DOCUMENT RESUME

ED 124 377 88 SE 018 329

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TITLE Physics of Communication Minicourse, Career Oriented Pre-Technical Physics. Preliminary Edition.
INSTITUTION Dallas Independent School District, Tex.
SPONS AGENCY Bureau of Elementary and Secondary Education (DHEW/OE), Washington, D.C.
PUB DATE 74
NOTE 51p.; For related documents, see SE 018 322-333 and SE 019 605-616

EDRS PRICE MF-$0.83 HC-$3.50 Plus Postage.
DESCRIPTORS *Electronics; Individualized Instruction; *Instructional Materials; *Physics; Program Guides; *Science Activities; Science Careers; Science Education; Science Materials; Secondary Education; Secondary School Science; Technical Education
IDENTIFIERS Elementary Secondary Education Act Title III; ESEA Title III

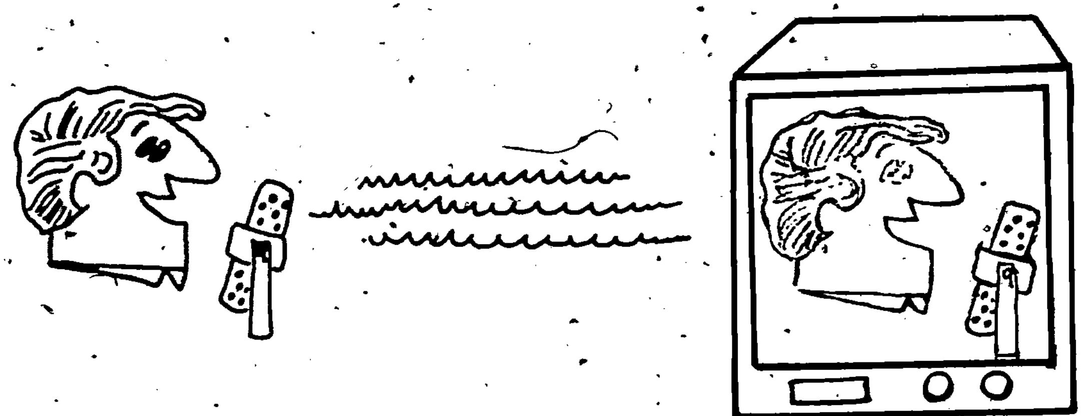
ABSTRACT

This minicourse was prepared for use with secondary physics students in the Dallas Independent School District and is one option in a physics program which provides for the selection of topics on the basis of student career needs and interests. This minicourse was aimed at providing students with a knowledge of the ways in which light, sound, and electricity are involved in everyday communication systems. The minicourse was designed for independent student use with close teacher supervision and was developed as an ESEA Title III project. A rationale, behavioral objectives, student activities, and resource packages are included. Student activities and resource packages involve defining communication, investigating communications-related vocations, building a string telephone and telegraph, studying wave theory, constructing a simple radio receiver circuit, and examining how a loud speaker works. (GS)

CAREER ORIENTED PRE-TECHNICAL PHYSICS

Physics of Communication

Minicourse



1974

PRELIMINARY EDITION

dallas independent school district

CAREER ORIENTED PRE-TECHNICAL PHYSICS

The Physics of Communication

Minicourse

ESEA Title III Project

1974

dallas independent school district

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This Mini Course is a result of hard work, dedication, and a comprehensive program of testing and improvement by members of the staff, college professors, teachers, and others.

The Mini Course contains classroom activities designed for use in the regular teaching program in the Dallas Independent School District. Through Mini Course activities, students work independently with close teacher supervision and aid. This work is a fine example of the excellent efforts for which the Dallas Independent School District is known. May I commend all of those who had a part in designing, testing, and improving this Mini Course.

I commend it to your use.

Sincerely yours,

Nolan Estes

Nolan Estes
General Superintendent

mfs

CAREER ORIENTED PRE-TECHNICAL PHYSICS TITLE III ESEA PROJECT

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CAREER ORIENTED PRE-TECHNICAL PHYSICS

PHYSICS OF COMMUNICATION

MINICOURSE

RATIONALE (What the minicourse is about)

How did you get the message that it was time to get up this morning? Was it the light of the sun, the clanging of a noisy alarm, the smell of breakfast bacon cooking, a vigorous shake, or the sound of a human voice that brought you this message? These means of transmitting your "time-to-get-up" message are only a few of the forms of communication (the giving and receiving of information) to which you are exposed every day. Everyday communication consists of an interpersonal type (information exchanges without the use of machines, such as voice, body language, etc.) and of a mass media type (exchanges involving machines, such as television, radio, etc.). In this minicourse we concern ourselves primarily with only one small aspect of communication; namely, an introduction to the technical physics of communication. When you have completed this short study, you should have some knowledge of the ways in which light, sound, and electricity are involved in everyday communication systems. You should also have become aware of some of the exciting vocational possibilities related to communication.

In addition to RATIONALE, this minicourse contains the following sections:

1) TERMINAL BEHAVIORAL OBJECTIVES (Specific things you are expected to learn)

2) ENABLING BEHAVIORAL OBJECTIVES (Learning "steps" which will enable you to eventually reach the terminal behavioral objectives)

3) ACTIVITIES (Specific things to do to help you learn)

4) RESOURCE PACKAGES (Instructions for carrying out the Activities, such as procedures, references, laboratory materials, etc.)

5) EVALUATION (Tests to help you learn and to determine whether or not you satisfactorily reach the terminal behavioral objectives):

   a) Self-test(s) with answers to help you learn more.

   b) Final test, to help measure your overall achievement.

TERMINAL BEHAVIORAL OBJECTIVES

When you have completed this minicourse, you will demonstrate a knowledge of communications technology by being able to:

1) write a definition of "communication."

2) construct a list of several past, present, and advanced communication methods.

3) assemble and operate two simple communication devices, and explain the function of the parts of these devices.

4) write a definition of "wave"; write a description of longitudinal and transverse waves; and recall (or otherwise identify) wave nomenclature such as node, crest, length, rarefaction, amplitude, trough, compression, etc.

5) identify a list of standard electrical symbols used in communication circuit diagrams.

6) identify the main parts of a simple radio receiver, using either an actual set or a circuit diagram.

7) write a paragraph describing briefly how television works.

8) (Optional) explain to classmates or teacher how a speaker changes electrical energy into sound energy.

9) (Optional) explain to classmates or teacher how an oscilloscope works, demonstrate its operation, and tell some of the ways that the oscilloscope can be used.

ENABLING BEHAVIORAL OBJECTIVE #1:

Write a definition of "communication."

ACTIVITY 1-1

Study Resource Package 1-1.

ACTIVITY 1-2

Write the definition of "communication"; then compare your definition with the one given in Resource Package 1-1.

RESOURCE PACKAGE 1-1

"Definition of Communication; Related Vocations"

<u>ENABLING BEHAVIORAL OBJECTIVE #2:</u> Write a list of ten (10) present methods of communication, five (5) primitive methods, and five (5) advanced methods (future methods).	<u>ACTIVITY 2-1</u> Read "communication" topic from an encyclopedia. (If the encyclopedia you use is <u>The World Book Encyclopedia</u>, new edition, this can be found in Vol. 4, Ci-Cz, pages 711-724a.)	
	<u>ACTIVITY 2-2</u> Write the answers to questions in Resource Package 2-2.	<u>RESOURCE PACKAGE 2-2</u> "Questions"
<u>ENABLING BEHAVIORAL OBJECTIVE #3</u> Assemble and operate a string telephone and a simple telegraph. Tell the function of the main parts of each. *(Optional) Describe the operation of a photo-electric cell and a wireless telegraph ("Marconi machine").	<u>ACTIVITY 3-1</u> Perform the lab exercises in Resource Package 3-1.1 and 3-1.2.	<u>RESOURCE PACKAGE 3-1.1</u> "String Telephone"
	<u>ACTIVITY 3-2</u> Turn in the written laboratory reports for Activities 3-1.1 and 3-1.2 and ask your teacher to review your results and to discuss them with you.	<u>RESOURCE PACKAGE 3-1.2</u> "Telegraph"
	*<u>ACTIVITY 3-3</u> (Optional) Operate and observe either the photo-electric cell and/or the wireless telegraph, using the instructions that accompany the equipment. Then complete Resource Package 3-3.	*<u>RESOURCE PACKAGE 3-3</u> "Photo-electric Cell and/or Wireless Telegraph"

<u>ENABLING BEHAVIORAL OBJECTIVE #4:</u>	<u>ACTIVITY 4-1</u>	
Write a definition for "wave"; write a description of longitudinal and transverse waves; recall the names of (or otherwise identify) the parts of longitudinal and compressional waves; and solve simple problems involving length, frequency, and speed of waves.	Read about waves in your textbook. You can consult your teacher for recommended sections to read. (If you have <u>Physics, A Basic Science</u>, read pages 186-197.)	
	<u>ACTIVITY 4-2</u> Read Resource Package 4-2.1	<u>RESOURCE PACKAGE 4-2.1</u> "Waves"
	<u>ACTIVITY 4-3</u> Answer questions in Resource Package 4-3.1 on a sheet of paper; then check answers against those in Resource Package 4-3.2.	<u>RESOURCE PACKAGE 4-3.1</u> "Self-test" <u>RESOURCE PACKAGE 4-3.2</u> "Answers to Self-Test"
	<u>ACTIVITY 4-4</u> Perform lab exercise in Resource Package 4-4. Turn in the report to your teacher.	<u>RESOURCE PACKAGE 4-4</u> "Lab Exercise On Waves"
<u>ENABLING BEHAVIORAL OBJECTIVE #5:</u> Identify twenty-one (21) electrical symbols used in communication devices.	<u>ACTIVITY 5-1</u> Study the symbols in Resource Package 5-1.	<u>RESOURCE PACKAGE 5-1</u> "Electrical Symbols"
	<u>ACTIVITY 5-2</u> Read about the fundamentals of radio in your textbook. (If your textbook is <u>Physics, A Basic Science</u>, read Supplementary Topic 7, pages 499-506.)	

