Actvity 3.7: Problems involving Simple and Physical Pendulum

Direction: Solve the following problems. Show your complete solutions legibly and concisely in a separate sheet of paper.

1. A simple pendulum is found to vibrate 50 times within 200s. When 1.5m ofits length is reduced to a certain length, it vibrates 50 times in 175s. Find the original length of the pendulum.

2. A Christmas ball in a shape of a hollow sphere is hung from the tree by a piece of thread attached to the surface of the ball. The mass and radius of the ball are 0.105kg and 0.12m, respectively. What will be its period of oscillation when slightly displaced from its equilibrium position?

What I Have Learned

Actvity 3.8: Self-check Questons

1.What are the things to be considered in describing the motion of a physical pendulum?
The mass of the object, gravity and axis of rotation.

____

____

2.What are the examples of a physical pendulum? Possible answers:
Chandelier, ceiling fan, lantern

3. What are the laws of simple pendulum?

What I Can Do

Actvity 3.9: Create Your Own Problem

Make **your own** word problem. One problem calculating the period and the frequency of simple pendulum and one in physical pendulum. Show your complete solutions to the problems. Be sure that the problems are not taken from the internet and that they are realistic.

What's In

We learned from Lesson 1 of this module that there are many kinds of motion that repeat themselves over and over. We call this motion as periodic motion or oscillation. As you read through the concepts of Lesson 1, you realized that periodic motion is used to model a wide range of physical phenomena. It is also important because it generates waves, which is the focus of this lesson. Many of the terms and equations we used in Lesson 1 to 2 will be applied in this lesson as we study wave motion especially that of the mechanical waves.

What I Need to Know

After this lesson, you should be able to:

Lesson 4 Mechanical Waves

1.Define mechanical wave, longitudinal wave, transverse wave, periodic wave, andsinusoidal wave **(STEM_GP12PM-IId-31)**;and

2.From a given sinusoidal wave function infer the speed, wavelength, frequency, period, direction, and wave number **(STEM_GP12PMIId-32).**

What's New

Actvity 3.10: Making Waves

: To generate and describe transverse and longitudinal waves string or

elastic band, coil or "slinky"

Tape one end of a string to a desk.Then pull the string so it is tight, but lays flat against the desk. Then generate travelling transverse waves by wiggling the free end of the string up and

Consider a coil or spring that is lying on a tabletop. Jerk one end horizontally to and fro to produce longitudinal wave.

A medium is a matter to which a wave travels. In Activity 1, what is the medium? In activity

What Is It

2, what is the medium?

Describe the motion of the medium and compare this with the movement of the travelling In your lower years, you came across the term "waves". You are aware

wave.that the ripples on a pond, sound, light, wiggles of the slinky, radio and

Direction: Perform Activity 3.10 and answer the questions. Use a separate sheet of paper for your answer.

Learning Target Materials:

Procedure:

Actvity 1:

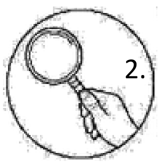
down briskly.

Actvity 2:

Questons:

1.

television transmissions are all wave phenomena.



2.

Wave is a periodic disturbance that travels through matter or space and transfers energy, not matter, from one location to another. The repetitive motion called vibration, causes the formation of waves. Therefore, wave is also considered as a simple harmonic motion.

Waves come in different types and forms such as the **mechanical waves** and the **electromagnetc waves**. In this lesson, we will focus on mechanical waves.

<u>Mechanical waves</u>

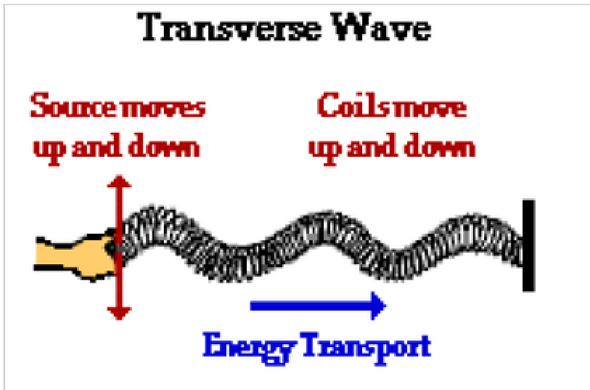
Mechanical waves are disturbances that transfers energy through a medium. Mechanical waves cannot propagate through a vacuum.

