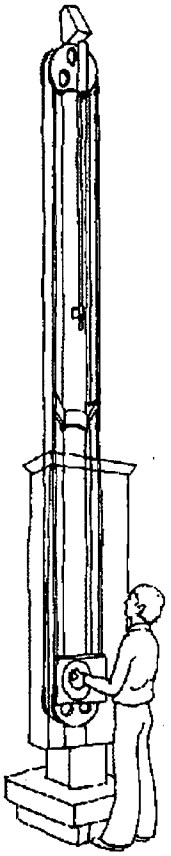
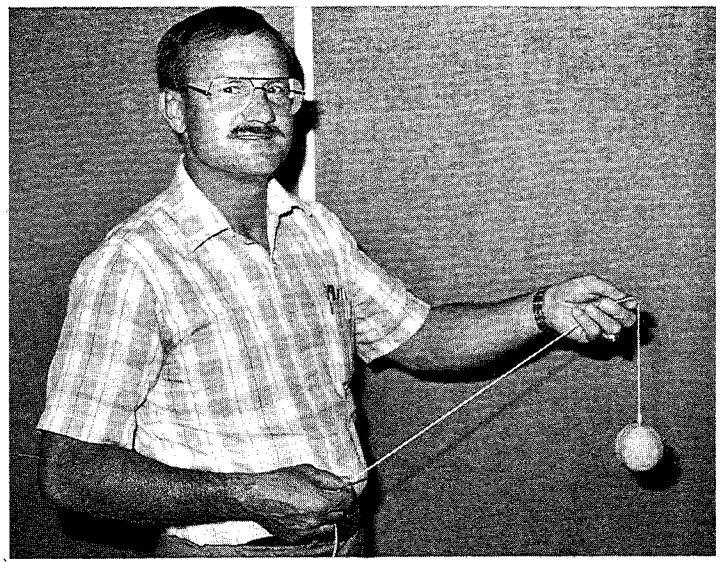


Doppler Effect

The Doppler effect causes the "neeeeeoowwm" sound of a speeding car passing by.



Materials

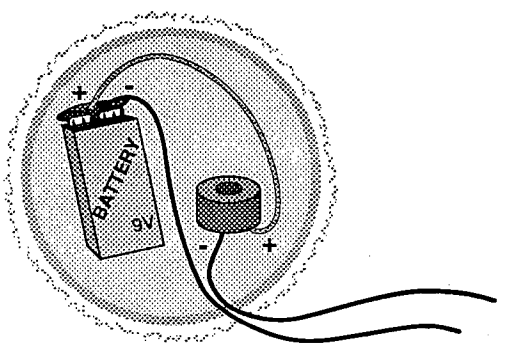
- ○ **Tennis ball** or wiffle ball.
- ○ **9-volt buzzer** (available at Radio Shack; high pitch works best).
- ○ **9-volt battery** and connectors.
- ○ **Strong string**.
- ○ **Heavy rubber bands**.
- ○ **Knife**.
- ○ **Scrap paper** to pack inside the ball.
- ○ **Optional:** On/off switch (available in Radio Shack or hardware stores).

Introduction

When a sound source moves toward or away from you, its pitch changes. From this effect you can determine whether the source is moving toward or away from you, and you can estimate how fast it's going.

Assembly

Cut a slit halfway around the ball with a sharp knife. Connect a wire between one terminal on the battery and one terminal on the buzzer. If the buzzer has a (+) and (-) terminal, be sure to connect the buzzer terminal to the proper battery terminal. Connect a wire to the remaining terminal on the battery, and another wire to the remaining terminal on the buzzer. Each of these wires will now have one unconnected end. Place both battery and buzzer inside the ball, leaving the two unconnected wire ends protruding from the ball. Pack the ball loosely with paper, leaving the buzzer near the outside. Close the ball with tape or rubber bands, and twist the wires together to turn the buzzer on. You may want to wire a switch into your circuit so you can turn the buzzer on and off more conveniently.



Waves Sound

Doppler Effect

To Do and Notice

Attach the ball to a string and twirl it around your head, or have your students toss the ball back and forth. Notice how the pitch of the buzzer changes as the ball approaches you or moves away from you.

What's Going On?

When an oscillator (the buzzer) moves toward you, in effect it is catching up slightly with its own sound waves. With each successive pulse of the buzzer, the sound source is a little closer to you. The result is that the waves are squeezed together, and more of them reach your ear each second than if the buzzer were standing still. Therefore, the pitch of the buzzer sounds higher. As the buzzer moves away from you, fewer waves reach your ear each second, so the resulting pitch sounds lower. The frequency of the buzzer itself does not change in either case.

For your ears to detect this effect, called the *Doppler effect*, the sound source has to be moving toward or away from you at a minimum speed of about 15 to 20 mph. As the source moves faster, the effect becomes more pronounced.

If the buzzer has a frequency of 100 hertz, and it is moving toward you through still air at 35 meters per second, then the pitch you hear will be 110 hertz. This result comes from the equation, pitch = $f/(1-v/v_s)$, where f is the frequency, v is the speed of the source of the sound, and v_s is the speed of sound, 350 meters per second. If the object is moving away from you, simply replace the minus sign with a plus sign.

Etc.

The Doppler effect is also observed with light. In the case of light, it's the color that changes. The color of an object moving away from us becomes slightly redder; if an object is approaching, it appears bluer. This effect allows astronomers to determine whether galaxies are approaching us or moving away, and even how fast they're moving (the bigger the "red shift," the faster they're moving away from us).

Police with radar guns use the Doppler effect to determine whether you're speeding! The bigger the Doppler effect of the radar waves, the faster you're going.