	ACTIVITY 5-3 Test yourself, using Resource Package 5-3.	RESOURCE PACKAGE 5-3 "Self-Test"
ENABLING BEHAVIORAL OBJECTIVE #6: Tell the class or your teacher the name and function of the main parts of a simple radio receiver, using either an actual radio set or a diagram (schematic).	ACTIVITY 6-1 Study Resource Package 6-1.	RESOURCE PACKAGE 6-1 "Simple Radio Receiver Circuits"
	*ACTIVITY 6-3 (Optional) Construct a simple radio receiver, such as those described in Resource Package 6-1 and demonstrate its use to the class.	
ENABLING BEHAVIORAL OBJECTIVE #7: Explain briefly, either orally or in writing, how television works.	ACTIVITY 7-1 Read a simple explanation of how television works (See REFERENCES page 45, of this minicourse). Study this so that you can explain in broad general terms how television works.	
ENABLING BEHAVIORAL OBJECTIVE #8: Explain to your classmates how a speaker changes electrical energy to sound (acoustical) energy.	ACTIVITY 8-1 Study Resource Package 8-1. Answer all questions in writing and discuss the answers with your teacher.	RESOURCE PACKAGE 8-1 "Speakers"

*ACTIVITY 8-2 (Optional)

Write out answers to Resource Packages 8-2. Have your teacher evaluate your answers.

*RESOURCE PACKAGE 8-2

"Optional Question on Sound"

*ENABLING BEHAVIORAL OBJECTIVE #9: (Optional)

Demonstrate to your classmates or your teacher how the oscilloscope works and tell some of the ways in which it is used.

*ACTIVITY 9-1 (Optional)

Following the directions found in the manual accompanying the oscilloscope, locate its main external parts. Perform the operations necessary to display a wave form. If the manual does not give applications (ways in which it is used), refer to any standard encyclopedia.

*ACTIVITY 9-2 (Optional)

Demonstrate the use of the oscilloscope to display wave forms of varying frequency and amplitude. Describe some of the uses of the oscilloscope to your classmates or your teacher.

EVALUATION

ACTIVITY 10-1

Test yourself, using Resource Package 10-1.1. Check your answers against those in Resource Package 10-1.2.

RESOURCE PACKAGE 10-1.1

"Self-Test"

RESOURCE PACKAGE 10-1.2

"Answers to Self-Test"

ACTIVITY 10-2

When you feel prepared for the final evaluation, ask your teacher for Resource Package 10-2.

RESOURCE PACKAGE 10-2

"Final Evaluation"

RESOURCE PACKAGE 1-1

DEFINITION OF COMMUNICATION: RELATED VOCATIONS

Communication: the act of sending-receiving; transmission and receipt of a message; transferring knowledge or information about.

Related Vocations: advertising, electronics, radio broadcasting, television broadcasting, and telephone communications.

Note: This course should serve as a general preparation for four-year colleges and as a preparatory course for technical studies in two-year colleges.

In our modern technological society, your occupation will be both a way of making a living and a way of life. So you will want to choose carefully. Do you know that there are at least 30,000 different jobs to choose from?

To Do: Examine Volumes 1 and 2, *The Encyclopedia of Careers and Vocational Guidance* (See REFERENCES, page 45*). Then:

1) List at least five (5) vocations related to communications. Include a one- or two-sentence description of each vocation listed.

2) Rank these vocations in order of interest to you. Put the most interesting first; the least interesting last.

3) In one or two paragraphs, tell how a person might select a vocation. You can include where to go for information; how to use personality, interest, and aptitude tests as aids in career selection; etc.

4) Turn in these materials to your teacher for discussion and evaluation.

*If not available, consult your school guidance counselor or librarian.

RESOURCE PACKAGE 2-2

QUESTIONS

Answer the following questions on notebook paper.

1) You constantly receive messages through your five senses: tactile sense (touch), olfactory sense (smell), auditory sense (hearing), optical sense (sight), and gustatory sense (taste). Listed below are examples of these kinds of messages and how you might interpret them:

	WHAT YOU SENSE (What Your Body Detects)	INTERPRETATION (What the Sensation Means to You)
TOUCH:	Car engine feels hot.	Car has run recently.
SMELL:	Bacon odor smells good.	Breakfast is nearly ready.
HEARING:	School bell rings loudly.	It is time to move quickly.
SIGHT:	Sunlight comes in window.	It is morning.
TASTE:	Food tastes spicy hot!	There is pepper in my food!

Now, using the same form above, list ten (10) more examples of messages sensed and their possible meanings.

2) What are some of the ways that primitive people communicated with one another and with future generations?

3) Name at least two methods of communication that are being developed for future use.

4) What are the two basic components, or parts, in any communication system?

5) According to the passages you read in the encyclopedia, were you able to recognize problems in communicating messages to people, especially problems of <u>mass media</u> (communication using machines such as radio, television, etc.)? What are they?

6) Consider an actual message that you have received recently, such as a television commercial or a classroom lecture. Write down how that message and its delivery were designed to overcome any or all of the problems listed in question 5, above (How effectively did it get your attention, etc.?).

7) List some ways that society has best benefitted from rapid, world-wide communication. Now, list some of the biggest problems that have been created or intensified by the technical progress of world-wide communication.

RESOURCE PACKAGE 3-1.1

STRING TELEPHONE

For this laboratory exercise you will need:

several meters (yards) of strong thread, such as carpet and button thread
several meters (yards) of cotton string
2 steel sewing needles (less than 2 inches long) or paper clips
2 disposable drinking cups made of heavy waxed paper or thin molded plastic
2 empty tin cans (clean) of about the same size
a meter stick or measuring tape
paper and pencil

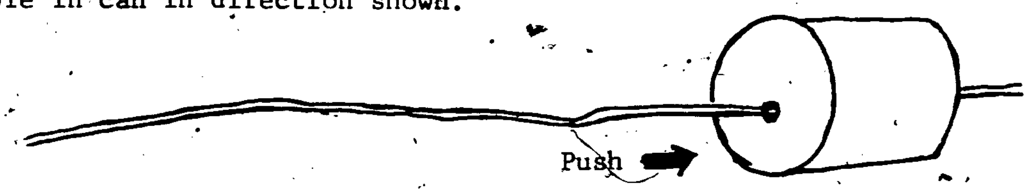
Purpose: To investigate some conditions under which sound can be transmitted through a non-metallic solid.

Procedure: You will make several tests to see if the human voice can be transmitted satisfactorily by this simple device. For this exercise, you will need a laboratory partner.

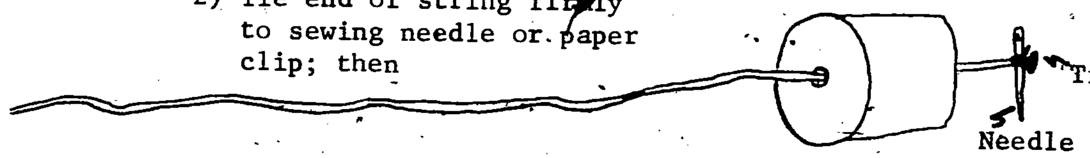
First, punch a small hole in the center of the bottom of each cup and each can. Next, measure and cut a piece of cotton string about fifteen (15) meters long.

Then, insert each end of the string through the hole in a can bottom, as shown:

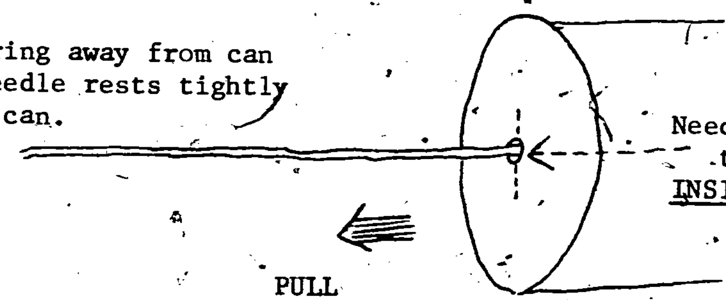
1) Push end of string through
hole in can in direction shown.



