Speak to Me

Kim Natale

Topic

Electromagnetism and sound reproduction

Time

1 to 1½ hours

Safety

Please click on the safety icon to view the safety precautions.
Be careful when using the scissors, particularly when removing the insulation from the wire.

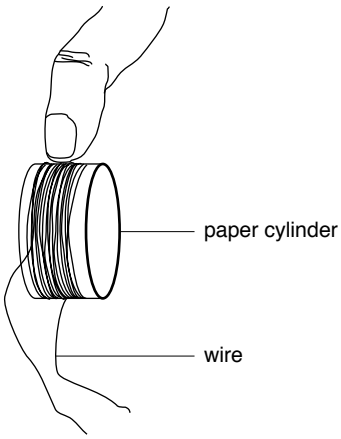
Materials

magnet wire 22-gauge or smaller (available at Radio Shack)
2 ½-in. diameter ceramic magnets (available at Radio Shack)
1 small empty margarine tub (10 cm diameter 2 4 cm deep works fine)
8 ½ in. 2 11-in. piece of paper
masking tape
white glue
scissors
transistor radio or Walkman™ with an earphone jack
⅛-in. phone plug (available at Radio Shack)

Procedure

1. Wrap three layers of masking tape around the circumference (outside edge) of a magnet.
2. Cut a strip of paper 1 cm wide 2 60 cm long (glue two pieces together if necessary). Wrap this around the outside of the magnet, placing glue along the outside surface of the paper so each layer sticks to the next one (make sure that you don't glue the paper to the magnet). The paper should wrap around the magnet 5 times. Cut off any excess, and tape the end of the strip so that it doesn't unroll.
3. Carefully slide the roll of paper off the magnet. You should have a cylinder. Set this aside to dry. Remove the tape from around the magnet.
4. Glue the magnet to the center of the margarine tub on the inside of the tub.
5. When the paper cylinder is dry, remove the piece of masking tape from the end. Cut a 2-m length of wire, and carefully using one blade of the scissors, scrape 2 cm insulation off each end. When the shiny copper appears, the insulation is removed. Leaving 20 cm of wire, carefully wrap the wire around the cylinder, stopping when only 20 cm of wire remain. With a finger, rub glue all over the wire and paper cylinder so that the wire is glued to it permanently (figure 1). Set the cylinder aside to dry, being careful that the wire doesn't unravel.

Figure 1



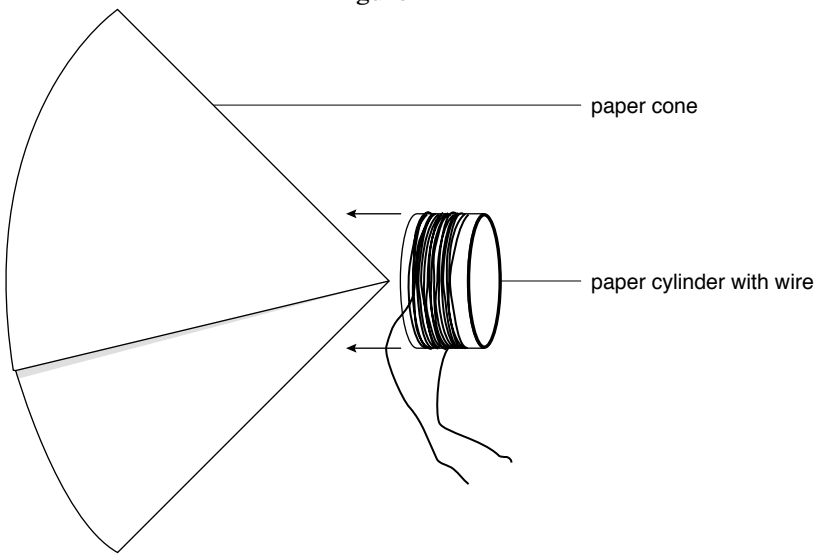
6. Hold the piece of paper by one end and shake it. Make notes on the data table about what you see and hear.

DATA TABLE

Procedure	Observations	
Shake Paper		
Paper megaphone		
Speaking, operating with radio or tape	Balanced bass/treble	Extra bass
Speaking, operating with radio or tape		

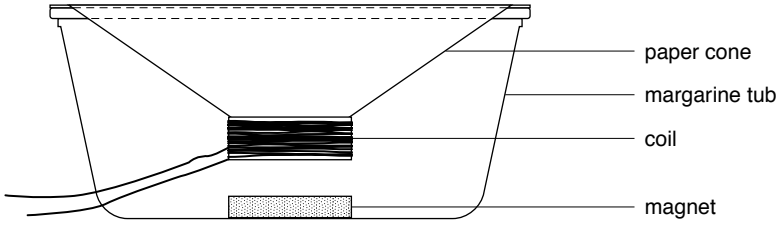
7. Turn the paper into a megaphone by rolling it into a long cone open at both ends. Holding the megaphone up to your mouth with one hand, speak into the smaller end, while running your other hand up and down the length of the cone. On the data table, make notes on anything you feel, hear, or see.
8. Roll the piece of paper into a shallower cone shape than the megaphone (the cone has to be able to fit into the margarine tub), and glue together the overlapping edges. Glue the paper cylinder with the wire to the back of the cone in the center (figure 2). Poke two small holes next to each other on one side of the tub near the bottom (this is to pass the wire through).

