ARCHIMEDES' SCREW

OBJECTIVE:

You will understand and demonstrate how a screw device can be used to raise granular material with minimum effort.

INTRODUCTION:

Being able to raise water from one level to another has always been crucial in agriculture, for irrigating farmland. In earliest times, water was raised by hand using buckets, or using a shadoof—a pole acting as a lever, with a bucket at one end, a counterbalancing weight at the other, and a pivot in between. By the third century BC, water wheels were in use to lift water from rivers and ditches. They were powered by a gear mechanism connected to one or more oxen which walked in a circle.

For raising fairly small volumes of water, Archimedes of Syracuse (287–212 BC) invented a very efficient device. His original design was for the removal of water from the holds of large ships. Archimedes' screw, as it became known, played a key role in agricultural development as well. It was hand powered and was used for raising water from rivers and ditches to irrigate surrounding land.

Today, the Archimedes' screw is still used for this purpose in Egypt and other parts of the Middle East. In mechanically driven versions, it is used in raising large volumes of particulate material, such as grain, up short distances, as in combine harvesters.

TIME NEEDED:

1 hour

MATERIALS:

- 3-liter plastic drink bottle, about 10 cm in diameter at its largest point
- drawing compass
- pencil
- heavyweight construction paper, 45 cm x 20 cm
- hardboard, 9 cm x 2.5 cm x 0.4 cm
- two lengths of 12mm wooden dowel, one 24 cm long, the other 5 cm long
- masking tape
- wood glue
- 2 thumbtacks
- scissors
- X-acto® knife
- cutting board
- drill (electric or battery operated)
- 14mm bit
- large bowl of puffed rice
- medium-sized bowl
- metric ruler
- books, to reach a height of 20 cm when stacked

Note: If using an electric drill, you will need a source of electricity, e.g. a wall outlet.

Safety Precautions

Adult supervision required. Please read and copy the safety precautions at the beginning of this book. Electricity can cause dangerous shocks. Be careful when using the drill, and when cutting with the knife.

PROCEDURE:

1. Using the X-acto® knife on the cutting board, cut off both ends of the bottle to make a tube 18 cm long.
2. Take the construction paper and use the drawing compass and pencil to draw ten circles, each with 10 cm in diameter. In the center of each circle, draw a small circle 14 mm in diameter.
3. Using the scissors, cut out the ten circles of construction paper. In each circle, make a slit from the edge to the small circle in the middle, and cut out the small circle (see figure 1).

4. Place the large circles in a pile, one on top of the other, with their slits aligned. Fold back one quarter of the top circle as shown in figure 2. Tape the left-hand cut edge of the top circle to the right-hand cut edge of the circle below. Continue in this way, from one circle to the next, until you have joined all the circles together.

Figure 1

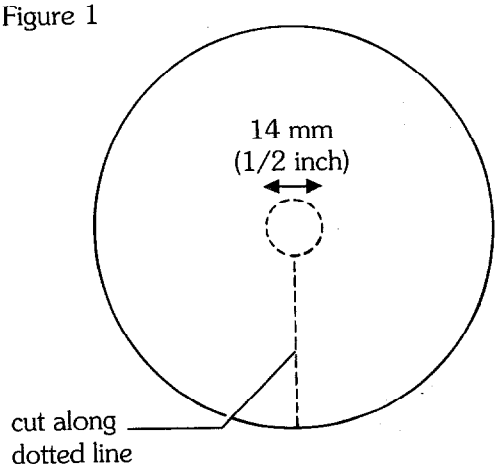
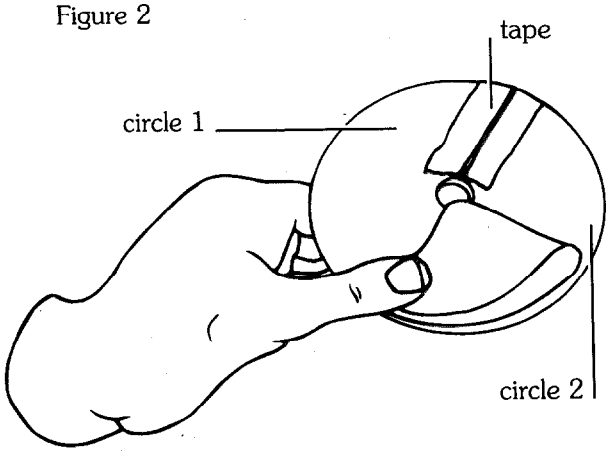