2) Tie end of string firmly to sewing needle or paper clip; then



Pull string away from can until needle rests tightly against can.



Tie one end of the string firmly around a sewing needle or paper clip, and pull the string back out of the can until the needle rests flat against the bottom of the can.

Next, do the following:

a) You and your partner should move apart now, each holding a can until the string is slack, but not touching the floor. Have your partner begin speaking into the can while the string is still slack; then, you move back carefully while your partner continues to talk into the can. Keep moving back while your partner talks, until the string is as tight as you can get it without breaking it. The cans should be kept in a straight line with the string at all times. If the weather permits, your teacher may prefer that you go outside to do this activity. Record your observations on a chart (Make a chart like the one below) using "+" to show when you could just barely hear, "++" when you could hear clearly, and "o" when you could not hear at all.

Note: If your partner talks too loudly, you will hear the sound without the string telephone and your observations will not be accurate. You may have to ask (him/her) to "pipe down."

b) Reverse roles with your partner and repeat the procedure.

c) Shorten the string to ten (10) meters and repeat the same procedures followed with the 15-meter string.

d) Replace the cans with the plastic (waxed paper) cups and repeat procedures a, b, and c, above.

e) Now, repeat procedures a through d, above, using thread in place of string. Continue to record your observations.

OBSERVATIONS: Use "++", "+", and "o" to indicate the results obtained.

STRING TELEPHONE

	SLACK (loose)		TIGHT
Cans and 15m string			
Cans and 10m string			
Cans and 15m thread			
Cans and 10m thread			
Cups and 15m string			
Cups and 10m string			
Cups and 15m thread			
Cups and 10m thread			

CONCLUSIONS: Answer the following questions in writing. Then show both the "Observations" and "Conclusions" to your teacher. Discuss these with (him/her).

1) Which set of materials seemed to give the best sound transmission? Write down your guess as to why.

2) Under what conditions did the string seem to transmit the message best?

3) Under what conditions did the thread seem to transmit the message best?

4) What do you think would happen if you ran your communication string around a corner? Try it.

5) <u>Based upon these observations</u>, can you think of a material that might be better than either string or thread as a sound transmitting medium? What physical properties do you think this better medium ought to have?

RESOURCE PACKAGE 3-1.2

TELEGRAPH

For this lab exercise, you will need the following:

Telegraph key, push-button switch, or knife switch
Teleghaph sounder, bell, or flashlight bulb
Four (4) or more meters of small diameter electric wire, solid or stranded, and preferably insulated
Two 1.5 volt dry cells with screw or clip binding posts (terminals)
Two copies of the Continental Code (a telegraph code found in this resource package, page 16)

Purpose: To observe the structure and operation of a simple telegraph system.

Procedure: Connect the sounder, light, or bell to the cells so that a complete circuit is established if the switch is closed. See the diagram below:

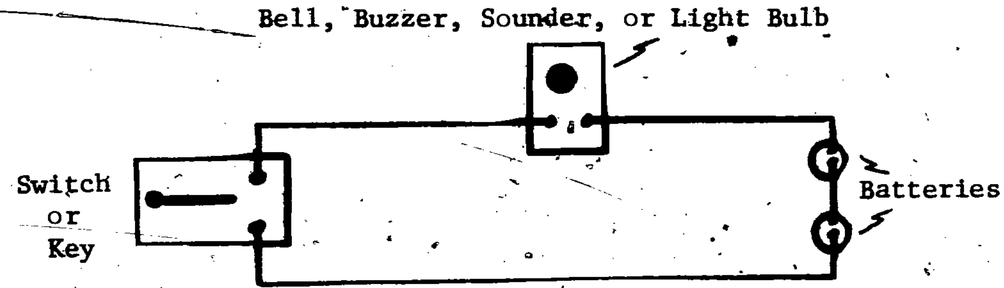


DIAGRAM OF A TELEGRAPH CIRCUIT

If you have difficulty connecting the wires, ask another student or your teacher for assistance. Practice using the key to make short (dot) and long (dash) sounds or flashes because the dots in the code you will use represent short signals and the dashes represent long signals. Make sure that both you and your partner hear or see the difference in long and short signals.

Now, using the Continental Code (Resource Package 3-1.2 Supplement), transmit a simple message to your partner. He/She will need a copy of the code also, as well as a pencil and paper for recording your message. It may require several attempts to send a sentence. Note how long it takes to transmit even a short and simple message. When you have successfully sent a telegraph message, exchange places with your partner and let (him/her) send a message to you.

OBSERVATIONS: Write a paragraph describing the transmission (sending) and reception (receiving) of your telegraph messages.

CONCLUSIONS: Write the answers to the following questions on notebook paper. Then discuss the answers with your partner and with your teacher. Then turn in both your "Observations" and "Conclusions."

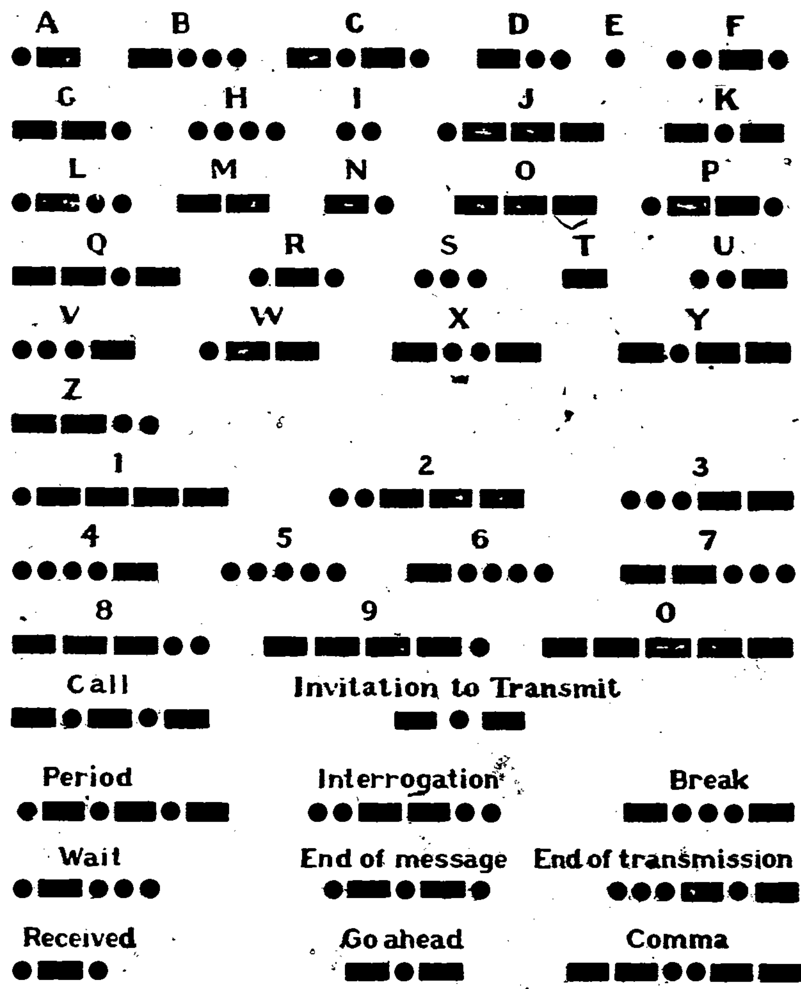
1) As you pressed the key, the chemical energy in your body was converted to what form of energy? What form of energy transmitted the message through the circuit to your partner?

2) What practical limits on distance and location do you see for this form of communication? (How would it work for messages to planes in the air, for instance?)

3) What about the speed of messages transmitted by the telegraph as opposed to the other forms of sound communication you've tried?

4) Compare the telegraph with the string telephone in terms of (a) kind of energy in the transmitting medium, (b) type of wave in the transmitting medium, and (c) flexibility of applications (Can telegraph go around a corner?).

THE CONTINENTAL CODE



THE CONTINENTAL CODE

RESOURCE PACKAGE 3-3

PHOTO-ELECTRIC CELL AND/OR WIRELESS TELEGRAPH

Answer the following questions in writing. Then discuss the answers with your partner and your teacher.

1) How was the message put into the device (that is, with what form of energy)?

2) Through what medium was the message actually transmitted? How does this medium differ from the string telephone and the wire telegraph?

3) What are some limits on the use of these devices (speed, distance, flexibility, interference)? Will either (or both) work around a corner?

4) What are some practical present-day uses of these devices that you have observed or know about?

5) Do you suppose the photo-electric cell and/or the wireless telegraph could be used to transmit messages where there was no medium (in a complete vacuum, for example)?

RESOURCE PACKAGE 4-2.1

WAVES

The word, wave, in physics, has a much, much broader and more fundamental meaning than simply the description of certain kinds of water motions. (In fact, you would likely find it much easier to understand the physics of waves if you had never seen water waves!).

We will start out by thinking of communication waves as simply "some form of energy in motion." Remember that sound waves travelled along the string of your string telephone. In this case, sound energy was in motion along the string even though the string was held tightly in place and went nowhere.

