Sound Waves and Pitch

Topic

The *pitch* of a sound is determined by the *frequency* of the sound wave.

Introduction

Do you have a high-pitched voice, or is your voice low-pitched? The sounds produced by your voice, like all sounds, are forms of energy that travel from one place to another through vibrating media. Sound can travel through all types of media, including solids, liquids, and gases. The only thing it cannot travel through is a *vacuum*.

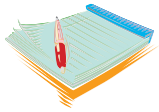
When a sound is produced, its energy pushes air molecules. These air molecules then push the molecules next to them, compressing them. Compressed air molecules form waves, and the energy of a wave moves from one molecule to the next. Eventually, the energy is exhausted, and the sound fades away. That is why the further away a sound is, the softer it seems.

The kind of wave made by sound is called a *longitudinal wave.* Longitudinal waves vary in length: If air molecules are moving slowly, long sound waves form. Long waves, which have low frequencies because few waves pass a given point every second, make low-pitched sounds. On the other hand, if air molecules are vibrating quickly, there is only a short distance between waves. These short waves have a higher frequency and therefore a higher pitch.

Musical instruments depend on the fact that pitch is determined by frequency. Instruments are designed to alter the rate at which sound waves vibrate, and therefore alter the pitch of sound. When a musician blows air inside a tubular wind instrument, air molecules vibrate back and forth from one end of the instrument to the other. By changing the length of the tube, the musician can change the time it takes for air waves to travel, and therefore change the pitch of the sound.

Time Required

50 minutes



Materials

- 2 feet (ft) of 1/2 inch (in.), schedule-40 PVC sprinkler pipe
- fine sandpaper
- 4 or 5 pennies
- duct tape
- black marker

Safety Note **Please review and follow the safety guidelines. Take care when using the ice pick.**

Procedure

1. Cut the pipe into four or five different lengths.
2. Sand the cut ends of the pipe until they are smooth.
3. Place a penny over one end of a section of pipe and secure it in place with duct tape. Wrap enough tape around it to make a good seal (Figure 1).

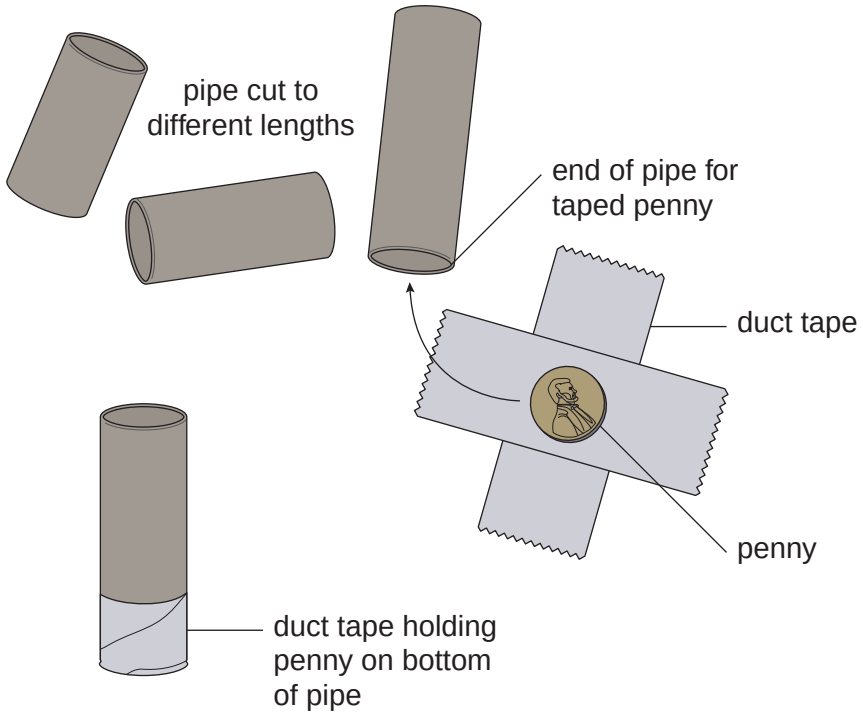


Figure 1

4. Repeat step 2 with the other pipes.
5. Test the pipes to determine which has the lowest pitch, and which has the highest. To test, blow across the open end of the pipe, as you would blow across the mouth of a bottle. Arrange the pipes on your desktop from lowest pitch to highest pitch.

