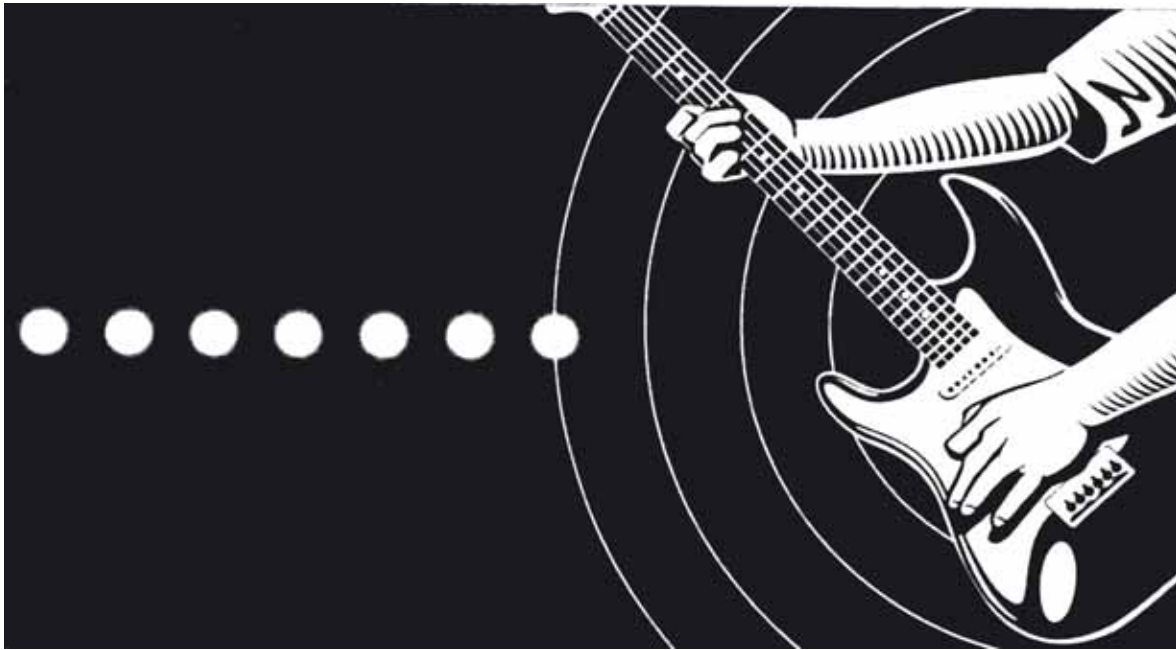# First You See It Then You Hear It

GRADE LEVEL:

5th through 12th

MATERIALS:

- Laser pointer - modified to allow an AC voltage to be applied in parallel with the DC (battery) voltage
- Portable CD/cassette tape player
- Photodiode or phototransistor
- Audio speaker with built in amplifier
- Modulation devices: comb, powder, etc.
- Wires to connect the player to the laser pointer and the photodiode to the speaker.
- Mounting hardware to hold the components in place relative to one another
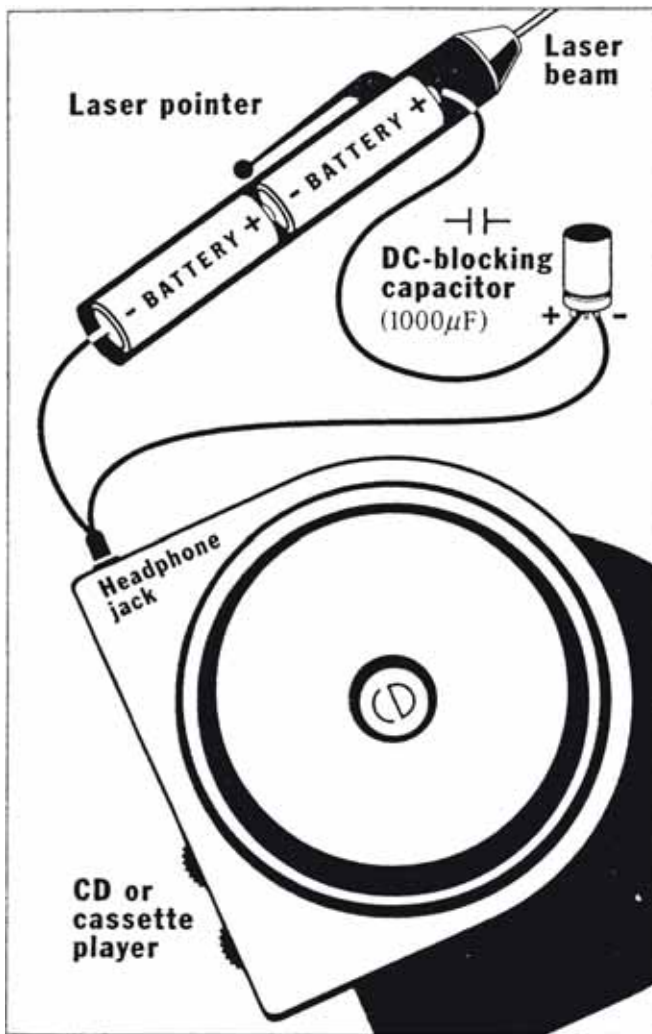
OBJECTIVES OF THIS ACTIVITY:

- Learn how sound can be encoded into and transmitted by a light beam
- See how energy is converted between light and electricity and sound
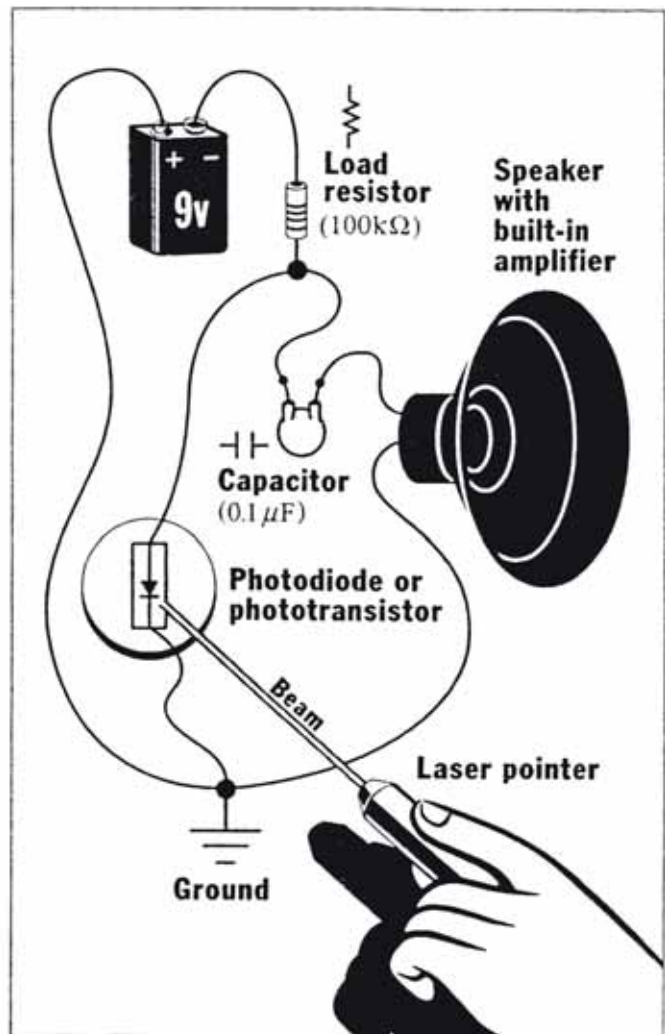- Understand optical communications

BACKGROUND:

People are familiar with lasers as special types of light sources. Common non-military applications of lasers include their use in CD players, laser pointers, supermarket scanners, optical character recognition, and surgery.

Another very important and widespread use of lasers is in optical communications. Most of the long distance transmission of information, from phone calls to internet data, is done with laser beams traveling over fiber optics networks.

A laser is a device that produces a special beam of light. LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. Lasers convert input energy (electrical, chemical, or incoherent light) into a concentrated, coherent beam of visible, infrared, or ultraviolet electromagnetic radiation. Light commonly refers to the visible band of electromagnetic radiation that we can detect with our eyes, i.e., "see". Infrared and ultraviolet electromagnetic radiation is commonly referred to as "invisible" light.