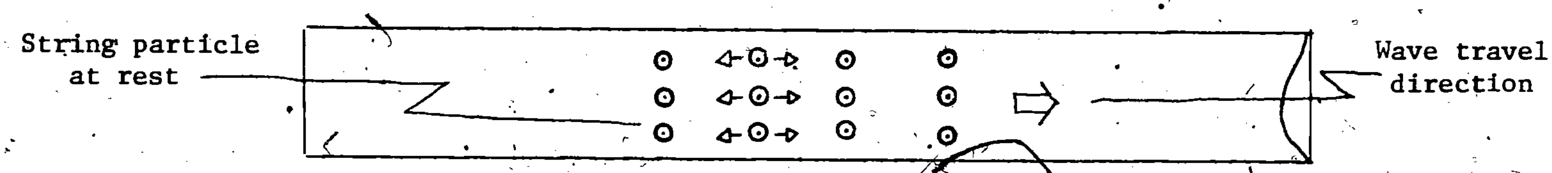
Wave forms which require a medium (solid, liquid, gas, or plasma) to travel through are called mechanical waves. The sound wave of the string telephone could not travel through a vacuum. Because sound waves require a medium to travel through, they are classified as mechanical waves. Other examples of mechanical wave forms are sonic booms, earthquake waves, and water waves. However, not all wave forms require a medium. Electromagnetic waves are examples of non-mechanical waves which need no medium and can travel even through a vacuum. X-rays, radar, radio, television, microwaves, "black light," radiant heat, and visible light are all electromagnetic wave forms.

Waves are commonly classified also as longitudinal waves or transverse waves. While all electromagnet waves are transverse, mechanical waves can be either longitudinal or transverse according to the following classification system:

Longitudinal - In a longitudinal wave, as the energy travels through the medium the particles of the medium move back and forth in the same direction that the wave form is traveling. These particles move parallel to the direction of wave travel.

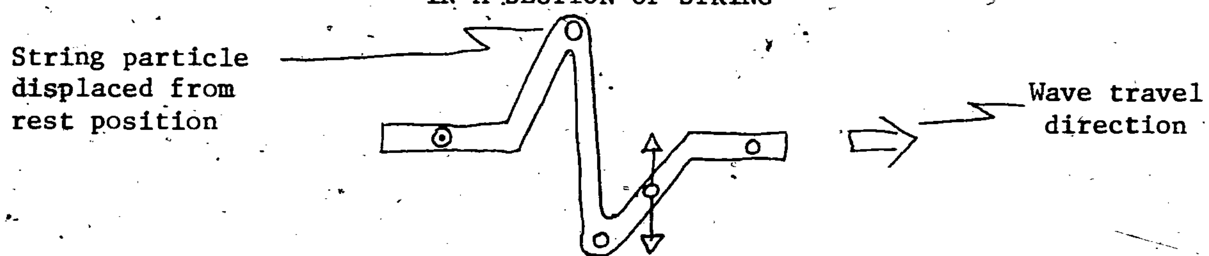
Transverse - In a transverse wave, as the energy travels through the medium the particles* of the medium move back and forth at right angles to the direction the wave is traveling. These particles move transverse to (at right angles to) the direction of wave travel.

LONGITUDINAL WAVE
IN A SECTION OF STRING



At the time the wave form is passing, each particle moves parallel to the direction of wave travel. The particles can move only back and forth about a "fixed" position in the string since the string itself does not travel.

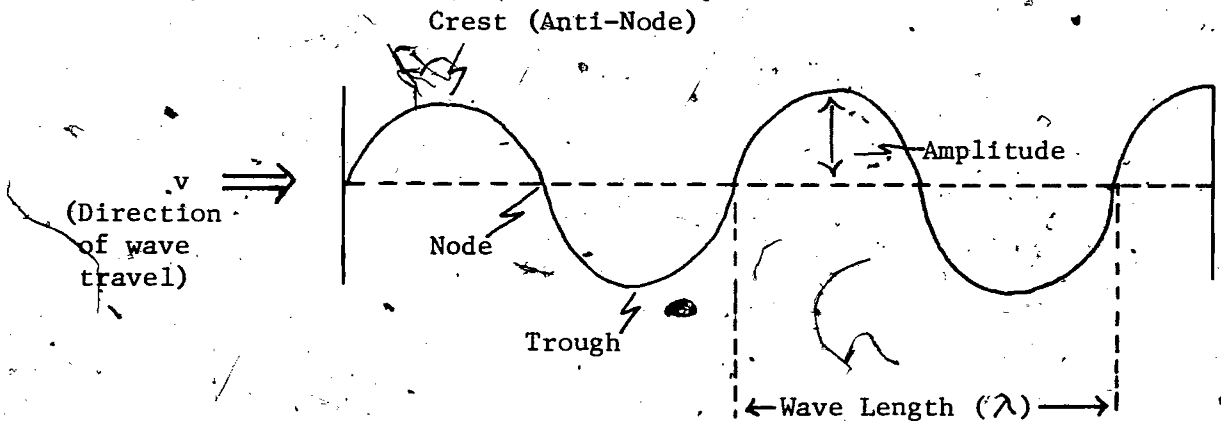
TRANSVERSE WAVE
IN A SECTION OF STRING



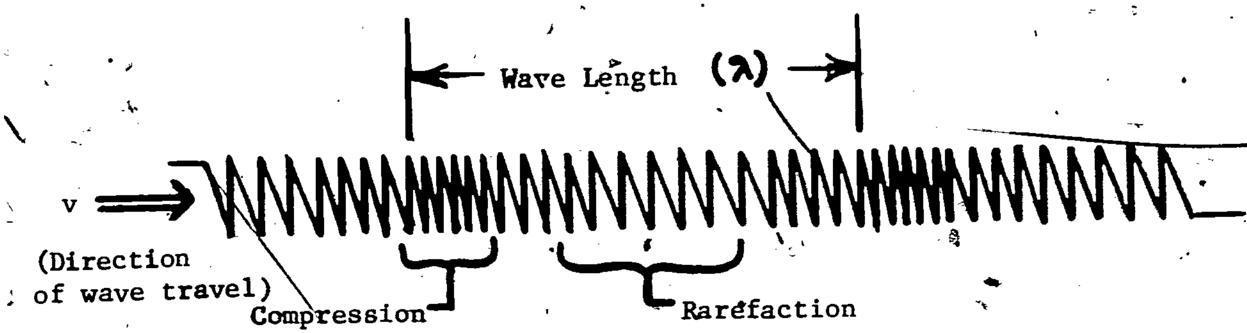
At the time the wave form is passing, each string particle can move only transverse to (at right angles to, or perpendicular to) the wave's direction of travel.

*Only mechanical waves are associated with particles; electromagnetic waves require no medium, but are called transverse waves because they have associated electric and magnetic fields which move back and forth at right angles to each other.

All waves have the characteristics of length, frequency, and speed. In addition, we designate other such characteristics as nodes, anti-nodes, crests, troughs, and amplitude (See diagram of transverse wave below.)



A longitudinal wave involves regions of compression and rarefaction (expansion) of the medium through which the wave travels. Below is a diagram of a longitudinal wave form traveling along a spring, such as a "Slinky." Can you see similarities (likenesses) between this diagram and the transverse wave diagram, in terms of nodes, anti-nodes, crests, troughs, and amplitude? Hint: The compression part of a longitudinal wave is analogous (that is, can be compared to) the crest of a transverse wave; the rarefaction part can be compared to its trough.



In both diagrams of these types of waves, the wavelength is indicated as the distance between two like points on the "wave train," where a wave train is defined as a series of repeated pulses of moving energy. (For example, repeated voice pulses result from vibrating vocal cords; these pulses produce the wave train we refer to as a continuous sound.) The distance from the center of the crest of one wave to the center of the crest of the next wave is one wavelength. It follows then that the distance from the trough center to the next trough center is also one wavelength. Wavelength is given in units of linear measure; such as millimeters, inches, centimeters, feet, meters, or kilometers.

The speed of the wave is the rate at which the energy form can travel. Wave speed is given in the usual speed units (distance per unit of time); such as miles per hour, meters per second, etc. The speed of sound in air, for example, is approximately the speed of a 22-calibre rifle bullet, which is $\approx$ 1,000 ft/sec, $\approx$ 750 mi/hr, or Mach 1.

The frequency of a wave is the number of complete pulses, waves, or vibrations that occur during a certain period of time. Frequency is usually expressed in cycles per second. The hertz is the name of the unit of frequency. Its symbol is Hz, and 1 Hz = 1 cps (1 cycle per second).

We will use the Greek letter lamda, λ, as the symbol for wavelength; the lower-case letter, f, to represent frequency; and lower-case, v, for speed (from the word "velocity"). For all waves there exists a fixed relationship between wavelength, frequency, and speed. Algebraically, this relationship is expressed by the formula: $v = f\lambda$. This formula can be rearranged to find wavelength, $\lambda = \frac{v}{f}$, or to find frequency, $f = \frac{v}{\lambda}$.

