Iridescent Lesson Plan

PRE-PLANNING	**OBJECTIVE** What will your students be able to do?	**KEY CONCEPTS AND VOCABULARY** What three-five key points will you emphasize?
	Understand the basics of amplitude modulation (AM) and build a crystal radio that can receive AM broadcast stations.	• Amplitude modulation: carrier signal, modulating signal, modulated signal • Crystal radio (Foxhole radio)
	CONNECTION TO THE BIG IDEA How does the objective connect to the big idea?	
	Learning about amplitude modulation and how crystal radios work will enable them understand how radio receivers work.	
	ASSESSMENT How will you know whether your students have made progress toward the objective? How and when will you assess mastery?	
	Exit slips and concept maps will enable us to check for student understanding.	

LESSON	**OPENING** (2 min) How will you communicate *what* is about to happen? How will you communicate *how* it will happen? How will you communicate its *importance*? How will you communicate *connections* to previous lessons?	**MATERIALS** What materials will you need for your lesson?
	Good morning everyone! Let us review quickly what we have learnt so far. Do you remember what fields interact to produce light? Right, the electric and magnetic fields. Do you remember the names of different kinds of waves that we learnt in last class? (Radio waves, infrared, visible light, ultra violet, x-rays, and gamma rays.) How do these waves differ from each other? Right, in terms of wavelengths. We also made a very simple device to produce electromagnetic waves; do you remember how it worked? It is called a spark gap transmitter. Today we are going to learn about two other important things that are related to radio transmitters - amplitude modulation and crystal radios. These elements form the basics of wireless communications and are fundamental to understanding how radio stations broadcast signals which you can hear by tuning to a particular channel.	(for each experiment) • A sturdy plastic bottle or a toilet paper roll, should be at least 2-3 inches in diameter • About 50 feet of enamel coated magnet wire between AWG 22-18. • A Germanium diode (1N34A) • A telephone handset (or buy a handset cord from Radio Shack and borrow a handset from the home phone) • A set of alligator jumper clips. • About 50-100 feet long stranded insulated wire. • A nail or sharp object for making holes on a plastic or cardboard.
	DIRECT INSTRUCTION (8 min) What key points will you emphasize and reiterate? How will you ensure that students actively take-in information? How will you vary your approach to make information accessible to all students? Which potential misunderstandings will you anticipate? How will your students be using a Concept Map or other structured tool?	
	Project slide 1 that shows two waves and ask them to point out the difference between the two - the waves have the same amplitudes, but the second one has a shorter wavelength (i.e., more waves are "packed" together for the same horizontal distance in meters). Remind them of the formula for calculating the frequency of a wave (i.e., f = c/lambda), and ask them which one has a higher frequency. Waves that oscillate regularly like this are called "sinusoidals" or "sine waves" (relate it with the sine function if they are familiar with trigonometry). A "carrier signal" is	

just a sinusoidal like this but of very high frequency. Ask them to write the term "sinusoidal" and "carrier signal" in their concept box along with its definition in their own words.

Project slide 2 that shows three signals/waves in three different colors (blue, green, red): the blue signal either takes the value 0 or 1; the green signal oscillates between +1 and -1 at regular intervals. Ask them to point out which among the three is a carrier signal (green one), and why (because it's a sinusoid)? Tell them that the red signal is generated by combining the blue and green signals. Ask them if they can explain how they are combined, either intuitively or mathematically (the red signal is a multiplication of the amplitudes of the blue and the green signals). So, basically the carrier signal is modified or "modulated" by multiplying its amplitude with that of the blue signal to generate the red signal. That's why the red signal is called the "modulated signal", and the blue signal is called the "modulating signal". Ask them if they think that the red signal has properties of both blue and green signals. (It does, because the red signal is 0 whenever the blue signal is 0, and it also oscillates just like the green signal when it is not 0.) This process of modifying the amplitude is called "amplitude modulation" (AM). Ask them to write down the term "amplitude modulation", "modulating signal", and "modulated signal" in their "Concept Box" along with their definition in their own words. Also ask them to draw the blue, green, and red signals in their "Sketch it Out" box.

Project slide 3 and 4 and ask them to explain the different examples of amplitude modulation.

Project slide 5 that shows a speech signal generated while talking. Ask them if they find the speech signal similar to the "modulating signal" (blue) or the "modulated signal" (red). Ask them if they can think of a use of amplitude modulation.