Medium is the matter through which the mechanical waves travel. The medium can be any state of matter (solid, liquid or gas).

There are two main types of mechanical waves based on the direction of the displacement of the particles of the medium through which the waves travel. These are longitudinal waves and transverse waves.

<u>Transverse wave</u>

If we wiggle the free end of the spring as in Figure 3.4, a transverse wave is formed. The particles of the medium are displaced perpendicular to the direction in which a wave travels. This means that the medium's particles oscillate up and down about their individual equilibrium positions at right angle to the direction of the wave propagation. Examples: ripples on the surface of the water, vibrations in a guitar string, seismic S-waves.

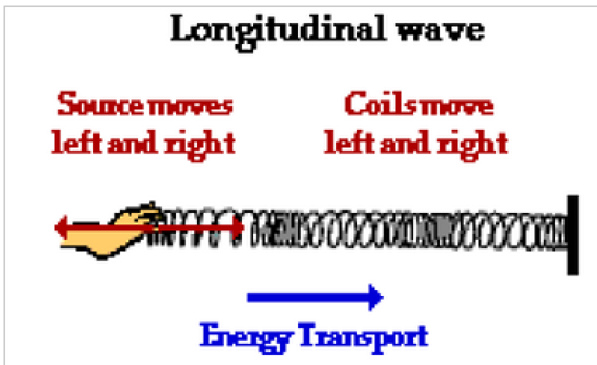


Source: physicsclassroom.com

Fig.3.4 A Transverse Wave

<u>Longitudinal wave</u>

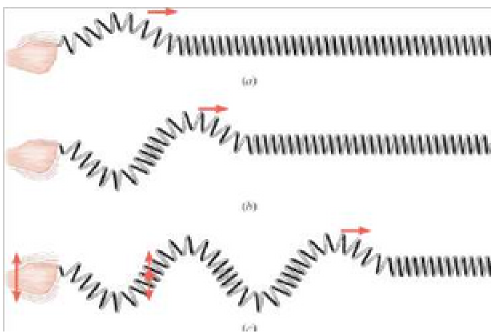
If we give the spring a back-and-forth motion as in Figure 3.5, a longitudinal wave is formed. The particles of the medium are displaced parallel to the direction in which a wave travels. This means that the medium's particles oscillate back and forth about their individual equilibrium positions along the same direction of wave propagation. Examples: sound waves, seismic P-waves, ultrasound waves.



Source: physicsclassroom.com

Fig. 3.5 A Longitudinal Wave

Consider a spring whose free end is given a repetitive motion as shown in the right. It can be13 noticed that a series of wave pulses is produced. It is also observed that each particle in the spring will also experience periodic motion as the wave travels through it. In this case, we have a **periodic wave.** **Sinusoidal waves** is produced when a periodic wave is in simple harmonic motion.



Source: pinterest.com

Fig. 3.6. A Perioidic Wave

Figure 3.7 shows the anatomy of a periodic wave, particularly a sinusoidal wave. The horizontal dashed line of Dtohwenl odaidaegd rbaym ald rrine palrceisso e(anldtrsin atlhcieso transverse wave. This is the position that the transverse wave would assume if there were no disturbance moving through it.

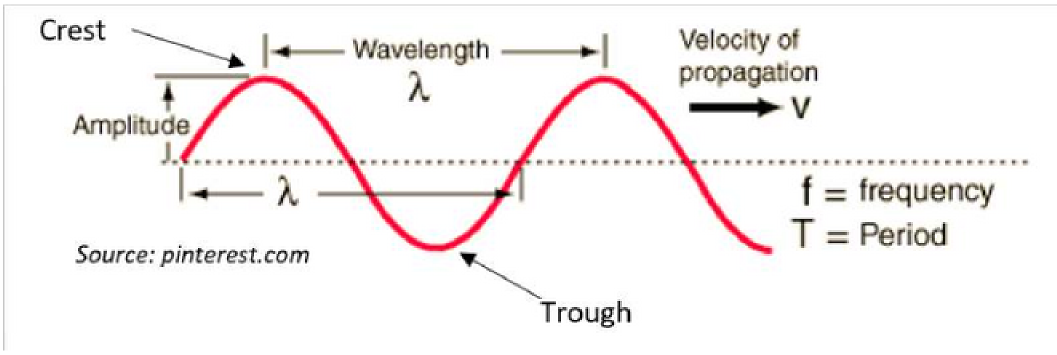


Fig. 3.7 A Sinusoidal Wave

Crest: It is the highest point or the peak of a transverse wave.