If you have listened to a shortwave (ham) radio or to citizen's band broadcasts, you have surely heard stations identified by <u>wavelength</u>, such as "80-meter band." When you have listened to AM or FM radio, however, it is <u>frequency</u> that is given to identify the station. For AM you may have heard frequency identifications such as "eleven-ninety kilohertz" (or kilocycles); and for FM, "101.4 megahertz" (or megacycles). You may wonder what these AM and FM frequency designations stand for. First, recall that the prefix, "kilo," means "thousand" and "mega" means "million." Then you can see that "1190 kilohertz" measn 1,190,000 hertz (pulses, cycles, or waves of energy per second). If you do not know what "AM" or "FM" stand for, look up "amplitude modulation" and "frequency modulation." (Try the glossary in your text.) You will find that <u>modulation</u> is a means for putting a desired message onto a wave train, and that frequency change and amplitude change are two ways of modulating (<u>coding</u>) a wave train. The speed of electromagnetic waves in air (light waves, radar waves, or radio waves, etc.) is about 300,000,000 meters per second (3×10^8 m/s) or 186,000 miles per second (1.86×10^5 mi/sec). Let us use the equation, $\lambda = \frac{v}{f}$, to find the wavelength of the AM station mentioned above:

Given: Speed $v = 300{,}000{,}000$ meters per second and frequency $f = 1{,}190{,}000$ hertz

Find: Wavelength

Solution: 252 meters

<u>Mathematical Steps for Solution:</u>

$$\lambda = \frac{v}{f} \overset{(1)}{=} \frac{300{,}000{,}000 \text{ m/sec}}{1{,}190{,}000 \text{ Hz*}} \overset{(2)}{=} \frac{300{,}000{,}000 \text{ m/sec}}{1{,}190{,}000 \text{ cycles/sec}} \overset{(3)}{=} \frac{30{,}000 \text{ m/sec}}{119 \text{ cycles/sec}} \overset{(4)}{=} 252 \text{ m/cycle}^{**} = 252 \text{ m}$$

<u>Note</u>: *Hz = cycles/sec = cps

**The unit "sec" was divided out of both numerator and denominator in solution step 4, leaving m/cycle. But "cycle" is considered to be a "dimensionless unit" so we simply drop it from the calculation.

Now, let us rearrange our wave relationship formula to find the frequency of the 80-meter shortwave broadcast:

$$f = \frac{v}{\lambda}$$

$$= \frac{300{,}000{,}000 \text{ m/sec}}{80 \text{ m}} = \frac{30{,}000{,}000}{80 \text{ sec}}$$

$$= \frac{3{,}750{,}000}{\text{sec}} = 3.75 \times 10^6 \text{ Hz}$$

Remember, the wave relationship, $v = f\lambda$ holds for all the types of waves you have studied. Now try to solve the problems on the next page on notebook paper. Check your answers with the answers on page 26. If you miss more than one (1) of the five (5) problems, ask your teacher to help you find out why you are having difficulty.

RESOURCE PACKAGE 4-3.1

SELF-TEST

Solve the following problems:

1) Sound waves travel at about 300 m/sec in air. What will be the wavelength of a sound whose frequency is 400 hertz?

2) What will be the speed of a wave whose wavelength is 14 meters and whose frequency is 20 hertz?

3) What is the wavelength of a radio wave whose frequency is 9,300 hertz?

4) What is the frequency of an electromagnetic wave whose length is 10^5 meters (100,000 m)?

5) What is the wavelength of a sound whose frequency is 75 hertz? (Assume sound travels 1,080 ft/sec.)

ANSWERS TO SELF-TEST

1) $\lambda = \frac{v}{f} = \frac{300 \text{ m/s}}{400 \text{ s}} = .75 \text{ m}$

2) $v = \lambda f \quad v = (14 \text{ m})\ (20 \text{ Hz}) = (14 \text{ m})\ (20 \text{ c/s}) = 280 \text{ m/s}$

<u>Solution in English Units</u>

3) $\lambda = \frac{v}{f} = \frac{186{,}000 \text{ m/s}}{9{,}300 \text{ Hz}} = \frac{1.86 \times 10^5 \text{ mi/s}}{9.3 \times 10^3 \text{ cps}} = 20 \text{ mi}$

<u>Solution in Metric Units</u>

$\lambda = \frac{v}{f} = \frac{300{,}000{,}000 \text{ m/s}}{9{,}300 \text{ cps}} = 32{,}258 \text{ m}$

4) $f = \frac{v}{\lambda} \quad f = \frac{300{,}000{,}000 \text{ m/s}}{100{,}000 \text{ m}} = \frac{3 \times 10^8 \text{ m/s}}{10^5 \text{ m}} = 3 \times 10^3 \text{ cps} = 3{,}000 \text{ Hz}$

5) $\lambda = \frac{v}{f} = \frac{1{,}080 \text{ ft/s}}{75 \text{ Hz}} = \frac{14.4 \text{ ft/s}}{\text{cps}} = 14.4 \text{ ft}$

RESOURCE PACKAGE 4-4

LAB EXERCISE ON WAVES

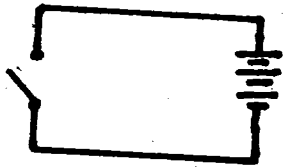
Read carefully the instructions for a laboratory exercise on observing wave phenomena in a coil spring. (If your text is Physics, A Basic Science, read pages 187 and 188.) Be careful not to stretch the spring beyond its stretch limit (elastic limit)!

Now get a "Slinky" or other coil spring and perform the activities. If a stopwatch is available, it will be useful in timing the waves.

Next locate a shallow container such as a pan or tray (As a last resort, use a sink). Fill the container with water to a depth of 1 to 2 inches. When the water surface becomes calm, drop a solid object (coin, steel ball, etc) into the center of the container and observe the wave patterns. Can you observe wave reflection? What kind of wave front is seen (straight? curved?)? Now drop an object into the water near one side of the container. What happens when two wave fronts meet? Finally, place a cork or other light object on the water and drop the coin into the center again. As the waves move out, what does the cork do? Does this fit in with your previous ideas about wave action?

RESOURCE PACKAGE 5-1

ELECTRICAL SYMBOLS

Circuit 

Battery 

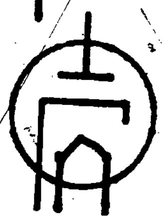
Switch 

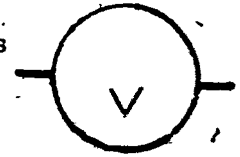
Diode 

Induction Coil 

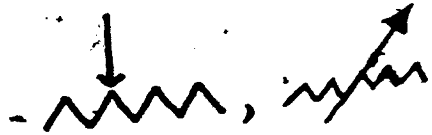
Ground 

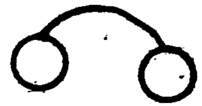
Antenna 

Tubes 

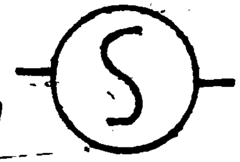
Meter (letter in center indicates which kind of meter) 

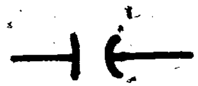
A - ammeter
G - galvanometer
V - voltmeter

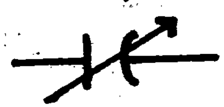
Variable Resistor 

Head Phones 

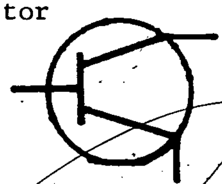
Resistance 

A. C. Voltage Source (alternator) 

Capacitor 

Variable Capacitor 

Transistor



Transformer
(air core)

Transformer
(iron core)

Lamp

Speaker

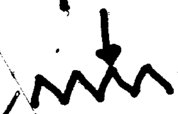
RESOURCE PACKAGE 5-3

SELF-TEST

On a separate sheet of paper write the name for each of the following symbols. Check your answers, using Resource Package 5-1. If you miss more than four (4) of the twenty-one (21) symbols, further study is indicated.

1. 

2. 

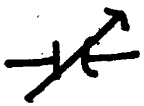
3. 

4. 

5. 

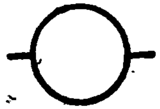
6. 

7. 

8. 

9. 

10. 

11. 

12. 

13. 

14. 

15. 

16. 

17. 

18. 

19. 

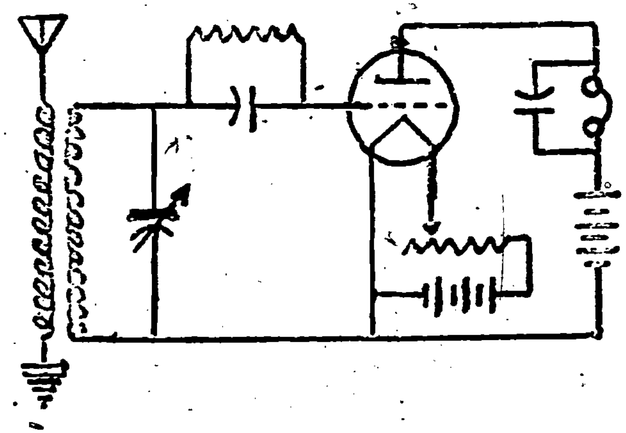
20. 

