VIBRATION OF METAL PLATES

TOPIC:

Sound Waves

SCIENTIST:

Ernst Chladni 1756–1827

INTRODUCTION:

Ernst Chladni was interested in all aspects of sound, especially in relation to music. In 1787 he decided to investigate the effect of vibrations on metal plates. Chladni used a brass plate clamped to a base at the center. He made the plate vibrate by drawing a violin bow over one edge. When he sprinkled sand onto the plate in order to see the effect of the vibrations, and then drew the bow over the edge, he noticed that the sand grains had become arranged in patterns. By holding down the plate at various points with his finger Chladni produced a variety of different patterns, or "Chladni figures" as they are now called. We now know that these patterns represent different modes of vibration of the metal plate. In all, Chladni found 52 different Chladni figures using a square plate. The resonance patterns of metal are used today to measure the quality of mass-produced sheet metal; sand and violin bows are not used, of course, but ultrasonics and optics are employed to make sure each plate vibrates as it should.

TIME NEEDED:

30 minutes

MATERIALS:

vise
6-in. bolt with two nuts
plate of tin, steel, or aluminum at least 45 cm x 30 cm and approximately 3 mm thick, with hole drilled through center large enough for bolt to fit through
electric or cordless drill (if necessary)
adjustable crescent wrench
fine sand in an old salt shaker
violin bow
rosin

Note: You will need an electricity source (*e.g.*, an outlet) if using an electric drill.

Original Materials:

Chladni used a brass plate.

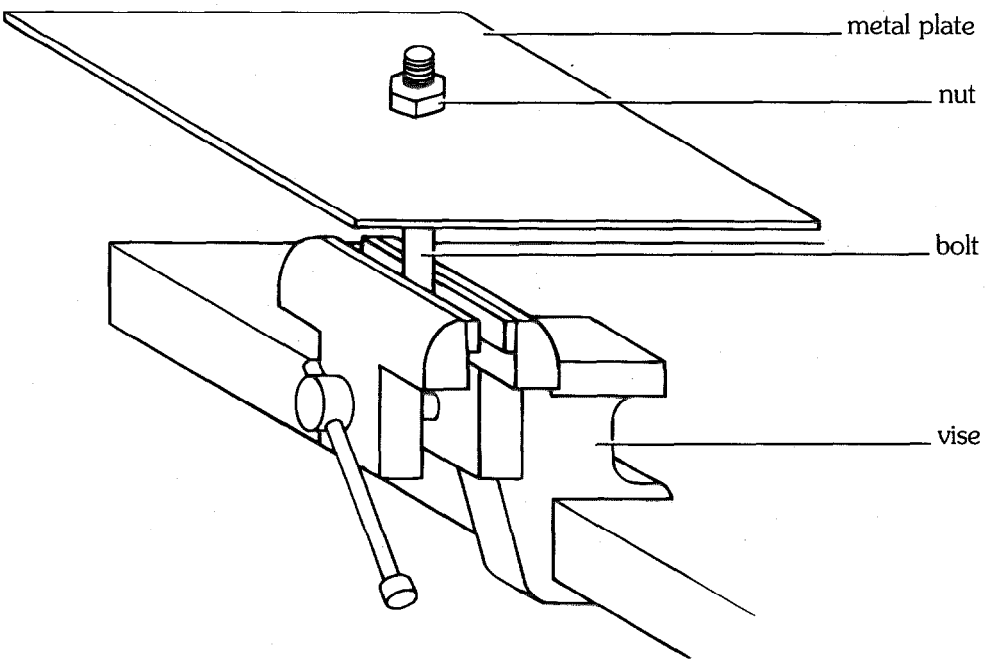
Safety Precautions

Adult supervision recommended. Please read and copy the safety precautions at the beginning of this book. Be careful if using a drill.

PROCEDURE:

1. Take the bolt, nuts, and the metal plate. (If the plate does not have a hole in it as described in Materials, have an adult use the drill to make a hole in the center large enough for the bolt.) Screw one of the nuts part of the way down the bolt. Push the bolt through the hole in the metal plate. Now screw the second nut onto the bolt.
2. Tighten the two nuts using the wrench so that the metal plate is held firmly between them.
3. Clamp the head of the bolt into the vise so that the metal plate is held firmly and horizontally (see figure 1).

Figure 1



4. Apply rosin to the strings of the violin bow. Draw it across one edge of the metal plate while holding the plate at one corner. Record your observations.
5. Sprinkle a thin layer of sand onto the plate. Repeat step 4. Record your observations, drawing any patterns you observe on the plate.
6. Repeat step 5, holding the plate at different points around the edge of the plate each time.

ANALYSIS:

1. What did you observe when you drew the bow across the metal plate in step 4?
2. What did you observe in the sand when you held the plate at different points and drew the bow across the edge?
3. Do some research. Why do patterns form when metals are vibrated?

OUR FINDINGS:

Click on above link to see what we found.

SPECIAL SAFETY NOTE TO EXPERIMENTERS

Each experiment includes any special safety precautions that are relevant to that particular project. These do not include all of the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is absolutely necessary that you read, copy, and remain mindful of the General Safety Precautions that follow this note.

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. Things can spill, break, even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following basic safety guidelines the *entire* time you are performing the 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. We made this choice 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 to your safety.

One further note: The book assumes that you will read the safety precautions that follow, as well as those in the box within each experiment you are preparing to perform, and that you will *remember* them. Except in rare instances, these precautions will not be repeated in the procedure itself. It is up to you to use your good judgment and pay attention when performing potentially dangerous parts of the procedure. Just because the book does not 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, wait to perform it until you find out for sure that it is safe.

GENERAL SAFETY PRECAUTIONS

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

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, eye wash, and first-aid kit
—Make sure there is adequate ventilation
—Do not horseplay
—Wear an apron and goggles
—Do not wear contact lenses, open shoes, loose clothing, or loose hair
—Keep floor and work space neat, clean, and dry
—Clean up spills immediately
—Never eat, drink, or smoke in laboratory or work space
—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 and other sharp or pointed instruments with caution
—Pull plugs, not cords, when 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 current materials such as lantern batteries
—Be careful when using stepstools, chairs, and ladders

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 goggles, apron, and gloves)
—Do not touch chemical solutions
—Wash hands before and after using solutions
—Wipe up spills thoroughly

HEATING SUBSTANCES:
—Use goggles, apron, and gloves when boiling water
—Keep your face away from test tubes and beakers
—Never leave 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 fire extinguisher on hand

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
—Clean up all residue and put in proper containers for disposal
—Dispose of all chemicals according to all local, state, and federal laws

BE SAFETY CONSCIOUS AT ALL TIMES