MODULE

2

WAVES AROUND YOU

This module introduces the student to the study of waves and its properties. There is one warm-up activity and three principal activities designed to target key concepts about wave motion. While the lesson is generally activity-centered, the teacher must set off the lesson by facilitating the class to give examples of waves in the environment and to think about what these waves can do.

I. Importance of the Topics to Real Life

Sound waves, earthquake waves, waves on stretched strings, and water waves are all produced by some source of vibration. To explain many other phenomena in nature, it should be emphasized that it is important to understand concepts of wave motion.

For instance, since the Philippines is one of the countries which is a part of the Pacific Ring of Fire, it experiences frequent earthquakes due to the movements of tectonic plates or segments of the earth's crust. It is therefore important to understand how earthquake waves propagate and to know what actions are taken by scientists, particularly the geologists, to address the challenges brought by the geographical location of the Philippines.

Architects and engineers also consider concepts in wave motion in designing skyscrapers and bridges. Although these structures appear to be rigid, they actually vibrate and this fact must be taken into account in their construction.

Finally, to understand how radio and television work, concepts about the origin, nature and propagation of electromagnetic waves have to be examined.

II. Hints for the Teacher

1. Prepare the students for this lesson by giving a demonstration to serve as motivation.

Demonstration Activity. Introduction to Vibrations

1) Prepare a metal can with both lids removed.
2) Cut a rubber balloon cut and stretched it over one end of the can. Use a rubber band to hold the stretched balloon in place.
3) Put the can and its balloon end up on a table.
4) Put a small amount of salt on top of the balloon.
5) Ask a student volunteer to shout (not blow) at the can.
6) Tell the class to observe what happens to the salt. Also, invite them to place their fingers lightly on their throat while creating a sound.

Guide Questions

1. What two things are vibrating?
   (1) The rubber balloon on the can and (2) the students' vocal cords in their throats

2. What caused the salt to move?
   The salt is moved by the balloon's vibrations, which are ultimately caused by sound waves traveling through the air. These sound waves are generated by the vibration of the vocal chords in the throat. Tell the students they will study the details in the next activities and in a separate module on sound.

2. Do the warm up activity with the class and relate it with the demonstration activity. The demonstration and the warm-up activity aim to bring out the following pre-requisite concepts:

(1) Waves are caused by a source of a vibration and
(2) Waves can set objects into motion.

Guide Questions

1. What do you do when you wave your hand?
   Tell the students that they are essentially "vibrating" their hands by doing a repetitive back-and-forth or side-to-side movement with your fingers or your palm. (Encourage the students to demonstrate their personal hand waves.)
2. Think of a still lake. How would you generate water waves on the lake?
   Water waves can be generated by vibrating the surface of the water. Students can have various answers from their experiences. Tell them

that the activities that they would perform will allow them to generate waves and to understand wave motion.

3. You may have to demonstrate to students how they can make periodic waves using the materials in the activities.

Objectives

After taking up this module, the students should be able to:

1. Infer that energy, like light and sound travel in the form of waves.
2. Explain how waves carry energy from one place to another.
3. Distinguish between transverse and longitudinal waves and mechanical and electromagnetic waves.
4. Create a model to demonstrate the relationship among frequency, wavelength, and wave speed.

III. Guide to Conducting the Principal Activities in the Module

The activities in the module are designed to be performed within the classroom. Each activity will take up one class period.

The following schedule of activities is suggested:

Session 1	Demonstration Activity Warm Up. What are waves? Activity 1. Let's Make Waves! Presentation of Group Output Discussion of the Answers to Activity 1
Session 2	Review of Key Concepts from Activity 1 Activity 2. Anatomy of a Wave Presentation of Group Output Discussion of the Answers to Activity 2
Session 3	Review of the Key Concepts from Activities 1 and 2 Activity 3. Mechanical vs. Electromagnetic Waves Discussion of the Answers to Activity 3 Summary of the Module Test Your Knowledge

Activity 1

Let's Make Waves!

What happens when waves pass by?

The students are given 30 minutes to perform the activity and to answer the questions in the activity sheet. After completing the activity, the teacher will facilitate a brief discussion of the findings.

It is best to choose three groups to present their findings on the different parts of the activity (i.e. one representative will show the work of their group on Part A only; representatives from other groups will talk about Part B and Part C respectively.)