21. 

RESOURCE PACKAGE 6-1

SIMPLE RADIO RECIEVER CIRCUITS

This schematic drawing of a simple radio receiver circuit is only one of many plans for building a radio receiver.

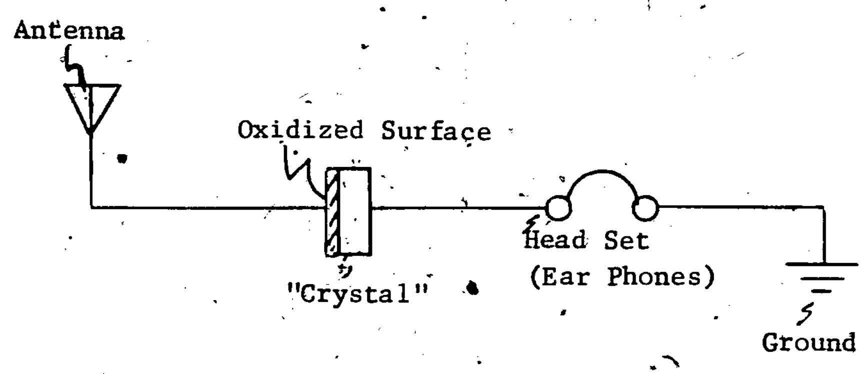


CIRCUIT DIAGRAM OF A
SIMPLE RADIO RECEIVER

Can you identify all of the parts by looking at such a drawing? You may need to review Resource Package 5-1, "Electrical Symbols."

The diagram on the next page shows how a very simple crystal radio receiver can be constructed easily and successfully. To construct it, buy a cheap commercial crystal (or make a crystal by oxidizing one side of a piece of metal; or simply employ a "ready-made crystal" by using an old razor blade--Gillete Blue Blades ought to work well). You can quickly oxidize a metal by heating it over a Bunsen burner or other flame for a little while.

Connect one side of the crystal to an antenna or to any large metal object; connect the other side through a head set to a ground (a water pipe, for example). See the diagram below.



CIRCUIT DIAGRAM OF CRYSTAL
RADIO RECEIVER

This radio should pick up the strongest station in your area.

Can you figure out what role the crystal plays in this radio receiver?

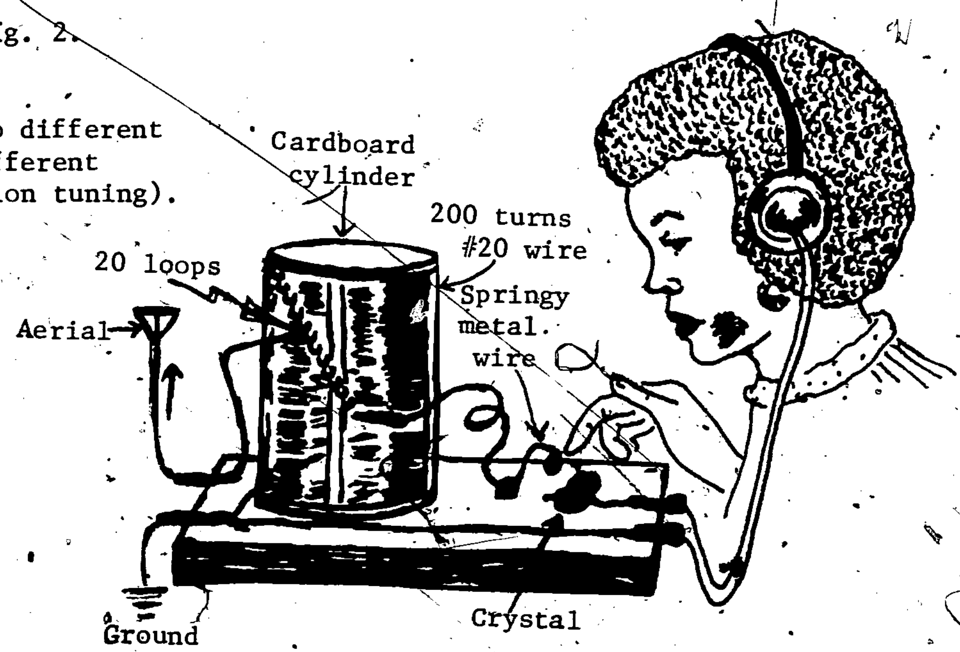
This section explains how you can take only a half dozen parts and put together fancier, yet simple, radio receivers able to pick up amplitude-modulated (AM) broadcasts. You will need some of the following materials:

1 coil (make it yourself)
1 crystal detector (or diode)
1 variable capacitor (optional)

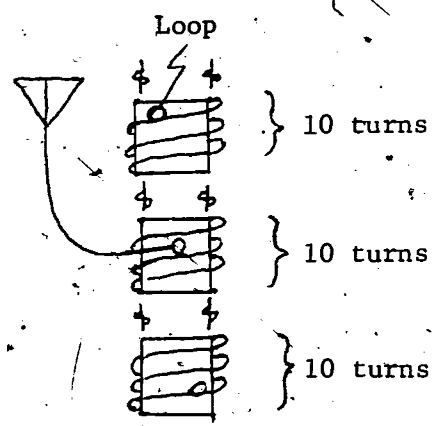
1 fixed capacitor (optional)
1 set of headphones
wires for ground, coil, antenna, and circuit

Start by cutting a cardboard cylinder to about an 8-inch length; a cardboard toilet paper roll insert will do*(See Fig. 1). Wind the coil as shown, using insulated electrical wire of small diameter. The coil should contain about 200 turns, with <u>loops</u> every 10 turns; the aerial attaches to different loops for tuning. Connect parts as shown in Figure 1. Test your radio set by connecting it to a long aerial and to a good ground. How many different stations can you pick up by changing the number of coil loops connected to the aerial? If you desire to make a fancier, more sensitive receiver then construct the set shown in Fig. 2.

Aerial hooks onto different <u>loops</u> to tune different stations (induction tuning).

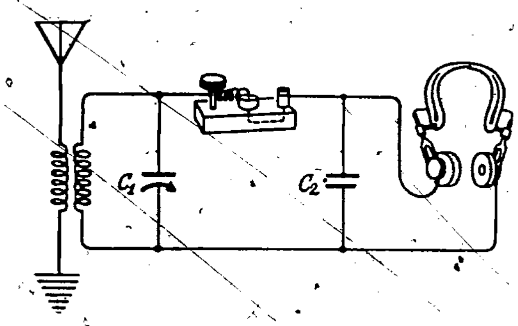


TUNABLE CRYSTAL RADIO RECEIVER
Fig. 1



Sections of tuning coil. Aerial clips to <u>loops</u> for station selection. Be sure to strip insulation from section of each loop.

*A larger diameter cylinder is better.



The variable capacitor C_1 is for tuning (capacitor tuning).

CIRCUIT DIAGRAM OF TUNABLE
CRYSTAL RADIO RECEIVER
Fig. 2

Some Additional Thoughts: Although radio receivers can have hundreds of parts, there are only three essential ones: (1) an antenna (usually a length of wire) to pick up some of the electromagnetic wave energy in a broadcast signal, (2) a detector (in our case, a crystal) for converting the broadcast energy into an electrical current to drive the speaker (in our case, a headphone), and (3) a headphone (speaker) for converting the electrical current (energy) in the radio circuit into sound waves.

Your crystal detector is what is known as a rectifier. The rectifier takes the alternating electrical current produced by the alternating radio-frequency broadcast signal and changes it into the direct current which drives the speaker. The message in the signal (AM radio wave) is carried by variations in the wave's amplitude*, and the direct current that comes out of the rectifier conforms to these

*Remember, some carrier waves are frequency modulated (FM) and FM receivers detect variations in frequency rather than in amplitude.

variations. Figure 3 pictorializes how a broadcast wave alternating at radio frequencies is eventually changed to a direct current pulsating at audio frequencies (frequencies we can hear).

