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1
Tools of the Trade

Are you convinced yet? You know, about simple machines being simple? Now that it is getting down to the time that you are starting to think about using some of these activities with students, the materials dilemma jumps up and bites you in the leg. This section should ease some of the tension by starting the students and you off on the road to success. At least I was sure of it until I got off the plane in Houston. Perhaps I should explain . . . .

In March of 1991, I was accepted to do a presentation on this very topic for the National Science Teachers Conference. After much planning, copying, and packing, I was ready to venture off into a part of the world that I had never seen before. With me was everything that is really important for teaching science: rulers, masking tape, and paper clips . . . lots of paper clips. In an hour we were to make spring scales, levers, and masses, as well as do a few experiments. All that was needed for the session was a couple hundred rocks about the size of a student's fist. Nothing to it, right? The day before the session, I started to do a little scouting out and about to snatch a bucketful of rocks from along the side of the road. Needless to say, this young lad from the Pacific Northwest was in for an unpleasant surprise in Houston (actually, just one of several).

Of course, all good science teachers are problem solvers. So, it was off to the Information Booth to find out where a person would be able to go find a few rocks. An hour and 26 "someone here must knows" later, I was no closer to having any rocks or a workshop. This is starting to sound a lot like a science lesson, isn't it? The resolution to the problem didn't come from the trip to the construction site just a few miles down the road. It actually came from a bunch of us poor lost waifs wandering around in a parking lot in the dark of night picking up chunks of broken-up concrete.

The descriptions that follow will help you and your students to make some very essential, and for the most part much more durable, pieces of scientific equipment for use in the activities described in this book. You will be making a mass, spring scale, lever, and pulley. These items can be purchased if you so choose, but in my experience the real value is in the students being involved in their construction. All you will need is a rock; a ruler or thin, narrow board; masking tape; paper clips; rubber bands; a wire clothes hanger; empty thread spools; and just a dash of patience.

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making a pulley

MAIN IDEA: A pulley is a form of a wheel and axle where the outer edge of the wheel has a groove

A pulley is a simple machine.

PROCESS SKILL: Measuring

MATERIALS:

Masking tape

Thread spools

Wire clothes hangers

Wire cutters

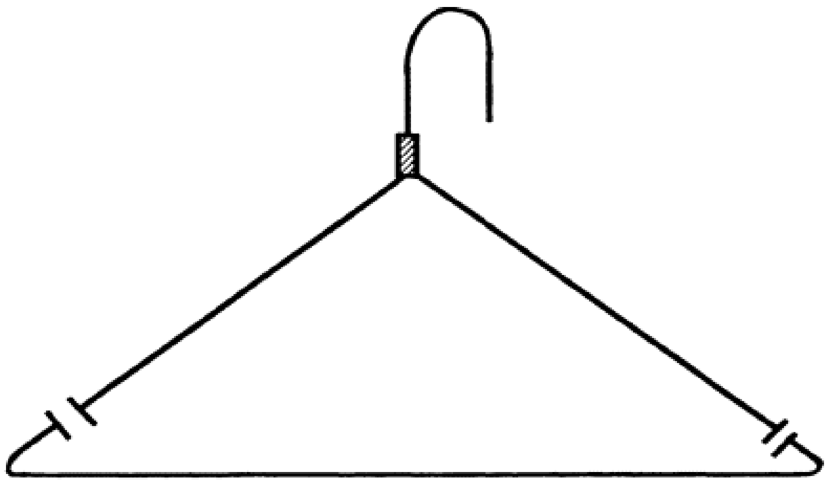
TIME: 30-45 minutes

PROCEDURE:

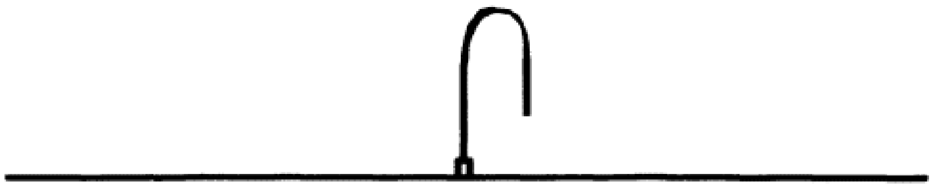
At some point previous to conducting the activity, have the students start collecting empty thread spools and wire clothes hangers.