The teacher will conclude the meeting by answering the summary part of the activity sheet with the class.

Answers to the Activity Sheet

A. What are transverse waves?

1. Sketches showing the motion of a wave pulse at three subsequent instances (snapshots at three different times).

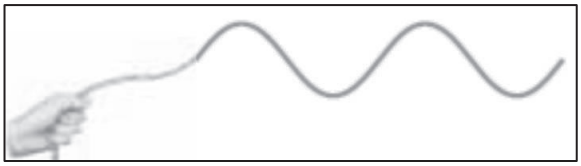
Time 1

Time 2

Time 3

a. What is the source of the wave pulse?
   A vibration due to a quick shake at one end of the rope
b. Describe the motion of your hand as you create the pulse.
   A quick up and down movement
c. Describe the motion of the pulse with respect to the source. *The pulse moved away from the source.*

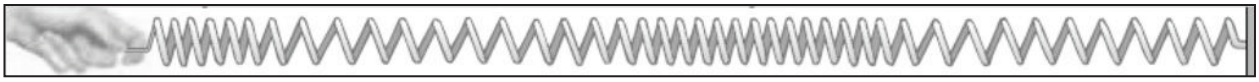
2. [Sketch of the waveform or the shape of the wave created by the students.]



a. Does the wave transport the colored ribbon from its original position to the end of the rope?
   No, it doesn't.
b. Describe the vibration of the colored ribbon. How does it move as waves pass by? Does it move in the same direction as the wave?
   As the waves pass by, the colored ribbon moves up and down repetitively. It does not move in the same direction as the passing waves. Instead, it vibrates along the axis perpendicular to the direction of travel of the passing waves.

B. <u>What are longitudinal waves?</u>

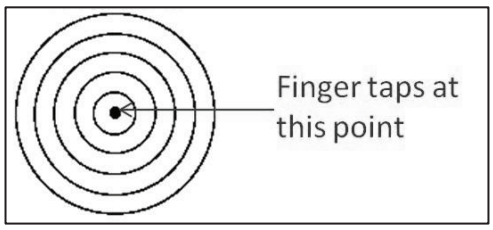
1. Sketch of longitudinal waves in a coil spring.



2. [Observations on the colored ribbon tied to the coil spring.]
   a. Does the wave transport the colored ribbon from its original position to the end of the rope?
      No, it doesn't.
   b. Describe the vibration of the colored ribbon. How does it move as waves pass by?
      As the waves pass by, the colored ribbon moves back and forth repetitively. It vibrates along the axis parallel to the direction of travel of the passing waves.

C. What are surface waves?

1. [Sketch of the waves as seen from above the water basin.] The source of the disturbance should be marked.



2. [Observation on the paper boat.]
   a. Do the waves set the paper boat into motion? What is required to set an object into motion?
      Yes, the waves moved the paper boat. Energy is required to set and object into motion.
   b. If you exert more energy in creating periodic waves by tapping the surface with greater strength, how does this affect the movement of the paper boat?
      The wave carried more energy causing the paper boat to vibrate strongly.

3. [Observations on the figure showing water waves.]
   a. As shown in the figure, the passage of a wave across a surface of a body of water involves the motion of particles following a *circular* pattern about their original positions.
   b. Does the wave transport water molecules from the source of the vibration? Support your answer using the shown figure.
      No, the water molecules are not transported from the source of the vibration. The figure shows that the water particles merely move in circular orbits about their original positions as waves pass by.

D. Summary

1. Waves can be typified according to the direction of motion of the vibrating particles with respect to the direction in which the waves travel.

   a. Waves in a rope are called *transverse* waves because the individual segments of the rope vibrate *perpendicular* to the direction in which the waves travel.

b. When each portion of a coil spring is alternatively compressed and extended, *longitudinal* waves are produced.
c. Waves on the surface of a body of water are a combination of transverse and longitudinal waves. Each water molecule moves in a *circular* pattern as the waves pass by.

2. How do we know that waves carry energy?
   Waves can set other objects into motion.

3. What happens when waves pass by?
   Particles vibrate alternately to transport the energy of the wave.

Activity 2

Anatomy of a Wave

How can you describe waves?

The students are given 40 minutes to perform the activity and to answer the questions in the activity sheet. After completing the activity, the teacher will facilitate a brief discussion of the findings.