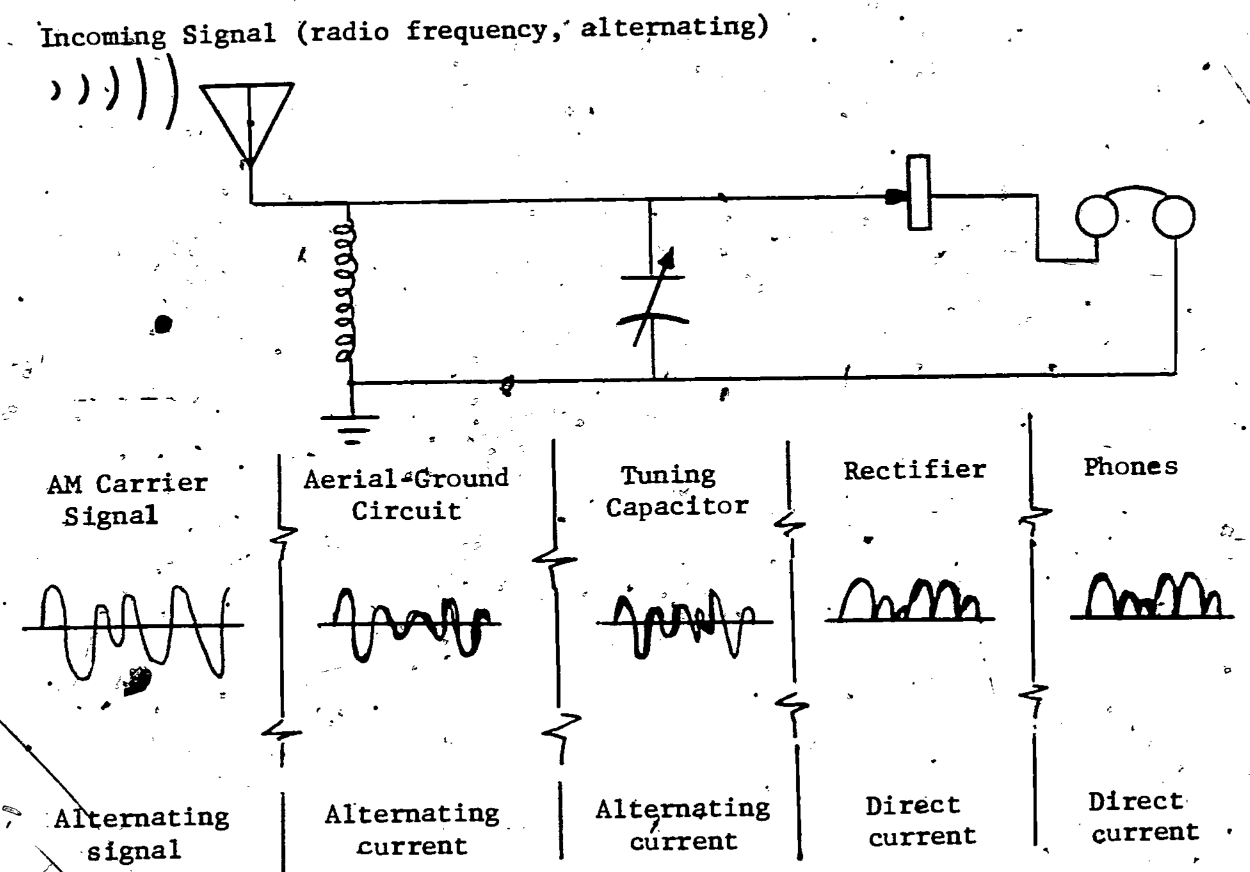
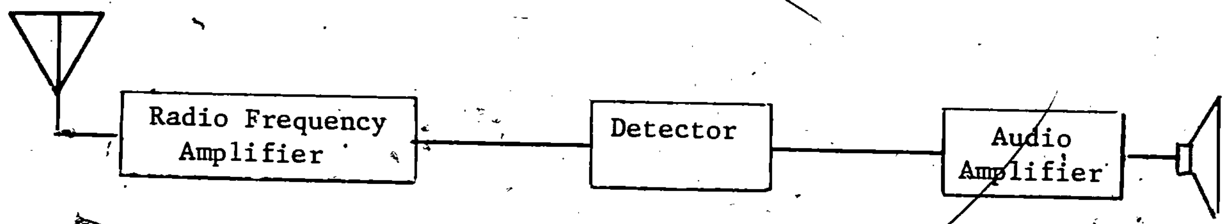


DIAGRAM OF AC-DC RELATIONSHIPS
IN CAPACITOR-TUNED CRYSTAL RECEIVER
Fig. 3

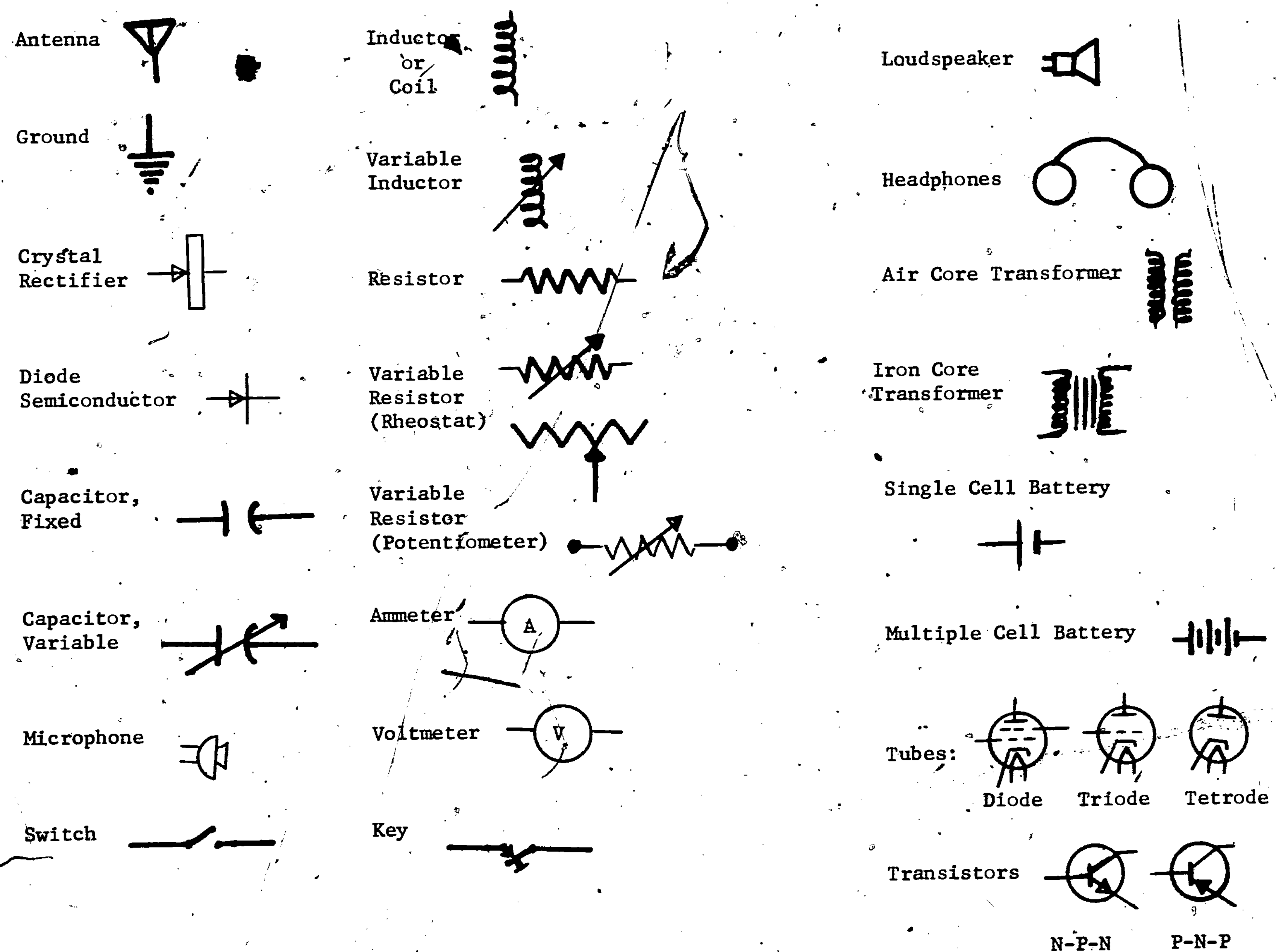
Fig. 4 is a block diagram of the components of a simple pre-detector and post-detector amplification system. The radio frequency amplifier builds up the <u>radio signal</u> before detection; the audio amplifier builds up the <u>audio signal</u> after detection. Both build-ups result in amplification (gain) of the energy (message) received from the broadcast wave.



BLOCK DIAGRAM OF PRE-DETECTOR AND POST-DETECTOR AMPLIFICATION

Fig. 4

Page 37 shows symbols you should know if you wish to study more about electronics or if you wish to read such magazines as <u>Popular Mechanics</u>, <u>Popular Electronics</u>, <u>Electronics World</u>, etc. for pleasure and greater understanding.