Trough: It is the lowest point on a transverse wave.

Characteristcs of a Periodic Wave

Amplitude*(A)*: The maximum displacement of a particle on the medium from the equilibrium position.
Wavelength (λ¿ **:** The distance between two successive crests or throughs. **Frequency (** f ¿ **:** The number of waves that pass a particular point for every one second
Period (T): The time required for one complete wave to pass a particular point.

These characteristics of the wave can be determined using the sinusoidal wave function.

Wave Functon for a Sinusoidal Wave

Recall that periodic waves that oscillates in simple harmonic motion generates ***sinusoidal waves***. When sinusoidal waves travel through a medium, every particle in the medium undergoes simple harmonic motion with the same frequency and is displaced from its equilibrium as a function of both position (x) and time (t). This is express in the general form of a sinusoidal wave below.

$kx \pm \omega t + \phi$

¿ **)** sinusoidal wave function Equation 3.7 $y(x,t) = A$

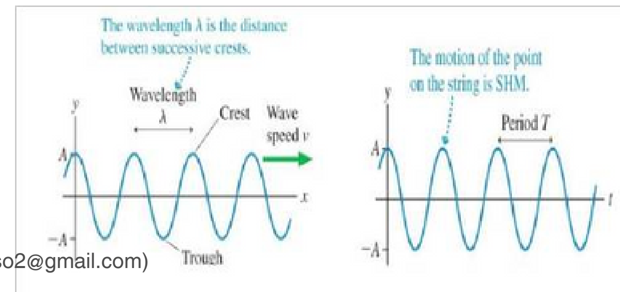
sin¿ *Where:*

y=displacement of the particle ∈ themedium (Unit: m) $A = Amplitude(Unit{:}m)$

Unit:

k=wavenumber¿ *rad/m) ω=angular frequency of thewave (Unit: rad/s) ϕ = phase constant*

Consider a transverse harmonic wave traveling in the positive x-direction as shown in Figure 3.8. The displacement (*y)* of a particle in the medium is given as a function of *x* and *t* as shown in this equation:



$kx + \omega t + \phi$

¿) Equation 3.8
$y(x,t)=A\sin¿$

(sinusoidal wave moving in +x-direction)

Fig. 3.8. A Sinusoidal Wave Travelling in the +x-directon

If the displacement *(y)* of the wave is zero at *t=0* and *x=0*, then $\phi=0$ Equation 3.8 is reduced to: $kx+\omega t$

¿ **)** (sinusoidal wave moving in +x-direction) Equation 3.9 $y(x,t)=A\sin¿$

When a transverse harmonic wave travels in the negative x-direction, the equation will become: $kx-\omega t$

¿) (sinusoidal wave moving in -x-direction) Equation 3.10 $y(x,t)=A\sin¿$

We can use these sinusoidal wave functions to determine the characteristics of the sinusoidal wave.

Steps in Finding the Characteristcs of a Sinusoidal Wave

1. To get the sinusoidal wave's amplitude, wavelength, period, frequency, speed, direction and wave number, write down the wave function in the form:

$$kx\pm\omega t+\phi$$

$$¿ \quad).$$

$$y(x,t)=A\sin¿$$

Use $y(x,t)=A\sin(kx-\omega t)$ *for wavemoving* $\in$ *+x−direction. Use* $y(x,t)=A\sin(kx+\omega t)$ *forwavemoving* $\in$ *−x−direction.*