Before discussing the results of the activity to the class, it is useful to show a large image of a sinusoidal wave and ask the class to name the parts of the wave.

The activity has three parts so the groups may be asked to assign a different representative to discuss the result of their work to the class (i.e. those who have been chosen as presenters in Activity 1 should not be assigned again).

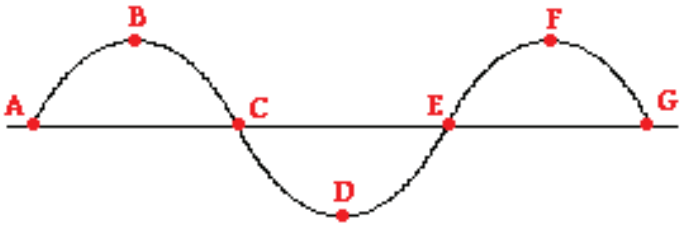
The teacher will conclude the meeting by answering the summary part of the activity sheet with the class.

Answers to the Activity Sheet

A. How can you measure the wavelength of a wave?

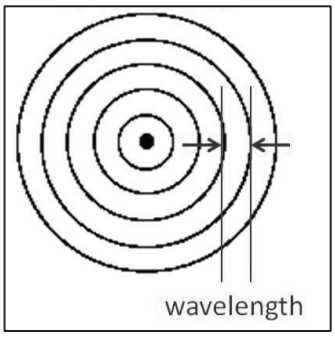
1. The **wavelength** of a wave refers to the distance between any successive identical parts of the wave. For instance, the distance from one crest to the next is equal to one full wavelength. In the

following illustration, this is given by the interval B to F. Identify the other intervals that represent one full wavelength.



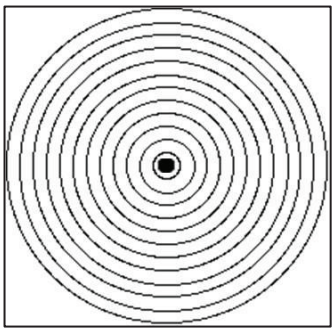
Intervals 1) A to E and 2) C to G

2. Sketch of the water waves as seen them from the above of the basin. One wavelength should be labeled in the drawing.



3. Increase the rate of the vibrations you create by tapping the surface of the water rapidly. What happens to the wavelength of the waves?
The wavelength becomes shorter.

[Sketch of the water waves as seen them from the top of the basin. Compared to the drawing in number 2, this one has shorter wavelengths.]



B. How can you measure the frequency of a wave?

1-3. Results are recorded in Table 1. Each group may have different answers.

Table 1. Frequency and period of the wave

Number of waves (N cycles) that passed by the ribbon in 10 seconds	**Frequency** of the waves (N cycles/10 seconds)	**Period** of the waves (seconds)
Example *15 cycles*	*15 cycles/10s = 1.5 Hz*	*1/1.5 Hz = 0.67 s*

4. If you increase the frequency of vibration by jerking the end of the rope at a faster rate, what happens to the wavelength?
   The wavelength becomes shorter.

C. How can you measure the speed of a wave?

1-2a. Results are recorded in Table 2. Each group may have different answers.

Table 2. The speed of a wave

Estimated wavelength (meters)	**Number of waves** (N cycles) that passed by the ribbon in 10 seconds	**Frequency** of the waves (N cycles/10 seconds)	**Wave speed** (meter/second)
Example *0.5 m*	*15 cycles*	*15 cycles/10s = 1.5 Hz*	*(0.5m)*(1.5Hz) = 0.8 m/s*

D. Summary

1. What is the relationship between wave speed, wavelength and frequency? *They are related by the equation: wave speed = frequency x wavelength. The frequency of a wave is inversely proportional to the wavelength.*

2. Suppose you observed an anchored boat to rise and fall once every 4.0 seconds as waves whose crests are 25 meters apart pass by it.
   a. What is the frequency of the observed waves?
      The frequency of the waves is 0.25 Hz.
      Frequency = 1/period = 1/4.0 seconds = 0.25 Hz
   b. What is the speed of the waves?
      The speed of the waves is 6.3 m/s.
      Wave speed = (frequency)(wavelength) = (0.25 Hz)*(25 m) = 6.3 m/s*

Activity 3

Mechanical vs. Electrical Waves

How do waves propagate?