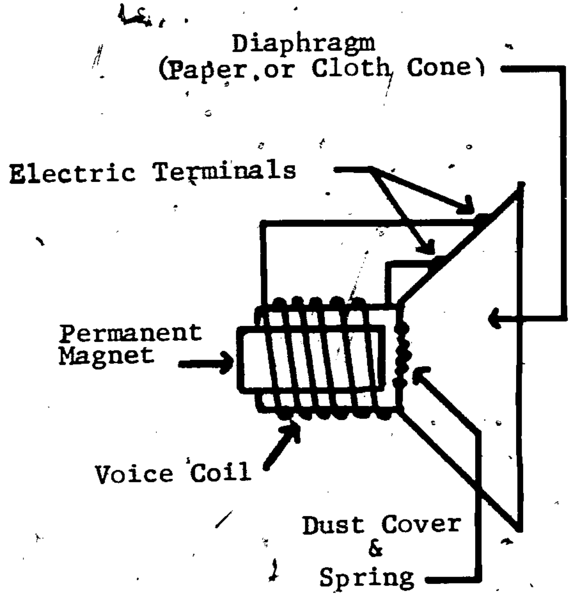


SCHEMATIC SYMBOLS YOU SHOULD KNOW

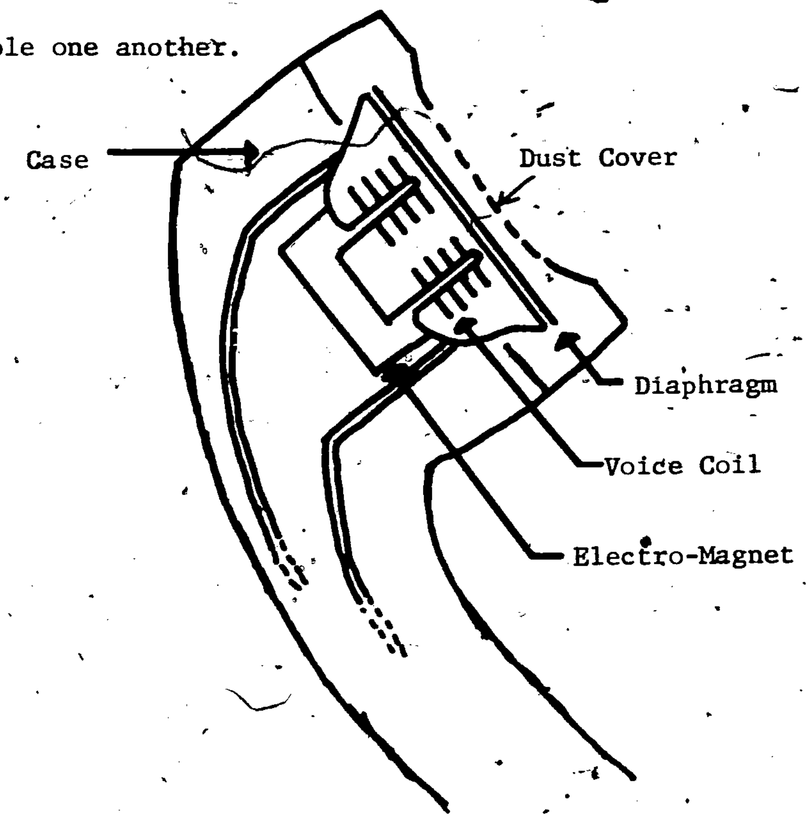
RESOURCE PACKAGE 8-1

SPEAKERS

Speakers that are often near you include those in the school's public address system, in conventional radios, in stereo systems, in television sets, and in your telephone. These speakers are usually enclosed or covered so that you cannot see their parts. If a speaker is available in your physics lab, examine it. Try to locate the typical parts that are illustrated in the drawings below. While the parts of the speaker you examine may not look exactly like the ones in these drawings, they should be in the same relative positions and should resemble one another.



LOUD SPEAKER



TELEPHONE SPEAKER

What differences and what similarities do you see between these two speakers? In what form does energy enter the speaker; that is, what kind of energy wave goes into the speaker? What form of energy (or wave) leaves the speaker?

There are several ways to increase the loudness or volume of sound from any speaker. One way is to increase the electrical signal fed into the speaker. Another is to increase the size or strength of the speaker magnets. Still another is to enlarge the vibrating surface that produces the sound waves in air. Look through one of the radio or electronic magazines in your school library, or look at an electronics catalog, to see the terms with which different kinds of speakers are described.

RESOURCE PACKAGE 8-2

OPTIONAL QUESTION ON SOUND

The Talmud is a book of Jewish law, dating from 400-500 A.D. Consider this quotation from The Talmud, "In the case of a cock putting his head into an empty utensil of glass where it crowed so that the utensil broke, the whole cost shall be payable." Explain, in simple terms, the technical physics of this quotation. (Hint: Look for the word "resonance" in your search for an explanation.)

Can you relate the physics of this ancient quotation to the acts of singers whose voices break wine glasses on television commercials?

SELF-TEST

Write the answers to the following questions on notebook paper. Check your answers against those in Resource Package 10-2.1. If you have missed more than two (2) of the ten (10) questions, you should review the appropriate activities in this minicourse. If you miss fewer than two questions, you are probably ready for Activity 10-3.

1) What does the work "communication" mean?

2) What are three (3) problems that must be solved if communication is to take place?

3) List at least ten (10) methods of communicaiton and note whether each is more associated with the past, the present, or the future. Example: smoke signals - past

4) Think about the string telephone. (a) In what form was energy put into that system? (b) In what form did energy come out of that system? (c) Was any energy lost? (d) What was the transmitting medium? (e) What are two obvious disadvantages of this as a communication system?

5) Now, think about the wire telegraph. (a) In what form is energy supplied to send a signal? (b) In what energy form is the message received? (c) What is the transmitting medium? (d) In what ways is this superior to the string telephone? (e) List two (2) communication situations in which the wire telegraph circuit could not be used.

6) Draw the symbol for each of these:

resistance	meter
battery	capacitor
switch	ground
transformer	A. C. power source

7) (a) What is a mechanical wave? (b) In a transverse wave, in what direction do the particles move? (c) In a longitudinal wave, in what direction do particles move? (d) What word is used to mean "maximum displacement" of a particle in a wave? (e) The distance from a point on one wave to a similar point on the next wave in a wave train is called the __________.

8) Think about how television works. (a) In what forms does energy enter the television camera? (b) What is the transmitting medium through which the television signal reaches the receiver? (c) Is this medium necessary? (d) What makes the television picture tube "light up"?

9) Speakers change electrical energy to sound energy. (a) What causes the cone or diaphragm to vibrate? (b) What are two (2) types of magnets used in speakers?

10) Solve these problems: (Select appropriate physical values from the list below.)

a) Find the frequency of a radio wave (speed = 186,000 miles/second) whose wavelength is .6 mile.

b) What is the speed of a wave whose length is 2 meters and whose frequency is 1,6000 hertz?

c) A sound wave (speed about 1,080 ft/sec) has a frequency of 256 hertz. What is its length?

Listed below are some speed values. Select the one appropriate to the problem you are working.

1,080 ft/sec
186,000 mi/sec
300,000 m/sec
390 m/sec

RESOURCE PACKAGE 10-1.2

ANSWERS TO SELF-TEST

1) See Resource Package 1-1. (Remember your deifinition does not have to be identical to this, but the meaning should be the same.)

2) Answers will vary. Some possibilities include: getting receiver's attention, having message interpreted, and having message accepted and acted upon.

3) Lists will vary. Some possibilities are:

stacked rocks - past
slashes on trees - past
semiphone (signal flags) - past and/or present
radio - present
telephone - present
satellite - present and future
speaking - past, present, and future

drums - past and/or present
smoke signals - past
telegraph - present
laser - future
writing and drawing - past, present, and future

4) (a) Sound. (b) Sound. (c) Yes. (d) String or thread. (e) Won't work over a long distance and won't work around corners.

5) (a) Mechanical. (b) Light or sound. (c) Wire. (d) Signal can go farther and can go around corners. (e) Sending messages to ships and airplanes.

6) Refer to Resource Package 5-1 for symbols.

7) (a) A disturbance in a medium. (b) At right angles to direction wave is moving. (c) Back and forth along the path of the wave's movement or parallel to wave motion. (d) Amplitude. (e) Wavelength.

8) (a) Light and sound. (b) Air. (c) No. (d) Electrons strike the tube face which is coated with a special chemical material which emits light (glows) when the electrons hit it.

9) (a) Changes in strength of magnetic field (or changes in the amount of electrical energy entering the coil of the magnet). (b) Permanent magnets and electromagnets.

10. a) $f = \frac{v}{\lambda} = \frac{186{,}000 \text{ mi/sec}}{.6 \text{ mi}} = 310{,}000$ hertz

b) $v = f\lambda = 2 \text{ m } (1{,}600/\text{sec}) = 3{,}200 \text{ m/sec}$

c) $\lambda = \frac{v}{f} = \frac{1{,}080 \text{ ft/sec}}{256 \text{ Hz}} = \frac{1{,}080 \text{ ft/sec}}{256/\text{sec}} = \frac{1{,}080 \text{ ft}}{256} = 4.2 \text{ ft}$

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4) Herron, Edward A., Miracle of the Air Waves, Julian Messner, New York, New York, 1969.

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9) **Schaum, D., Schaum's Outline Series, Theory and Problems of College Physics, McGraw-Hill, New York, New York, 1961.

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PERIODICALS

1) Electronics World, Ziff-Davis Publishing Co., New York, New York.

2) Popular Mechanics Magazine, Hearst Magazines, New York, New York.

*Girls can use this reference as well! For too long, males have been the only sex encouraged to study the fascinating worlds of radio and electronics.

**Strongly recommended for students seeking assistance in the problem-solving aspects of physics; contains over 625 solved problems, with explanations.