Figure 2



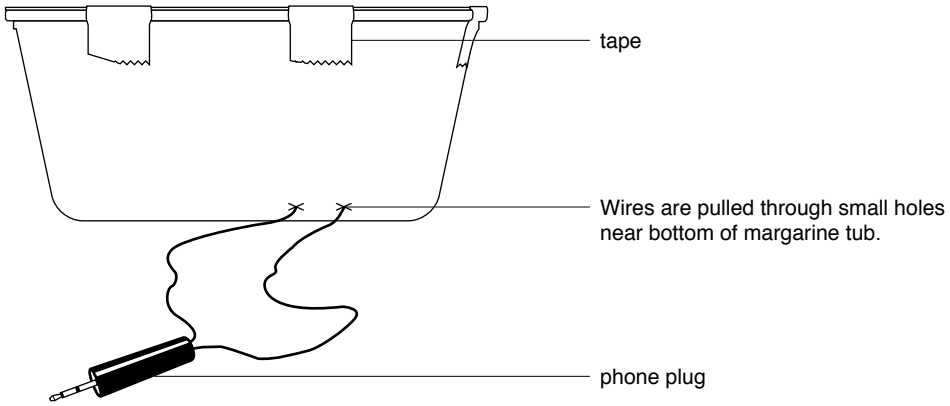
9. Pass the end of each wire through one hole in the tub. Place the cone into the margarine tub, making sure that the paper-and-wire cylinder on back sits over the magnet glued inside. Cut the outer edge of the cone so that it fits the outside edge of the tub, and attach it to the tub with four small pieces of tape (figure 3). Gently pull the wires all the way through.

Figure 3



10. Unscrew the phone plug, and slide the plastic cap over the ends of the wire. Attach one wire to each terminal on the plug, and screw the cap back on the plug (figure 4).

Figure 4



11. Turn on your radio and tune in a station with a strong signal. Then plug the speaker into the earphone jack. You may have to turn the volume up louder than you normally would. Observe the paper cone on your homemade loudspeaker as it operates. If your radio or tape player has a treble/bass control, turn up the bass. Observe the cone. Touch the cone. Record your observations on the data table.
12. If you have a large stereo available, you can detach one of the speakers, take the phone plug off your speaker, and connect the stereo speaker wires to those on your speaker. You should hear a big difference in volume between the radio and the stereo, particularly as you raise the volume on the stereo. (Make sure you only do this for a couple of minutes, as the stereo is designed for a much larger speaker than yours and could be damaged by playing it through your speaker for too long.) Observe and record your observations, as in step 11.
13. What happened when you shook the piece of paper? Explain what you saw and heard.
14. What happened when you made a megaphone out of the paper? Explain what you felt and heard.
15. Which part of your loudspeaker moves to produce the sound that you hear? How does it do this?
16. Which part of the speaker is the electromagnet (solenoid)? What purpose does the electromagnet serve in the loudspeaker? The permanent magnet?
17. The stronger the magnetic field is from the electromagnet or the permanent magnet, the louder the sound will be. What effect do you think adding the second permanent magnet will have? Try it. What would be a different way to create the same effect?

What's Going On

Shaking the paper causes a rattling sound. The paper vibrates, which disturbs the air around the paper. On reaching your eardrum, these disturbances (sound waves) cause it to vibrate, and you hear the sound. The megaphone directs and amplifies your voice, making the sound louder. As you moved your hand up and down the length of the cone you felt it vibrate. This vibrating of the cone also vibrates the air around it, which reinforces and amplifies the vibrations of your voice. The cone shape of the megaphone amplifies your voice because as the sound waves travel along its length, they disturb a larger volume of air.

Starting at the small end of the cone, the sound waves spread out as the cone gets wider. The cone also directs the sound by confining it to the direction in which the cone is pointing. The paper cone produces the sound. The movement of the magnets vibrates the paper cone. As it vibrates, it sets off waves that are the frequency and shape of those coming from the radio. This in turn sets the air around it vibrating at the same rate. The vibrations of the air reach your ears and set your eardrums vibrating, so you hear the sounds.