Figure 2



5. Push the longer length of wooden dowel through the middle of the spiral. Use a thumbtack to tack one end of the spiral about 4 cm from one end of the dowel (see figure 3). Use a thumbtack to tack the other end of the spiral over the other end of the dowel. Carefully arrange the turns of the spiral so that the circles are evenly spaced, and glue the spiral to the dowel to hold it in place.

Figure 3

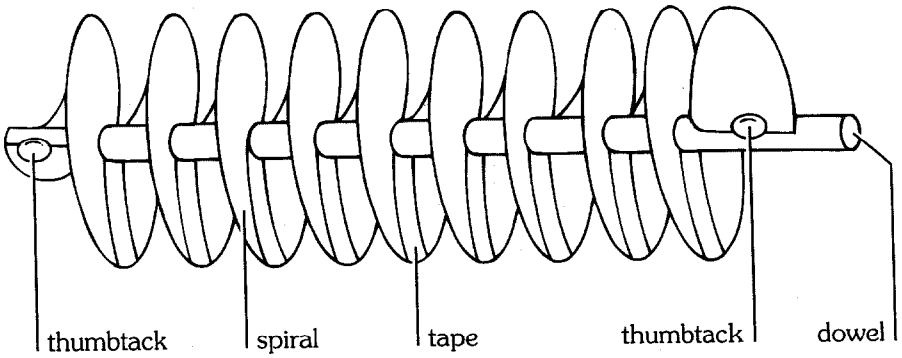
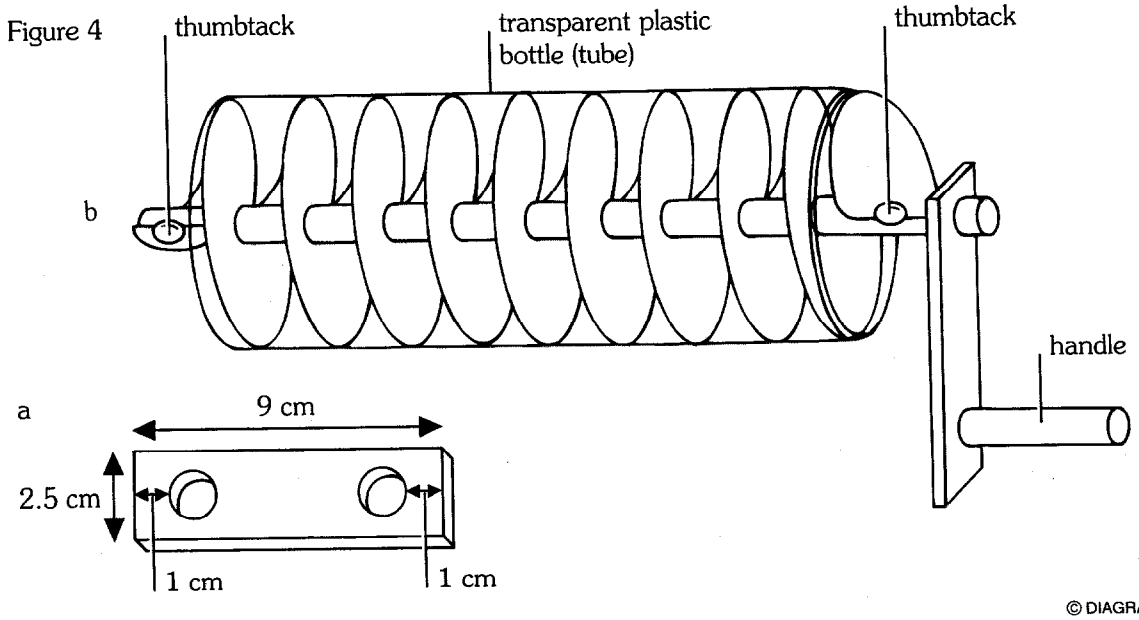
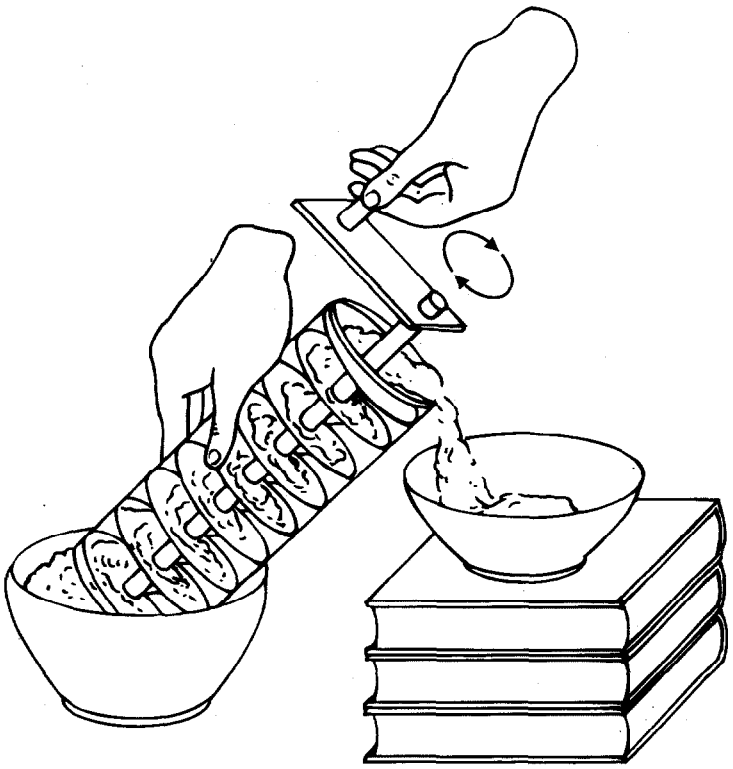