1. Pass out one wire hanger and thread spool to each student.

2. Clip off the base of the hanger.



3. Bend the 2 legs of the hanger straight out.



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4
Things that Slide

Inclined planes! It's hard to believe, but we are on our way home already. See, this simple machines stuff wasn't so hard after all. Just a few short activities ago we were teaching our students that simple machines help us do work by trading force for distance; now we are on the last family of simple machines!

Inclined planes can be fragmented into about four subgroups if you wish. The groups are typically: inclined planes, moving inclined planes, screws, and wedges. For our purposes, humor me, and pretend that they are all basically the same . . . because they are. Whenever you throw a board on a step a little higher or lower than you are so that it is easier to walk or move a heavy or awkward object that you do not want to lift, you have created an inclined plane. Now pretend that you could take that board and mold it as if it were made of modeling clay so that you could make your ramp curve around a corner as it rises. Hmmmm, this is starting to sound a lot like a spiral staircase, isn't it? Now, keep this spiral going up for three or four complete turns. If you could stand off to the side and look at it, it would look like the threads on a giant bolt! Aha! A screw!

As you stand back and look at the basic shape of the inclined plane, you will see that the comparisons hold true for the remaining subgroups. Basically, the outline of the inclined plane is a triangle with the ground as one side, the plane as the second side, and the height from the ground to the top of the plane as the third side. As you keep this triangular shape in your mind, tip it up on the point and have it split a log as you make the pieces small enough to fit into the fireplace. Aha! A moving inclined plane or a wedge. If the points of two inclined planes were placed toward each other and an object placed between them, the planes could be forced together at the same time to cut the object in two. Examples of this situation would be a pair of scissors cutting a piece of paper or a pair of wire cutters cutting a wire.

In its basic form as an inclined plane, we often refer to it as a ramp. The purpose of a ramp is to overcome the pull of gravity. Gravity is the force that pulls objects toward the center of the earth. The greater the mass of the object, the heavier it feels to us and the harder it is to overcome the force of gravity. The inclined plane supports a portion of the weight of the object. The steeper the slope of the ramp, the less pull of gravity it overcomes. Therefore, you are only overcoming the friction between the ramp and the object as well as the portion of the pull of gravity absorbed by the ramp.

Simple machines help us do work by trading force for distance. The longer the ramp and the more shallow the slope, the easier it will be to move the object using an inclined plane. You will need to travel a greater distance with the object you are trying to move, but the force required will be significantly less. When we discuss work a little later on, you will find that the amount of "work" is the same, it was just easier to do the job.

Enough of this. This concept will become much simpler after we work through some activities.

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more trucks

MAIN IDEA: An inclined plane is a sloped surface.

An inclined plane helps us do work by trading force for distance.

The steeper the slope, the more force it takes to move an object along an inclined plane.

PROCESS SKILLS: Interpreting data

Measuring

Predicting

MATERIALS:

Books

Desks or boards

Masses

Spring scales

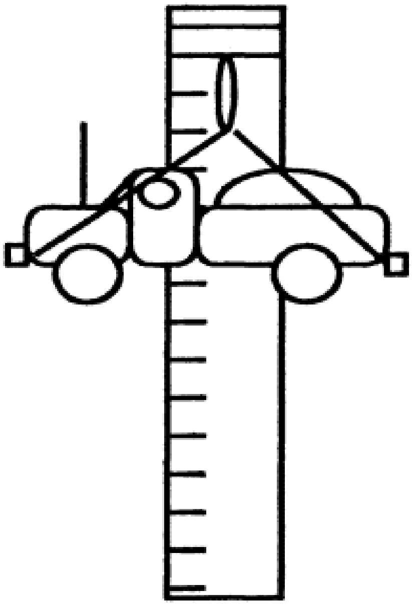
Toy trucks or cars

TIME: 30-45 minutes

PROCEDURE:

1. Earlier, when you were finding out about wheels and axles, you used toy trucks or cars and put a mass in the vehicle to find out how much the wheel and axle assisted in reducing the amount of force it takes to move an object. You will be setting this experiment up in much the same way, except that you will be varying the angle or slope on which the truck will travel.

2. Attach the spring scale to the truck and mass and find out the combined weight of the pair by lifting the spring scale
Record the weight on the activity sheet titled "more trucks."