Analysis

1. How is the pitch of a long pipe different from the pitch of a short pipe?
2. How is the pitch of the sound coming from a pipe related to the length of the pipe?
3. Based on this experiment, which statement would you consider to be true:

   (a) In a long pipe, air molecules are compressed into long, low-frequency waves. (b) In a long pipe, air molecules are compressed into short, high-frequency waves.
4. A pipe organ is made of a series of pipes very similar to the ones used in this experiment. Which pipes produce the bass (low) notes: the long ones or the short ones?
5. If you wanted to make a musical instrument from sections of PVC sprinkler pipe, how would you go about it?

What's Going On?

The pitch of a sound is determined by the frequency of the sound wave, and the frequency of a wave in a hollow tube is related to the length of the tube. In this case, the PVC pipes were not cut to specified lengths, so a variety of pitches were generated.

To make a simple musical instrument from these materials, cut 2 ft of 1/2 in., schedule #40 PVC sprinkler pipe into the following lengths with a PVC pipe cutter: 6 in., 5.4 in., 4.7 in., 3.8 in., and 3.4 in. With a black marker, label the 6-in. pipe as C, the 5.4-in. pipe as D, the 4.7-in. pipe as E, the 3.8-in. pipe as G, and the 3.4-in. pipe as A. These letters represent the pitches of each pipe. A pipe of this construction can be used to play simple tunes.

Want to Know More?

See Our Findings.

OUR FINDINGS

SOUND WAVES AND PITCH

Analysis

1. The pitch of a long pipe is lower than the pitch of a short pipe.
2. the longer the pipe, the lower the pitch
3. (a); In a long pipe, air molecules are compressed into long, low frequency waves.
4. the long ones
5. Answers will vary. Students might suggest cutting pipes at different lengths and testing their pitch against a pitch pipe or a musical instrument.

SAFETY PRECAUTIONS

Review Before Starting Any Experiment

Each experiment includes special safety precautions that are relevant to that particular project. These do not include all the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is necessary that you read and remain mindful of the General Safety Precautions that follow. Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly while you are performing an experiment. Materials can spill, break, or even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following the basic safety guidelines during the entire experiment, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual experiments. For one reason, we want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical.

Read the safety precautions here and at the beginning of each experiment before performing each activity. It is difficult to remember a long set of general rules. By rereading these general precautions every time you set up an experiment, you will be reminding yourself that lab safety is critically important. In addition, use your good judgment and pay close attention when performing potentially dangerous procedures. Just because the text does not say “be careful with hot liquids” or “don’t cut yourself with a knife” does not mean that you can be careless when boiling water or punching holes in plastic bottles. Notes in the text are special precautions to which you must pay special attention.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking an unnecessary risk can be avoided by practicing safety procedures and being alert while conducting experiments. Be sure to check the individual experiments in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone. When you are working off site, keep in

groups with a minimum of three students per group, and follow school rules and state legal requirements for the number of supervisors required. Ask an adult supervisor with basic training in first aid to carry a small first-aid kit. Make sure everyone knows where this person will be during the experiment.

PREPARING

- Clear all surfaces before beginning experiments.
- Read the instructions before you start.
- Know the hazards of the experiments and anticipate dangers.

PROTECTING YOURSELF

- Follow the directions step-by-step.
- Do only one experiment at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure there is adequate ventilation.
- Do not horseplay.
- Keep floor and workspace neat, clean, and dry.
- Clean up spills immediately.
- If glassware breaks, do not clean it up; ask for teacher assistance.
- Tie back long hair.
- Never eat, drink, or smoke in the laboratory or workspace.
- Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult.

USING EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives or other sharp-pointed instruments with care.
- Pull plugs, not cords, when removing electrical plugs.
- 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 alcohol-filled thermometers, not mercury-filled thermometers.

USING CHEMICALS

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

HEATING SUBSTANCES

- Wear safety glasses, apron, and gloves when boiling water.
- Keep your face away from test tubes and beakers.
- Use test tubes, beakers, and other glassware made of Pyrex™ glass.
- Never leave apparatus unattended.
- Use safety tongs and heat-resistant gloves.
- If your laboratory does not have heat-proof workbenches, put your Bunsen burner on a heat-proof mat before lighting it.
- Take care when lighting your Bunsen burner; light it with the airhole closed, and use a Bunsen burner lighter in preference to wooden matches.
- Turn off hot plates, Bunsen burners, and gas when you are done.
- Keep flammable substances away from flames and other sources of heat.
- Have a fire extinguisher on hand.

FINISHING UP

- Thoroughly clean your work area and any glassware used.
- Wash your hands.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Do not dispose of materials in the sink unless instructed to do so.
- Clean up all residues and put them in proper containers for disposal.
- Dispose of all chemicals according to all local, state, and federal laws.

BE SAFETY CONSCIOUS AT ALL TIMES!