The students are given 30 minutes to perform the activity and to answer the questions in the activity sheet. After completing the activity, the teacher will facilitate a brief discussion of the findings.

Before discussing the results of the activity to the class, it is useful to show a set of large images of the mechanical waves, which the students were able to generate in Activity 1, and a chart of the electromagnetic spectrum which can be used by the students in answering the questions in the activity sheet. The class must be divided into small discussion groups until all of each group's members are able to complete the activity sheets. Proceed with the discussion of the answers to the class while keeping the small discussion groups intact. Before giving the correct answers, have each group announce their answers to the class.

The teacher will conclude the meeting by answering the summary part of the activity sheet with the class.

Answers to the Activity Sheet

A. What are mechanical waves?

1. [Identifying the **medium** of wave propagation for mechanical waves]
   a. In Activity 1 Part B, what is the medium of wave propagation?
      Coil spring
   b. In Activity 1 Part C, what is the medium of wave propagation?
      Water
2. [Characteristics of mechanical waves]
   a. How can you generate mechanical waves? *They can be generated by vibrating a medium. A medium is required because vibrating particles are needed for the wave to travel.*

3. [Application of the concept of mechanical waves to earthquakes]
   a. What do you think is the source of earthquake waves? *Earthquake waves are caused by a vibration due to colliding tectonic plates.*
   b. What is the medium of propagation of earthquake waves?
      The Earth

B. What are electromagnetic waves?

1. [Knowing the electromagnetic waves]

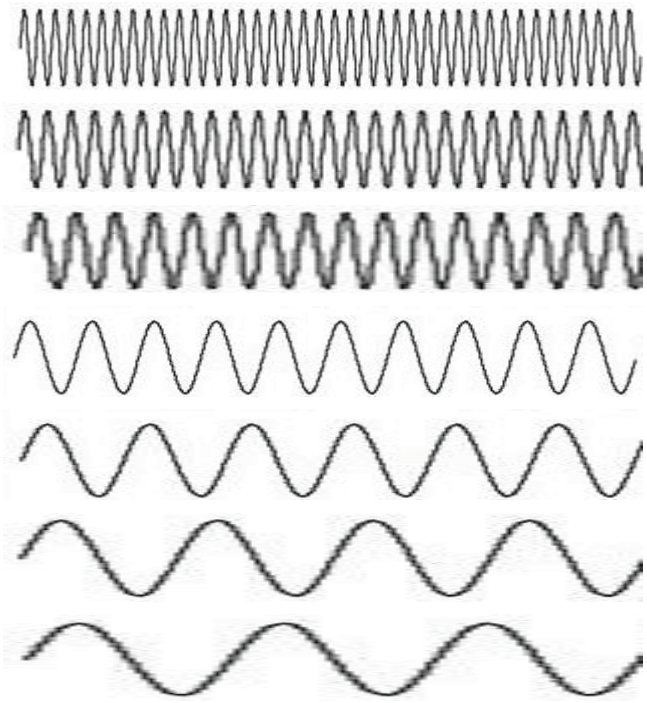
   1. *Radio waves*
   2. *Microwaves*
   3. *Infrared Waves*
   4. *Visible Light*
   5. *Ultraviolet Waves*
   6. *X-rays*
   7. *Gamma Rays*

2. [Some characteristics of electromagnetic waves]