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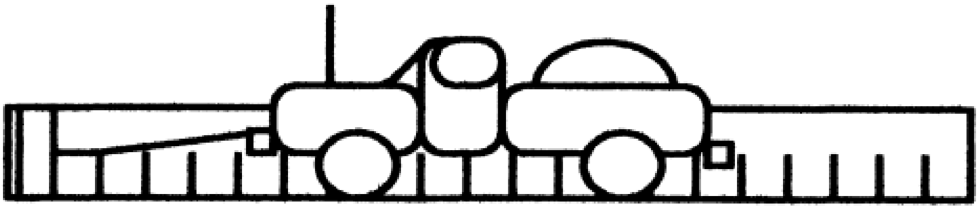
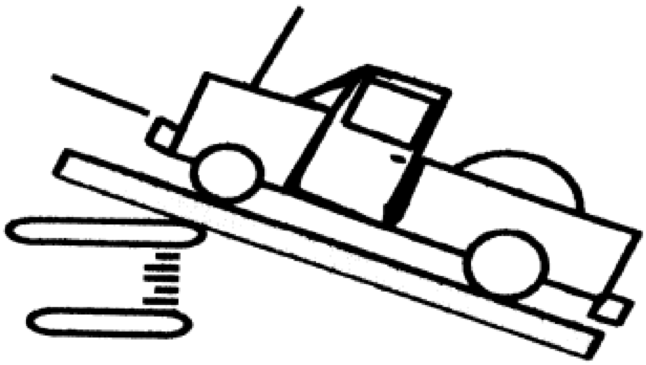
3. Move the truck and mass across the board or surface of the desk with it in a horizontal position. Record the informat



4. Now place a book under one end of the board or legs of the desk and move the truck up the ramp. Record the results



5. Repeat the procedure, adding more books under the end of the inclined plane and testing the force it takes to move t
up the ramp.

6. Discuss the results. As you steepen the slope or incline of the plane, you should experience that it takes more force to do the job. As the slope increases, the ramp is absorbing less and less of the pull of gravity and you are having to do more and more of the lifting. (It's one of those physics/vectors things again.)

An alternative to using trucks or cars if you cannot come up with a reasonable number for use with your class is to use that old science text instead!

1. Take about 18 inches of string or so and tie it into a loop.

2. Open the book to the approximate middle and insert the loop into the book. Close the book. (Phew! I thought I was going to have to read it!)

3. Open a paper clip into a C shape and attach it to the loop of string. Attach your spring scale to the clip and progress through the procedures that you would have done with the toy trucks. You could also do this activity as a reteach of the prior activity.

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Name
Date

more trucks

What is the combined weight of your truck and mass? ______________ units

Number of books under the end of your inclined plane	How much force do you think it will take to pull/push your vehicle up the ramp?	How much force di to move your vehic the ramp?

Describe what you see happening as the number of books increases under the ramp.

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levitating the teacher

MAIN IDEA: An inclined plane is any surface that slopes.

An inclined plane can be fixed or moving.

An inclined plane can be used to lift a weight.

PROCESS SKILLS: Inferring

Interpreting data

Measuring

Predicting

MATERIALS:

Hammer

Shingles, shakes, or wedges cut from a piece of hardwood

2 tables or desks

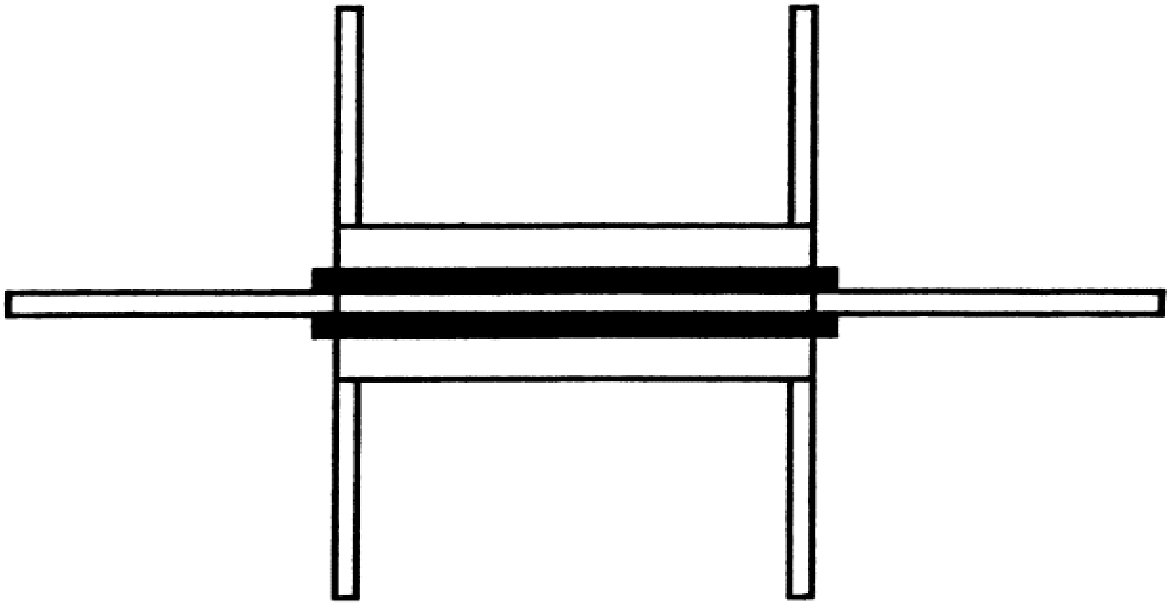
TIME: 20-30 minutes

PROCEDURE:

1. Stand a table in a normal position in the middle of the room.

2. Turn a second table over and set it on top of the first table.

3. Between the two table surfaces place the inclined planes (shingles, shakes, or hardwood wedges) as evenly spaced as possible.



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4. Tell the students that you will be sitting in the middle of the table on top. Individuals will be tapping on the ends of the wedges with the hammer. Ask them the following:

a. What do you think will happen?

b. How much force do you think it will take to lift the teacher?

c. How far do you think I will be lifted with each tap of the hammer?

These predictions will help them to focus their attention on the process and provide some investment into their observations.

5. Have the students take turns measuring how far you are lifted at each tap (mm or cm on the metric side of their ruler be easiest to use). They should measure on all 4 sides of the table (if it is rectangular). They should observe that the tab doesn't lift at all on the side opposite the wedge, lifts less on the sides adjacent to the wedge, and lifts the most on the s the wedge.

6. Each student should experience the process of how much or how little force it takes to lift you with the hammer.

7. Discuss their observations.

8. If several hammers and a supply of wedges are available, you could do this as smaller groups after the class demons

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wisecrackers

MAIN IDEA: An inclined plane is any surface that is sloped.

An inclined plane can be fixed or moving.

The slope of the inclined plane determines the amount of force required to move an object.

PROCESS SKILLS: Inferring

Interpreting data

Measuring

Predicting

MATERIALS:

Boards with holes about 2 inches apart

Bolts with matching nuts3/8 inch is a good size

The bolts should be around 4 inches long or a little longer; obtain sets that have both "coarse" and "fine" threads. The p at the hardware store should be happy to help you: Just tell him or her that it is for a science project and he or she won' and get too technical with you. (Remember, no one understands science!)

Walnuts or other hard nuts in the shell

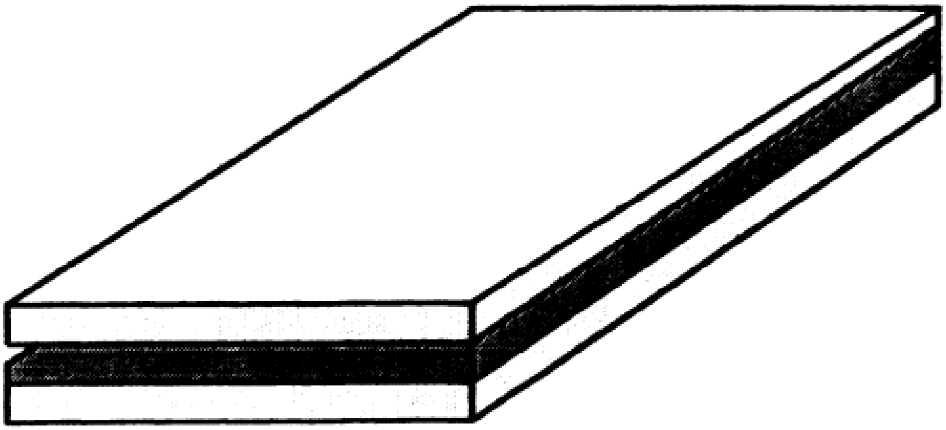
Washers

Wrenches to fit the bolts and nuts (not the walnuts!)

TIME: 30 minutes

PROCEDURE:

1. Acquire some sets of 2 boards with holes drilled about 2 inches apart. If you are building the sets, I would recomme the boards be at least 6 inches square.