The coiled wire is the electromagnet. Current flowing through a wire creates a magnetic field. The radio transforms sound waves into electrical current, which is then sent through the electromagnetic coil. Since the sounds vary in shape and size, the amount of current to the magnet varies, which alters the strength of the magnetic field accordingly. The permanent magnet has a magnetic field that does not vary. The interaction of the magnetic fields causes the cone to vibrate. By adding the second magnet you increase the intensity of the permanent magnetic field, increasing the motion of the cone. This has the effect of increasing the amount of air that

the cone can vibrate, increasing the volume of the sound. Another way to have the same effect would be to increase the number of loops in the electromagnet's coil. There is still one other way of making the sound louder. You can send more current through the electromagnet, which is what turning up the volume on your radio or stereo actually does.

Connections

When an electric current moves through a wire, it generates an *electromagnetic field*. Coiling the wire increases the strength of this field and creates an electromagnetic device called a *solenoid*, which is an important part of communications technology today. Telephones, televisions, and radios have made communication easier, faster, and much more far ranging than ever before. All these devices have in common an electromagnetic apparatus called a *loudspeaker*. The solenoid in loudspeakers makes them capable of transforming electrical impulses transmitted by wire into sound waves. In this experiment you constructed a working loudspeaker and learned how it operates.

Safety Precautions

READ AND COPY BEFORE STARTING ANY EXPERIMENT

Experimental science can be dangerous. Events can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. Basic safety procedures help prevent serious accidents. Be sure to follow additional safety precautions and adult supervision requirements for each experiment. If you are working in a lab or in the field, do not work alone.

This book assumes that you will read the safety precautions that follow, as well as those at the start of each experiment you perform, and that you will *remember* them. These precautions will not always be repeated in the instructions for the procedures. It is up to you to use good judgment and pay attention when performing potentially dangerous procedures. Just because the book does not always say "be careful with hot liquids" or "don't cut yourself with the knife" does not mean that you should be careless when simmering water or stripping an electrical wire. It *does* mean that when you see a special note to be careful, it is extremely important that you pay attention to it. If you ever have a question about whether a procedure or material is dangerous, stop to find out for sure that it is safe before continuing the experiment. To avoid accidents, always pay close attention to your work, take your time, and practice the general safety procedures listed below.

PREPARE

- Clear all surfaces before beginning work.
- Read through the whole experiment before you start.
- Identify hazardous procedures and anticipate dangers.

PROTECT YOURSELF

- Follow all directions step by step; do only one procedure at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure that there is adequate ventilation.
- Do not horseplay.
- Wear an apron and goggles.
- Do not wear contact lenses, open shoes, and loose clothing; do not wear your hair loose.
- Keep floor and work space neat, clean, and dry.
- Clean up spills immediately.
- Never eat, drink, or smoke in the laboratory or near the work space.
- Do not taste any substances tested unless expressly permitted to do so by a science teacher in charge.

USE EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives and other sharp or pointed instruments with caution; always cut away from yourself and others.
- Pull plugs, not cords, when inserting and removing electrical plugs.
- Don't use your mouth to pipette; use a suction bulb.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Clean up broken glassware immediately.

- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use only low-voltage and low-current materials.
- Be careful when using stepstools, chairs, and ladders.

USING CHEMICALS

- Never taste or inhale chemicals.
- Label all bottles and apparatus containing chemicals.
- Read all labels carefully.
- Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING INSTRUCTIONS

- Use goggles, apron, and gloves when boiling liquids.
- Keep your face away from test tubes and beakers.
- Never leave heating apparatus unattended.
- Use safety tongs and heat-resistant mittens.
- Turn off hot plates, bunsen burners, and gas when you are done.
- Keep flammable substances away from heat.
- Have a fire extinguisher on hand.

WORKING WITH MICROORGANISMS

- Assume that all microorganisms are infectious; handle them with care.
- Sterilize all equipment being used to handle microorganisms.

GOING ON FIELD TRIPS

- Do not go on a field trip by yourself.
- Tell a responsible adult where you are going, and maintain that route.
- Know the area and its potential hazards, such as poisonous plants, deep water, and rapids.
- Dress for terrain and weather conditions (prepare for exposure to sun as well as to cold).
- Bring along a first-aid kit.
- Do not drink water or eat plants found in the wild.
- Use the buddy system; do not experiment outdoors alone.

FINISHING UP

- Thoroughly clean your work area and glassware.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Don't dispose of materials in the sink unless instructed to do so.
- Wash your hands thoroughly.
- Clean up all residue, and containerize it for proper disposal.
- Dispose of all chemicals according to local, state, and federal laws.

BE SAFETY-CONSCIOUS AT ALL TIMES