2. The amplitude can be taken directly from the equation and is equal to A .
3. Derive the period of the wave from the angular frequency, thus, you will get,

$$T=\frac{2\pi}{\omega}$$

4. Use $f=\frac{1}{T}$ to get the frequency of the wave.
5. The wave number can be found using the equation: $k=\frac{2\pi}{\lambda}$
6. The wavelength can be derived from the wave number

$$\lambda=\frac{2\pi}{k}$$

7. The speed of the wave is: $v=\frac{w}{k}$

Sample Problems:

1. A transverse wave on a string is described by the wave function:

$y(x,t)=0.2m\sin(6.28m^{-1}x-1.57s^{-1}t)$ Find the:

a)amplitude e) period

b)wave number f) speed of the wave

c)angular frequency g) direction of the wave

d)wavelength h) frequency of the wave

Soluton: The wave function is in the form $y(x,t)=A\sin(kx-wt)$ .Therefore,

a. Amplitude $A=0.2m$

b. The wave number can be read directly from the wave equation:

$k=6.28\ rad/m$

c. The angular frequency is: $\omega=1.57 rad/s$

d. The wavelength can be found using the equation: $\lambda=\frac{2\pi}{k}=\frac{2\pi}{6.28 m^{-1}}=1.0$ m

e. To get the period: $T=\frac{2\pi}{\omega}=\frac{2\pi}{1.57 s^{-1}}=4\ s$

f. Speed of the wave, $v=\frac{\omega}{k}=\frac{1.57 s^{-1}}{6.28 m^{-1}}=0.25 m/s$

g. The wave function is in the form $y(x,t)=A\sin(kx-wt)$ .Therefore, the wave is moving in the positive direction as denoted by the negative sign between $kx \wedge wt$.

h. The frequency is $f=\frac{1}{T}=\frac{1}{4\ s}=0.25Hz$

2. A wave travelling along a string is denoted by:

$y(x,t)=0.005m\sin(80.0m^{-1}x-3.00s^{-1}t)$. Solve for:

a)Amplitude e) period

b)wave number f) speed

c)angular frequency g) direction of the wave

d)wavelength h) frequency **Soluton:**

a) $A=0.005m$

e) $T=\frac{2\pi}{\omega}=\frac{2\pi}{3.00 s^{-1}}=2.09s$

b) $k=80.0 rad/m$

f) $v=\frac{\omega}{k}=\frac{3.00s^{-1}}{80.0m^{-1}}=0.0375 m/s$

c) $\omega = 3.00 rad/s$ g) $+ x$- *direction*

$\underline{2\pi}$ 2π $\underline{1 \quad 1}$

d) $\lambda = k =$ ________ $80.0m{-}1 = 0.0785m$ h) $f = T = 2.09s = 0.48Hz$

3. A sinusoidal wave travelling on a rope has a period of 0.025 s , speed of 30 m/s and an amplitude of 0.021525 m. At t=0, the element of the string has zero displacement and is moving in the +x-direction. Find the following wave

characteristics: a)

b) frequency, f

c) angular frequency, ω

Directon: Solve the following problems. Show your complete solutons legibly and concisely in a separate sheet of paper.

1. A travelling wave is represented by the function:

$$1.2m{-}1x{-}5.0$$

$$(x, t) = 0.009$$

Find the following:

a) Amplitudeb) wave number c. wavelength

d) angular frequency e) frequency

2. A travelling sinusoidal wave has this equation:

$$25.12$$

$$y(x, t) = 0.0450$$

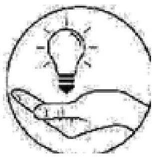
Find the following:

a) Amplitudeb) wave number c. wavelength

d)wave number, k

e)wavelength, λ

f)Write the wave function



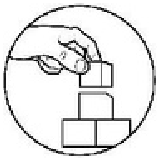
______

Soluton

a) $f = T1 = 0.0251\ s = 40\ Hz$

2π _______

b) $\omega = T$ $= 251.2 rad/s$ $\omega\ 251.2\ rad\ s$



2 c) $k = v =$ $30m s = 8.37 rad/m$

π 2π

d) $\lambda = k = 8.37\ rad = 0.75m\ m$

e) $y(x,t) = 0.021525m \sin(8.37m - 1x - 251.2s - 1t)$

What's More

Actvity 3.11: Solving Sinusoidal Wave Functon

 What I

Have Learned Actvity 3.12: Fill the Wave

Directions: Read each statement below carefully and fill in the blanks with the correct answer. Choose your answer from the word bank provided below. Each word can only be used once. Use separate sheet of paper for your answer.