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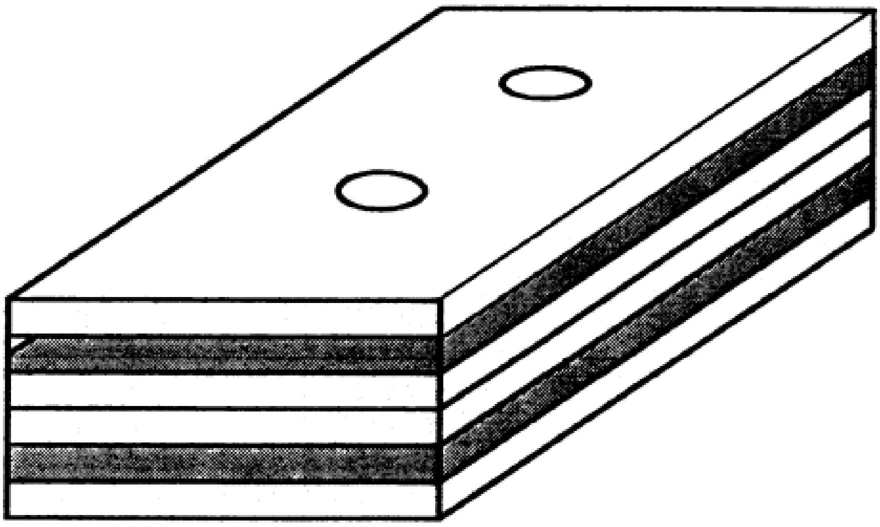
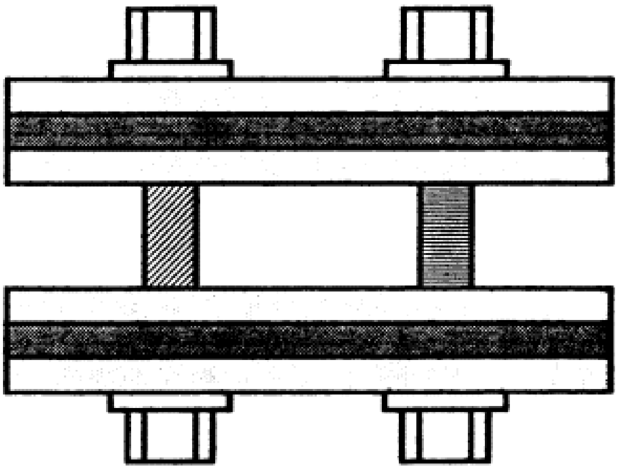
2. Place 2 boards on top of each other and drill two holes that are about 2 inches apart. The holes should be large enough, 1/2 inch, to accommodate the bolts without them binding in the holes.



3. Place a washer on a coarse and a fine threaded bolt and feed the bolts down through the holes in the board. Then put on a second washer and nut on the bolts.



4. Have the students hold onto a walnut or other hardshell nut and let them try to crush it by squeezing it in their fist. T insert the nut between the bolts. Twist the nuts on the bolts with your fingers until they are snug (see page 108).

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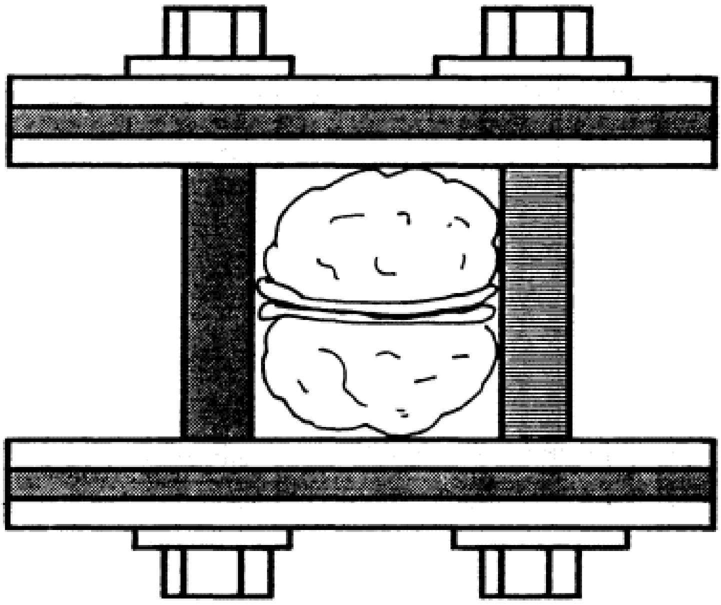
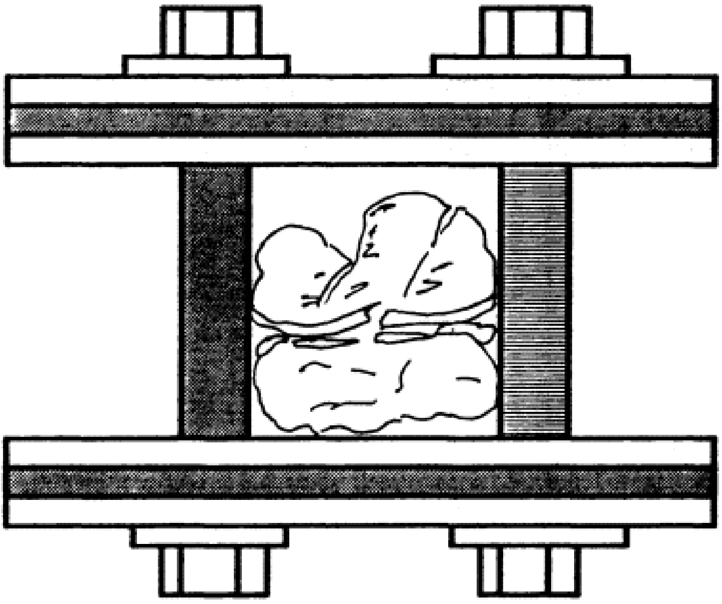