Figure 4



6. Holding the piece of hardboard as an upright rectangle, drill two 14mm-diameter holes in the hardboard—one at the center top, about 1 cm from the top edge, and the other at the center bottom, about 1 cm from the bottom edge (see figure 4a).
7. Take the dowel with the paper spiral (the screw rod) and glue the longer end into the top hole in the hardboard (see figure 4b).
8. Take the 5cm-long dowel (the handle) and glue it into the bottom hole of the hardboard (see figure 4b).
9. Place the plastic tube over the screw rod and spiral so that it covers all of the spiral (see figure 4b).
10. Place the medium-sized bowl on top of the stack of books on a table. The bowl should be about 20 cm higher than the tabletop.
11. Place the larger bowl, containing the puffed rice, on the table. Place the bottom of the screw rod in the puffed rice, and hold the device so that the handle is at the top (see figure 5).

Figure 5



12. Hold the device at an angle of 45–60 degrees to the horizontal and turn the handle in a clockwise direction. Note what happens. Make sure rice is emptying into the bowl at the top.
13. Turn the handle more quickly and note what happens.

ANALYSIS:

1. Describe what happens when you turn the handle in step 12.
2. Suggest a means of monitoring how the rice progresses up the tube.
3. From your knowledge of inclined planes (see 7.03), and based on your observations in this investigation, explain how the rotary motion pushes the puffed rice up the screw thread inside the tube.

OUR FINDINGS:

Click on above link to see what we found.

SPECIAL SAFETY NOTE TO INVESTIGATORS

Each invention 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 investigation. 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 when you are constructing or demonstrating a model invention. 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 carrying out the project, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual projects. 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 project 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 carrying out these projects. Be sure to check the individual projects 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 projects
—Read the instructions before you start
—Know the hazards of the procedures and anticipate dangers

PROTECTING YOURSELF:
—Follow the directions step-by-step; do only one project 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 or bench
—Use knives and other sharp or pointed instruments with caution
—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 touch metal conductors
—Use only low voltage and current materials such as lantern batteries
—Be careful when using stepstools, chairs, and ladders
—Never look directly at the sun with your observation devices

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