LIFEPAC®

SCIENCE

STUDENT BOOK

12th Grade | Unit 4

Alpha Omega
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SCIENCE 1204
INTRODUCTION TO WAVES

LIFEPAC Test is located in the center of the booklet. Please remove before starting the unit.

Author:
Mary Grace Ferreira, M.A.T., M.N.S.

Editor:
Alan Christopherson, M.S.

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Alpha Omega
PUBLICATIONS

804 N. 2nd Ave. E.
Rock Rapids, IA 51246-1759

Introduction to Waves

Introduction

A wave is a disturbance in a medium that transfers energy from one place to another without transferring matter. Nonrepetitive waves are called *pulses*, or nonrecurrent waves; whereas other waves consisting of several identical pulses in a rhythmic pattern are called *periodic waves*. In this LIFEPAC® you will observe and study waves and their characteristics, their various phenomena, and their applications in the area of sound.

Objectives

Read these objectives. The objectives tell you what you will be able to do when you have successfully completed this LIFEPAC. When you have finished this LIFEPAC, you should be able to:

1. Identify a pulse and a periodic wave.
2. Calculate the velocity, frequency, period, and length of a wave.
3. Identify and generate transverse waves and longitudinal waves.
4. Describe the properties of a torsional wave.
5. Identify reflection, refraction, diffraction, and interference.
6. Calculate problems that involve interference phenomena.
7. Explain standing waves.
8. Calculate problems involving beats.
9. Describe resonance.
10. Describe and explain the Doppler effect.
11. Describe and explain shock waves.
12. Calculate speed of sound problems.

Survey the LIFEPAC. Ask yourself some questions about this study and write your questions here.

1. ENERGY TRANSFER

Energy is transferred in only two ways, by particle motion and by **wave** motion. A moving particle has kinetic energy proportional to its mass and **velocity**. The energy of a wave is not so simple to assign. Under certain conditions, energy is proportional to the wave height. Under other conditions, wave energy is proportional to the number of pulses per unit time.

Waves are periodic moving pulses of energy. The shape, or form, of a wave is to some degree determined by the medium through which the wave travels.

Section Objectives

Review these objectives. When you have completed this section, you should be able to:

1. Identify a pulse and a periodic wave.
2. Calculate the velocity, frequency, period, and length of a wave.
3. Identify and generate transverse waves and longitudinal waves.
4. To describe the properties of a torsional wave.

Vocabulary

Study these words to enhance your learning success in this section.

amplitude	**condensation**	**crest**	**frequency**
longitudinal wave	**nonrecurrent wave**	**period**	**periodic wave**
pulse	**rarefaction**	**torsional wave**	**transverse wave**
trough	**velocity**	**wave**	**wavelength**

Note: *All vocabulary words in this LIFEPAC appear in* **boldface** *print the first time they are used. If you are not sure of the meaning when you are reading, study the definitions given.*

PULSES

A **pulse** (a **nonrecurrent wave**) is a **wave** of short duration. Although it is nonrepetitive, it transfers energy. In some cases, the energy transferred is huge. Surf crashing onto a beach carries energy from a storm generated at sea. Nuclear energy released in a nuclear device transfers energy for miles as heat, light, sound, and mechanical energy (earth tremors and quakes). In A.D. 1054 Chinese astronomers reported seeing a supernova. The aftermath of this explosion can still be seen in the nebula that is continuing to expand at high velocities. A seismic sea wave, or tsunami (misnamed a "tidal wave"), caused by a typhoon, hurricane, or undersea earthquake, hit Lisbon in 1755. Traveling at 500 miles per hour, it caused tremendous damage with waves up to fifty feet high. Knocking down a row of dominoes by touching the first one is still another example of a pulse.

Two characteristics of a pulse are **amplitude** and **velocity**.

Amplitude. The maximum height of a pulse is its amplitude and is a function of the energy that created the pulse.

Try this investigation of pulses.

This item is needed:

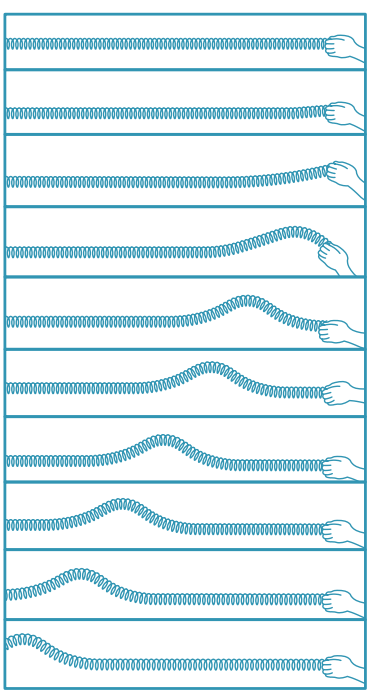
- extra large metal coiled spring (This should be an extra large physical science version of the classic Slinky)

Follow these directions and complete the activities. Put a check in the box when each step is completed.

☐ 1. If no partner is available, secure one end of the coiled spring to a permanent fixture at floor level so that the end cannot move.

☐ 2. Stretch the coiled spring approximately 10 meters along a smooth floor. Whip the coiled spring sideways from its equilibrium position and back again. (Do not go past this starting position.) Notice that as the pulse propagates, only the pulse moves along the coiled spring and not the coils. The coils are moved out of position as the pulse passes by and then returned to their original position.

☐ 3. Generate pulses of various sizes.