5. Using a wrench, twist the bolt and nut combination until the nut cracks. Try with the coarse thread first, then again v fine thread and a new nut. The students should make observations about:

a. how many turns it takes to crack the nut, and

b. how much force was needed to turn the wrench with both kinds of threads.



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6. Discuss the observations. The students should notice that it takes fewer turns with the coarse thread to crack the nut, but that it requires measurably more force. This should be painfully obvious now, because "simple machines help us do work by trading force for distance."

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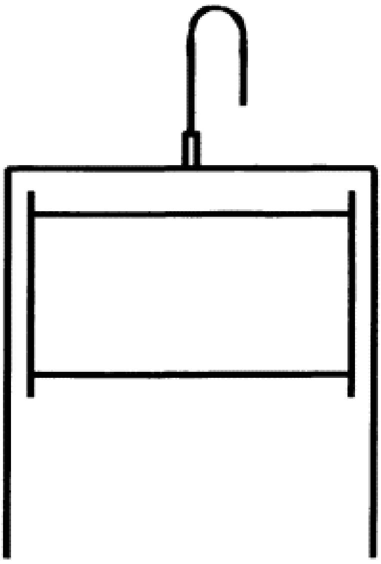
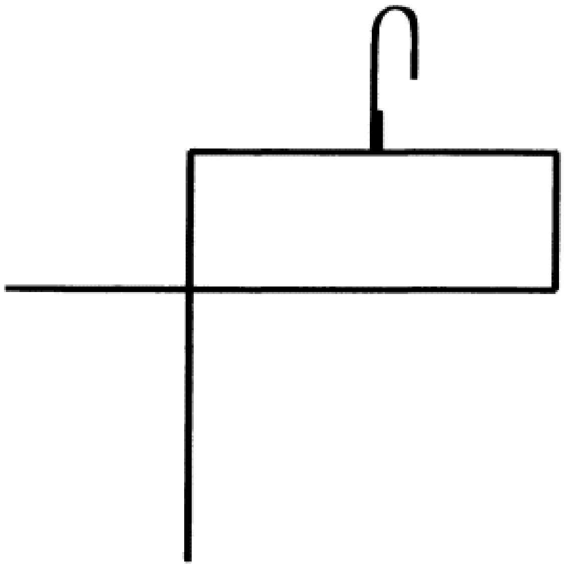
Page 11

4. Place the spool on the table so the center of the spool lines up with the center of the wire hanger. Allow a little room on each side of the spool and bend the wires straight down along the ends of the spool.



5. Bend 1 wire straight in at a right angle.



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cut ups

MAIN IDEA: An inclined plane is any sloped surface.

An inclined plane can be fixed or moving.

A moving inclined plane can be used to reduce the force necessary to do a job.