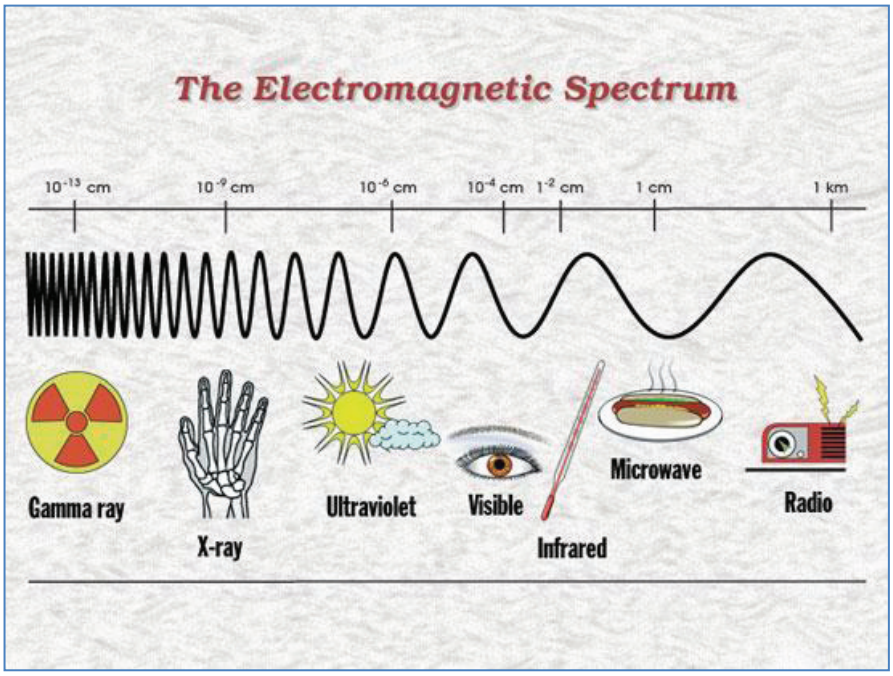
   a. Describe the relationship between frequency and wavelength of each electromagnetic wave.
      Among electromagnetic waves, the higher the frequency, the shorter the wavelength.
   b. Draw waves to represent each electromagnetic wave. Your illustrations must represent the wavelength of a wave relative to the others. For instance, gamma rays have a very small wavelength compared to the other waves in the spectrum.

      High energy electromagnetic waves have (*high*, low) frequency and (long, *short*) wavelengths.

1. **Gamma Rays**
2. **X-rays**
3. **Ultraviolet Waves**
4. **Visible Light**
5. **Infrared Waves**
6. **Microwaves**
7. **Radio Waves**



The following image can also be used.



c. The Sun is an important source of ultraviolet (UV) waves, which is the main cause of sunburn. Sunscreen lotions are transparent to visible light but absorb most UV light. The higher a sunscreen's solar protection factor (SPF), the greater the percentage of UV light absorbed. Why are UV rays harmful to the skin compared to visible light?

   Compare the frequency and energy carried by UV waves to that of visible light.
   UV waves have higher energy and frequency compared to visible light.

C. Summary

1. Mechanical waves like sound, water waves, earthquake waves, and waves in a stretched string propagate through a *medium* while *electromagnetic* waves such as radio waves, visible light, and gamma rays, do not require a material medium for their passage.

Review. Waves Around You

The activities in the module are all about wave motion or the propagation of a pattern caused by a vibration. Waves transport energy from one place to another thus they can set objects into motion.

What happens when waves pass by?

Activity 1 introduced transverse waves, longitudinal waves, and surface waves. The students were able to observe the motion of a segment of the material through which the wave travels.

1. Transverse waves occur when the individual particles or segments of a medium vibrate from side to side perpendicular to the direction in which the waves travel.
2. Longitudinal waves occur when the individual particles of a medium vibrate back and forth in the direction in which the waves travel.
3. The motion of water molecules on the surface of deep water in which a wave is propagating is a combination of transverse and longitudinal displacements, with the result that molecules at the surface move in nearly circular paths. Each molecule is displaced both horizontally and vertically from its normal position.

4. While energy is transported by virtue of the moving pattern, it is important to remember that there is not net transport of matter in wave motion. The particles vibrate about a normal position and do not undergo a net motion.

How can you describe waves?

In Activity 2, the students encountered the important terms and quantities used to describe periodic waves.

1. The crest and trough refer to the highest point and lowest point of a wave pattern, respectively.
2. The amplitude of a wave is the maximum displacement of a particle of the medium on either side of its normal position when the wave passes.
3. The frequency of periodic waves is the number of waves that pass a particular point for every one second while the wavelength is the distance between adjacent crests or troughs.
4. The period is the time required for one complete wave to pass a particular point.
5. The speed of the wave refers to the distance the wave travels per unit time. It is related to the frequency of the wave and wavelength through the following equation:

$$wave\ speed = frequency\ x\ wavelength$$

How do waves propagate?

Finally, Activity 3 prompted the students to distinguish between mechanical and electromagnetic waves.

1. In mechanical waves, some physical medium is being disturbed for the wave to propagate. A wave traveling on a string would not exist without the string. Sound waves could not travel through air if there were no air molecules. With mechanical waves, what we interpret as a wave corresponds to the propagation of a disturbance through a medium.