Project slide 6 that shows the schematic of a crystal radio. Ask them if they can identify the components. Depending on their responses explain the circuit briefly. (i) The antenna is attached to the middle of the coil by a tap; an arrow is used to indicate a connection that can move, (ii) The diode is a one-way valve for electricity – current flows through it only in one direction and gets blocked in the other direction, (iii) The ground represents a connection that goes into the Earth – it can me made by connecting the other end of the wire to an iron water pipe which is inserted into the ground. Ask them to write the term "crystal radio" in their concept box and to draw the schematic under the "sketching" box. It is called a crystal radio because the diode, which is made of Germanium, used to be called a crystal.

The crystal radio is the simplest radio that can detect radio waves without any power supply – it uses the energy associated with the radio waves that's in the air. Energy from the sky! Explain its working briefly along the following lines:

The antenna, which is a very long wire, picks up the radio waves and passes them through the coil as electric current, and then down to the ground. Depending on

where the antenna is tapped to the coil, the set can be tuned to a desired frequency from the many that are picked up by the antenna. The electric signals cannot be directly converted into sound because they vibrate back and forth too rapidly. The crystal (or diode) between the tuned circuit and the headphones allows the current to pass through in one direction only. The headphone contains a small solenoid and a thin metal plate. The current passing through the circuit and then through the diode causes the solenoid to move, which in turn moves the metal plate, whose vibrations create (faint) sound waves in the air.

DIRECTIONS FOR EXPERIMENT(5 min)

How will you clearly state and model behavioral expectations?
How will you give 3-5 clear directions for the activity and model them?

Now we are going to make a very primitive crystal radio called the "Foxhole Radio", using which you can tune and listen to AM broadcast radio stations.

Distribute the materials and project slide 6 to show a diagram of a foxhole radio.

EXPERIMENT (40-60 min)

What kind of activity can be performed by students that directly relates to your objective and the big idea?
How will you engage students and capture their interest to explore the concept?
What exactly will your students be doing during the activity? What will you be doing?
How will your students be using a Concept Map or other structured tool?

The students make a foxhole radio that can receive AM waves, and they can listen to it using a headphone or a telephone handset. Briefly, the steps are as follows (illustrations are on the slides):

1. *Punching holes (Project slide 8): Using a nail, punch two holes near the top side and two holes near the bottom side of the tube. The holes on each side should be about 1/2 inch apart. These holes will hold the wire in place. Thread the wire through the two holes at the top of the tube, and pull about 8 inches of wire through the hole. (If the holes are large and the wire is loose, it is OK to loop the wire through the holes again, making a little loop of wire that holds snuggly.)*

2. *Making a coil (Project slide 9): Take the long end of the wire and start winding neatly around the tube. When you have about 5 windings, make a little loop of wire that stands out of the tube. Use a pencil/pen to make the loop. Continue winding another 5 turns, and then a loop. Keep doing this until the bottle is completely wrapped in wire, and you have reached the second set of holes at the bottom of the bottle.*
   (Project slide 9) Cut the wire so that at least 8 inches remain, and thread this remaining wire through the two holes like in Step 1. Now remove the insulation (using a sandpaper or knife) from the tips of the wire and the small loops we made every 5 turns.

3. *Making connections (Project slide 11): Attach the diode to the wire connected to the bottom of the tube. Cut one end off the handset cord to remove the modular telephone connectors. There will be 4 colored wires inside, and we will use the yellow and black wires. Attach one handset wire to the free end of the diode. Attach the other wire to the wire from the top of the bottle. Now clip an alligator jumper to the antenna. Clip the*

	other end to one of the taps of the coil. Clip another alligator lead to the wire coming from the top of the bottle. This is our 'ground' wire, and should be connected to a cold water pipe or some other metal object or wire that has a good connection to the earth. 4. *At this point, if all went well, you should be able to hear radio stations in the telephone handset. To select different stations, clip the alligator jumper to different taps on the coil. In some places, you will hear two or more stations at once. The longer the antenna is, the louder the signal will be. Also, the higher you can get the antenna the better.*	
	REFLECTION (5 min) How will students summarize what they learned? How will students be asked to state the significance of what they learned? How will students relate what they learned back to your objective and big idea using key vocabulary?	
	Exit Slip questions: 1. What can you do to make the sound coming from the radio louder? 2. Can you use something else instead of a diode that will also work as a crystal? 3. What can you do to increase the number of channels received by the foxhole radio? 4. Now that you can hear to different radio stations, do you think such a foxhole radio forms the basics of wireless communications? 5. What are you most proud of learning today?	