PROCESS SKILL: Interpreting data

MATERIALS:

Copper wire, 14 gauge or larger

Wire cutters

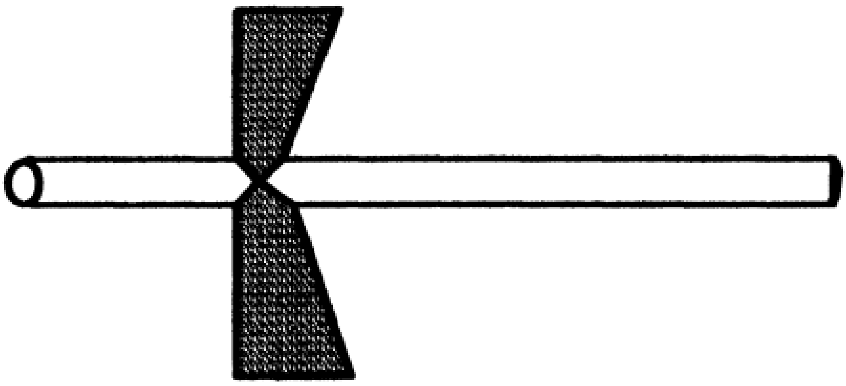
TIME: 15 minutes

The purpose of this activity is to show the path of a moving inclined plane and how it can be used to do a useful job.

PROCEDURE:

1. Strip several short sections of copper wire.

2. Ask the students to predict what the shape of the end of the wire will be when you cut it with the wire cutters. Most will probably anticipate that the wire will be cut cleanly across at right angles to the length of the wire. The resulting cuts will actually be at the same angle as the angle of the cutters on the wire-cutting pliers. The cutters are not only entering the wire, but separating it as well.



3. Let the students cut sections of the wire themselves to verify the cutting angle and the process.

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threads

MAIN IDEA: An inclined plane is any sloped surface.

The slope of inclined planes varies.

Threads of a bolt or screw are curving inclined planes.

PROCESS SKILLS: Interpreting data

Predicting

MATERIALS:

Paper scraps

Pencils

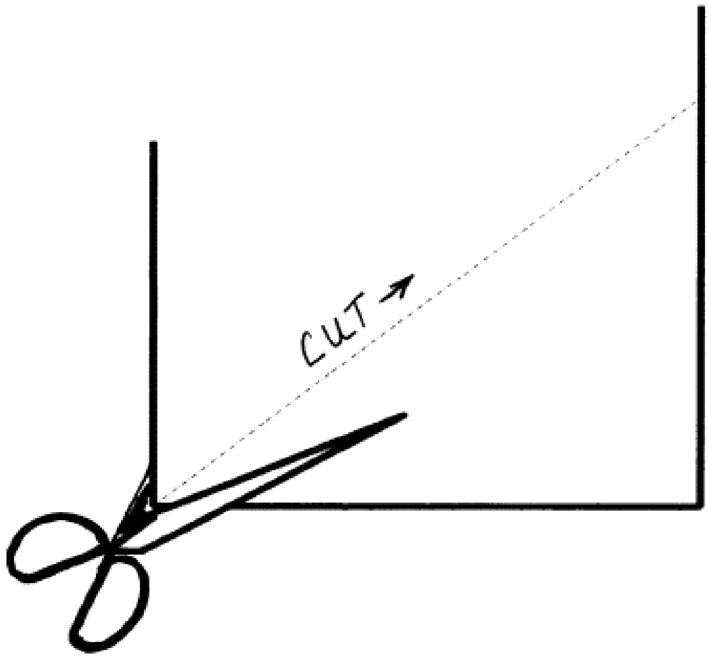
Scissors

TIME: 15-20 minutes

PROCEDURE:

1. Have the students collect a number of old pieces of scrap paper.

2. From any corner of the paper, cut across to the opposite side. This should give them a right triangle. Have them cut s
right triangles from their scraps of paper.



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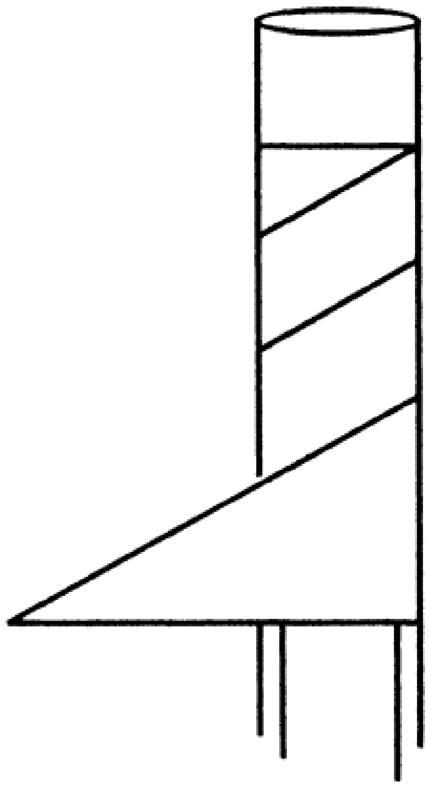
3. Place the right angle of the triangle next to the eraser of the pencil and either adjacent side along the pencil. Then wr
paper around the pencil until it runs out. Compare the edge that wraps around the pencil as it wraps upward. Draw the
comparison with the threads on a screw or bolt.