1. A ______ is a vibration that moves through space.
2. The source of a wave is a ___________ or ______________________.
3. The material through which a wave travel is called the ________________.
4. Waves carry _____ and can be described as a ___________ which travels uniformly from its source.
5. Amplitude of a wave is measured from a wave's crest to its______.
6. Wave ______ = frequency x wavelength
7. A________wave requires a medium to propagate
8. In a longitudinal wave, the motion of the particle is________ the wave's direction of propagation.
9. In a transverse wave, the motion of the particles is _____ the wave's direction of propagation.
10. A sinusoidal wave is a periodic wave in ___________.

Word Box

Simple harmonic moton	**wave**	**parallel**	**oscillaton**	**mechanical**
Equilibrium positon	**perpendicular**	**vibraton**	**medium**	**speed energy**

What I Can Do

Actvity 3.13 : Geology: Physics of Seismic Waves

Geologists rely heavily on physics to study earthquakes since earthquakes involve several types of wave disturbances, including disturbance of Earth's surface and pressure disturbances under the surface. Surface earthquake waves are similar to surface waves on water. The waves under Earth's surface have both longitudinal and transverse components. The longitudinal waves in an earthquake are called pressure waves (P-waves) and the transverse waves are called shear waves (S-waves).

Excerpt from openstax.com

Questons:

1. Which among the three earthquake waves is a longitudinal wave?
2. Which among the three earthquake waves is a transverse wave?
3. Can s-waves travel through the interior of the Earth? Why or why not?
4. How does the earthquake waves provide evidence that waves carry energy?

Summary

- Periodic motion is motion of an object that regularly repeats—the object returns to a given position after a fixed time interval.
- Simple harmonic motion is a periodic, vibratory motion where the restoring force is proportional to but opposite in direction to the displacement of the particle from its equilibrium position.
- Amplitude is the maximum displacement of a vibrating particle from its equilibrium position
- Period is the time taken to complete one cycle of oscillation. Frequency is the number of cycles per second. Its SI unit is hertz (Hz). Frequency is the reciprocal of period.
- A simple harmonic pendulum consists of a concentrated mass suspended by a light thread and attached to a fixed support, while a physical pendulum is one where the hanging object is a rigid body.
- A wave is a disturbance that travels from its source and carries energy.
- Mechanical wave needs a medium to propagate.
- A transverse wave is a wave in which the disturbance is perpendicular to the direction of propagation.
- A longitudinal wave is a wave in which the disturbance is parallel to the direction of propagation.
- A periodic wave consists of a series of pulses.
- The wave function's general form is: $y(x,t) = A \sin(kx \pm \omega t + \phi)$

19 **Assessment:**

MULTIPLE CHOICES. Directions**:** Read and understand each item and choose the letter of the correct answer. Write your answers on a separate sheet of paper.

1.At which position is the speed of a particle executing SHM greatest?

a) It's extreme position
b) at its equilibrium position
c) at its maximum displacement
d) somewhere between amplitude and equilibrium position

2.At which position is the acceleration of a particle executing SHM equal to zero?

a) at its extreme position
b) at its equilibrium position
c) at its maximum displacement
d) somewhere between its amplitude and equilibrium position

3.The total energy of a simple harmonic oscillator is equal to $\frac{1}{2}kx^2$. What does x represent?

a) any value
b) amplitude of the oscillator
c) equilibrium position of the oscillator
d) position between the maximum displacement and equilibrium position