Pulse Experiment

(Continued on next page)

1.1 What provides the energy for this type of pulse?

_____

_____

1.2 Does the slow motion of the hand produce a long pulse or a narrow pulse?

_____

1.3 Does moving the hand a short distance produce a tall pulse or short pulse?

_____

1.4 Does the shape of the pulse change as it travels along the coiled spring? _____

_____

1.5 Do pulses change size? _____

_____

Pulse Experiment

Velocity. Different waves travel at different velocities. A seismic sea wave, or tsunami, may travel at speeds up to 830 kilometers per hour. Sound waves travel at about 330 meters per second through air depending on the air's temperature. Light and other electromagnetic radiation travels at $3 \cdot 10^8$ meters per second through space, but slower through glass or water.

| At a baseball game, you hear the crack of the bat after the hit if you sit far from home plate.

Try this investigation of the effect of the medium on wave speeds.

These supplies are needed:

- extra large metal coiled spring
- stopwatch or sweep second hand
- meter stick

Follow these directions and complete the activities. Put a check in the box when each step is completed.

☐ 1. Fix one end of the coiled spring and extend it exactly 6 meters.

☐ 2. Generate a pulse by plucking and time its travel from the pluck to the far end. Repeat several times to obtain an average time.

☐ 3. Extend the coiled spring exactly 8 meters.

☐ 4. Repeat Step 2.

☐ 5. Extend the coiled spring exactly 10 meters.

☐ 6. Repeat Step 2.

☐ 7. Calculate the velocities, using $^{d}/_{t}$.

1.6 How did the different stretches (densities) affect the velocity of the pulse?

_____

_____

_____

Wave Velocity Experiment

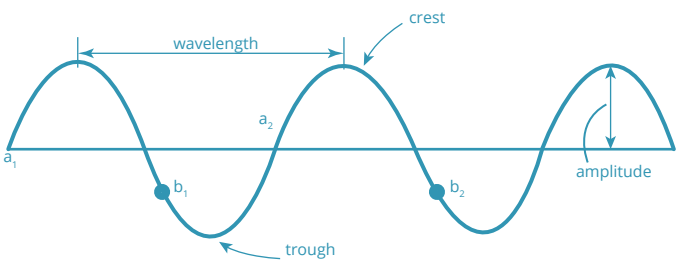
PERIODIC WAVES

A series of identical pulses rhythmically produced (equally spaced in time) is called a **periodic wave**. Periodic waves have certain characteristics and are of three basic forms.

Characteristics. The **wavelength** is the distance between two consecutive points where the wave repeats itself. It may be measured crest to **crest** or **trough** to trough. The distance from point a_1 to point a_2 or from point b_1 to point b_2 also defines the wavelength. Maximum displacement from equilibrium or undisturbed position is called the amplitude (A) of the wave. The crest is the highest part of the wave and the trough is the lowest.

The **frequency** of a wave is the number of waves passing a given point in a unit of time. The period of a wave is the time required for a complete wave (one wavelength) to pass a given point. The wave velocity is the distance one wave travels per second.

The symbols and metric units (SI) used are as shown in this table.



wavelength	λ	meters (λ = Greek letter lambda)
frequency	f*	hertz or $^{cycles}/_{second}$ (hertz is abbreviated Hz.)
period	T	$^{seconds}/_{cycle}$
amplitude	A	meters
velocity	v	$^{meters}/_{second}$

* The Greek letter, ν (nu), is sometimes used.

The velocity of a wave may be determined by multiplying its frequency times its wavelength.

$$V = f \lambda$$

The frequency and period are reciprocals of each other.

$$f = {}^{1}/_{T} \text{ or } T = {}^{1}/_{f}$$

Complete these activities.

1.7 Waves are observed passing under a dock. Wave crests are eight meters apart. The time for a complete wave to pass by is four seconds. The markings on the post submerged in water indicate that the water level fluctuates from a trough at six meters to a crest at nine meters.

a. What is the amplitude of the wave? _____

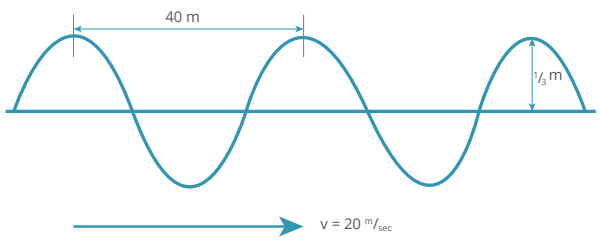
b. What is the wavelength of the wave? _____

c. What is the period of the wave? _____

d. What is the frequency of the wave? _____

e. Calculate the velocity of the wave. _____

1.8 Answer the questions based on this wave form.

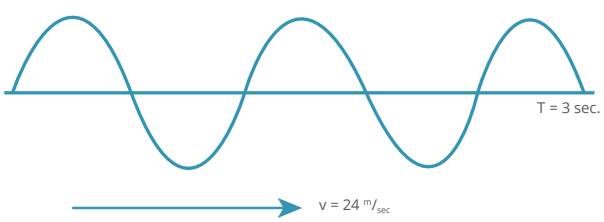


a. What is the distance from crest to trough (2A)? _____

b. What is the frequency of the wave? _____

c. What is the period of a wave? _____

1.9 A wave has a velocity of 24 m/sec. and a period of 3 sec.



a. What is the frequency of the wave? _____

b. Calculate the wavelength of the wave. _____

c. Can the amplitude be determined from the given information?

_____

_____

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800-622-3070
www.aop.com

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