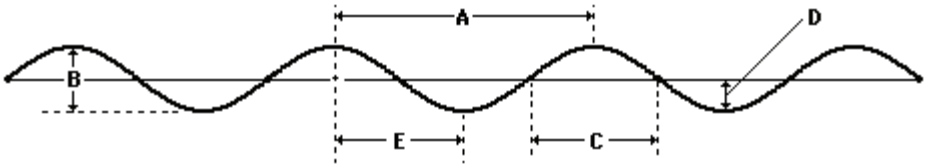
2. On the other hand, electromagnetic waves do not require a medium to propagate; some examples of electromagnetic waves are visible light, radio waves, television signals, and x-rays.

PRE/POST TEST

(For Modules 2 to 4)

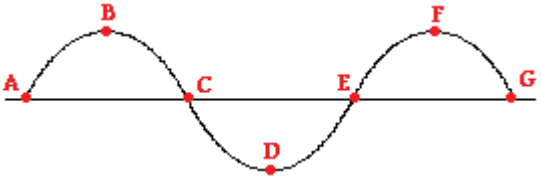
Part A: WAVES

Consider the diagram below to question 1 below



1. The amplitude of the wave in the diagram above is given by letter __.

2. Indicate the interval that represents a half wavelength.



a. A to E
b. B to F
c. A to B
d. C to E

3. Mechanical waves transport energy from one place to another through
   A. Alternately vibrating particles of the medium
   B. Particles traveling with the wave
   C. Vibrating particles and traveling particles
   D. None of the above

4. In a transverse wave, the individual particles of the medium
   A. move in circles
   B. move in ellipses
   C. move parallel to the direction of travel
   D. move perpendicular to the direction of travel

5. The higher the frequency of a wave,
   A. the lower its speed
   B. the shorter its wavelength
   C. the greater its amplitude
   D. the longer its period

6. Waves in a lake are 5.00 m in length and pass an anchored boat 1.25 s apart. The speed of the waves is
   A. 0.25 m/s
   B. 4.00 m/s
   C. 6.25 m/s
   D. impossible to find from the information given

7. Energy from the sun reaches the earth through
   A. ultraviolet waves
   B. infrared waves
   C. mechanical waves
   D. electromagnetic waves

Part B: SOUND

8. Which of the following objects will produce sound?
   A. soft objects
   B. radio stations
   C. vibrating objects
   D. objects under pressure

9. Which of the following best describes a high frequency sound? It has _____.
   A. low pitch
   B. high pitch
   C. low energy
   D. A and C

10. Compared to a thin string of the same length and tightness a thick string produces sounds of _____.
   A. the same pitch
   B. lower pitch
   C. higher pitch
   D. lower then higher pitch

11. A sound wave is a _____.

A. longitudinal wave
B. transverse wave
C. standing wave
D. shock wave

12. Which of the following is not capable of transmitting sound?

A. air
B. water
C. steel
D. a vacuum

13. Which of the following would most likely transmit sound best?

A. Steel in cabinet
B. Water in the ocean
C. Air in your classroom
D. Water in a swimming pool

Part C: LIGHT

1. Which of the following is **NOT** an electromagnetic wave?

A. Infrared
B. Radio
C. Sound
D. X ray

2. How does the wavelength of infrared (IR) compare with the wavelength of ultraviolet (UV) waves?

A. Infrared waves have longer wavelength.
B. Infrared waves have shorter wavelength.
C. IR waves have the same wavelength as the UV waves.
D. IR is not comparable in wavelength with the UV waves

3. Among all the electromagnetic waves (EM), which has the highest frequency?

A. Infrared radiation
B. Radio wave
C. Ultraviolet
D. Gamma rays

4. ROYGBIV is the basic component of white light. Which color of light carries the most energy?

   A. Blue
   B. Green
   C. Orange
   D. Red

5. Light is an electromagnetic wave. Which characteristic is common in all electromagnetic waves?

   A. amplitude
   B. frequency
   C. speed
   D. wavelength

Answer Key		
Part A	**Part B**	**Part C**
1. D	1.C	1.C
2. D	2.B	2.A
3. A	3.B	3.D
4. D	4.A	4.A
5. B	5.D	5.C
6. B	6.A	
7.D		

References and Web Links

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[4] The anatomy of a wave. Available at: http://www.physicsclassroom.com/class/waves/u10l2a.cfm
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