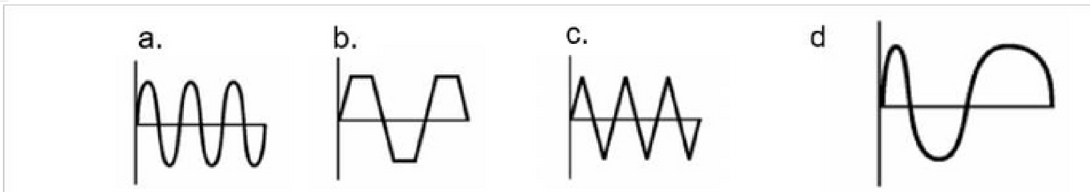
4.Which type of harmonic motion refers to oscillatory motion with decreasing amplitude?

a) critically damped c) simple
b) overdamped d) under dumped

5.For a given frequency of a longitudinal wave, which characteristic is directly 14 related to the energy of the wave?

a. amplitude b. speed of wave c. period d. wavelength

6.Which diagram below does not represent a periodic wave?



7.The wavelength of a sinusoidal wave divided by the speed of propagation refers towhat quantity?

a. angular frequency b. frequency c. period d. wave number

Refer to the wave function below to answer Questions 8 to 10.

$$y(x,t) = 0.15m\sin(0.157m^{-1}x - 50.3\,s^{-1}t)$$

8. What is the amplitude of the wave?

a. $0.15m$ b. $0.157m$ c. $50.3m$ d. $0.955m$

9. What is the direction of the wave?

a. +x-direction b. –x-direction c. +y-direction d.-x-direction

10. What is the wave number of the wave?

a. $0.15 rad/m$ d.

b.

ACTIVITY 3.5 □ 0 .

1. for a periodic motion to be classified as simple harmonic motion, the restoring force must be say less than or equal to

10

proportional to the displacement from equilibrium position of the object executing periodic motion.

$0.955 rad/m$

20

KEY TO ANSWERS

WHAT I KNOW

1. b
2. b
3. b
4. d
5. a
6. a
7. b
8. b
9. b
10. c

LESSON 1

Activity 3.2

Down

1. FREQUENCY

3.PERIODIC

4.GRAVITY

8. KINETIC

Across

2. RESTORING FORCE

5. EQUILIBRIUM

ACTIVITY 3.7

1

LESSON 3

. T1 = 4.0s

T2 = 3.5s

L1 = 6.4m

The period of a simple pendulum is directly proportional to the square root of its length.

The period is independent of the angular 8kaibigan amplitude if angular displacement is small,

ASSESSMENT

1. b
2. b

Lesson 4:

Activity 3.10

1. Activity 1- string Activity 2- spring or coil
2. Activity 1: The motion of the medium is perpendicular to the movement of the travelling wave. In Activity 2, the motion of the medium is parallel to the movement of the travelling wave.

Activity 3.11

1. a) $A = 0.009\,m$
   b) $k = 1.2\,m^{-1}$
   c) $\lambda = \frac{2\pi}{k} = 5.2\,m$
   d) $\omega = 5.0\,rad/s$
   e) $f = \frac{\omega}{2\pi} = 0.80\,Hz$
   f) $v = 4.17\,m/s$

2. a) $A = 0.0450\,m$
   b) $k = 25.12\,m^{-1}$
   c) $\lambda = \frac{2\pi}{k} = 0.250\,m$
   d) $\omega = 37.68\,rad/s$
   e) $f = \frac{\omega}{2\pi} = 6.00\,Hz$
   f) $\phi = -0.523\,radian$

3 .a) $f = 25.0\,Hz$, $T = 0.0400\,s$, $k = 19.6\,rad/m$ $\omega = 156.8\,rad/s$
   $19.6\,m^{-1} x - ¿$
   b) $¿$ 156.8 s^{-1} t)
   $y(x,t) = 0.0700\,m \sin ¿$

4. a) $A = 0.075\,m$ $\omega = 12.6\,rad/s$ $T = \frac{1}{f} = 0.500\,s$ $\lambda = \frac{v}{f} = 6.00\,m$
   $k = \frac{\omega}{v} = 1.05\,m^{-1}$
   b) $1.05\,m^{-1} x - 12.6\,s^{-1} t$)
   $y(x,t) = 0.075\,m \sin ¿$

Activity 3.12

1. Wave
2. Vibration, oscillation
3. Medium
4. Energy
6. speed
7. mechanical
8. parallel
9. perpendicular

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