Laser pointer

Laser beam

BATTERY / BATTERY

DC-blocking capacitor (1000μF)

Headphone jack

CD or cassette player

Load resistor (100kΩ)

9v

Speaker with built-in amplifier

Capacitor (0.1μF)

Photodiode or phototransistor

Beam

Laser pointer

Ground

The output light of a laser, the laser beam, is usually pictured as a continuous beam having constant power. But for laser communications, the beam can be changed, i.e. modulated, in a controlled manner. This modulation can be in the form of amplitude modulation, i.e., AM, which changes the strength or power of the beam, or frequency modulation, i.e., FM, which changes the frequency, or color of the beam. Such modulation adds information to the beam, information that can be carried by the beam and transmitted to a distant location, where it can be extracted and used. For example, a telephone conversation can be encoded in a modulated laser beam and sent across the United States or undersea to Europe or Asia, where the conversation is decoded and heard as a spoken voice.

CIRCUITS:

See diagram A- A battery is connected, through a load resistor, to the photodiode to provide a reverse bias. When light falls on the photodiode, current flows through the circuit. Only the AC component of this current contributes to the signal that is transmitted through the capacitor to the speaker/amplifier.

See diagram B - The laser pointer consists of a laser diode powered by DC batteries. Open the battery compartment and connect insulated (low current) wires to the positive and negative terminals of the batteries. It may be necessary to cut open the battery compartment and reconnect the batteries with a battery holder/clip. Use a blocking capacitor to prevent DC current from flowing through the CD/cassette player audio output circuit. Connect the audio output, normally reserved for a headphone connection, to the

wires going to the positive and negative terminals of the batteries.

ACTIVITY:

- Explain the goal of the demonstration: To add information to a laser beam by "modulating" the beam.

- Explain that telephone, television, and internet data are transmitted over fiber optics cables by modulated laser beams.

- Show the students a laser pointer. Explain that it is powered by DC batteries. The laser converts the electrical energy from the batteries into light energy

- Show the students the photodetector. Explain that it converts fight energy into electrical energy.

- Connect the photodetector to the speaker/ amplifier (see circuit A) and turn on the amplifier.

- Direct the laser beam into the photodetector.

- Block and unblock the laser beam with your hand or finger, so the photodetector is alternately illuminated and dark. A clicking sound will be heard from the speaker. Explain that you are modulating the power of the laser beam and the speaker is demodulating it to produce sound.

- Ask a student to come up to the setup and modulate the laser beam. Give the student a comb and ask him/her to use the comb as a modulator. Help the student to discover how to move the comb so the teeth alternately block and transmit the laser beam. By drawing the teeth of the comb through the laser beam at various speeds, sounds of various frequencies can be produced from the speaker. Invite several students to use several combs to

simultaneously modulate the laser beam.

- Invite another student to modulate the laser beam using talcum powder or chalk dust. Dim the room lights. When the student throws the powder/dust into the beam, one hears a rushing sound, like thunder, from the speaker, while simultaneously seeing light scattering from the powder/dust particle.

- Connect the CD/cassette player to the laser using a mini-coaxial cable, one end plugged into the players headphone jack and the other end connected across the batteries that power the laser (see circuit B).

- Play a music CD/cassette. The sound will emerge from the speaker. Block the laser beam, and the sound will stop. Invite a student to modulate the laser beam with a comb while the music is playing.

- Explain that this is the way information (conversation, music, TV, internet data) is sent around the world, with fiber optics cables guiding the light along utility poles, underground, and underwater rather than the light traveling through free space. Ask the students what might go wrong if the light traveled through free space (bad weather, clouds, rain, dust).

CONCLUSION:

Laser communications systems are conceived of, designed and built by engineers. They ask questions, develop a theory or a model, test out their ideas, create designs, build working models, and refine them until they meet performance standards. In order to do this, they need a strong background in math and science.

This activity and discussion was written for National Engineers Week by James J. Wynne of IBM. Web sites: *www.ibm.com*; *www.watson.ibm.com/leo*.