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more threads

MAIN IDEA: An inclined plane is any sloped surface.

The slope of inclined planes varies.

Threads of a bolt or screw are curving inclined planes.

PROCESS SKILLS: Interpreting data

Predicting

MATERIALS:

Screwdrivers

Screws, in a variety of sizes and threads2 to 5 depending on availability (Hardware stores typically sell bulk screws at a penny or two apiece.)

Wood scraps

A hammer and nail

(Sometimes the screws are hard to start for kids; if you make a small hole by hitting a nail once with the hammer and pulling it out with your hands, the screws usually start quite easily.)

TIME: 30 minutes

PROCEDURE:

1. Pass out screws, a screwdriver, and a block of wood to each group.

2. Ask them to lay the screws out on the table in the order in which they think the screws will be easiest to hardest to drive into the wood with the screwdrivers.

3. Ask them to share why they chose the order that they did.

4. Have them drive the screws into the block of wood.

5. Compare their predictions concerning which was actually easiest to hardest.

6. If each group has the same variety of screws, you can compare the results to do something very scientific called veri
your data.

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5
Things that Rub

"Say, hey, Ralphie, what's the rub?" That's one of those kind of sayings that happens to stick in your mind when you have a name like mine. I have a hard time with the citations for this kind of trivia, but it seems like a very appropriate introduction for the topic of friction.

Friction occurs when two objects rub together. The amount of friction that is created is determined by the amount and texture of the surfaces that are rubbing together and how hard they are rubbing together. The by-product of friction is always heat, and usually wear or fatigue of the surfaces.

This brings us to good friction and bad friction. Now wait a minute, if the by-product of friction is heat and wear, how can there be good friction? Good friction is often called traction. When the roads are icy or wet, our tires have a tendency to slip or skid because there is not enough friction between the tires and the road. Lack of friction is what I experience whenever I try to roller skate or ice skate! There is a severe tendency to experience a lot of movement back and forth without moving ahead. Good friction is what we are looking for when we dry our hands just before we try to take the lid off the new pickle or jam jar. It's why we put a rubber band around the top of the jar before trying to loosen the lid.

Bad friction is when two moving objects rub together, causing permanent damage to the moving parts. That's why oil companies run commercials that claim their products can prevent excessive engine wear through their superior lubricating ability. This is one of those half-full or half-empty arguments because, if friction and abrasion didn't occur, then sandpaper would not serve the purpose for which it was intended.

For our study of simple machines, we will say that friction occurs when two objects rub together. Its presence can be useful or can require more force to conduct a task if it has to be overcome. Greater friction occurs when surface area increases and the pressure holding the two surfaces together increases.

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rub-a-dub-dub

MAIN IDEA: Friction occurs when two objects rub together.

Friction increases when there is greater surface area or pressure.

PROCESS SKILLS: Inferring

Interpreting data

MATERIALS:

Two hands each

TIME: 5 minutes

The following is a useful anticipatory set when introducing friction activities with students.

PROCEDURE:

1. Ask the students to hold their hands out in front of themselves.

2. Have them rub their hands gently together. Ask what they feel.

3. Now have them rub their hands harder. What changes in sensation do they feel?

4. Now have the students rub their hands together as fast as they can. The reaction is almost immediate. Through discussion you should be able to determine with the group that the elements of friction are two objects that rub together, and that the by-product is heat.

5. Next, repeat the activity, but have the students rub only the tips of their index fingers together. They will be able to experience the sensation of friction, but they will not be able to produce the heat they did when they were rubbing the palms of their hands together. From your discussion you should be able to compare the two incidents and find that the difference is the amount of surface area of the fingertips compared to the palms of the hands.

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easy slider

MAIN IDEA: Friction occurs when two objects rub together.

Friction increases when surface area increases, texture roughens, and pressure increases.

PROCESS SKILLS: Interpreting data

Measuring

Predicting

MATERIALS:

Small carpet squares

Cooking oil

Cornstarch

Masking tape

Masses

Plastic wrap

Sandpaper

Spring scale

Drinking straws

Waxed paper

TIME: 45 minutes

The activity works well if students can work in groups of two.

PROCEDURE:

1. Give each group a spring scale, mass, and about a foot of masking tape.

2. Refer the students to the activity sheet titled "easy slider." Indicate that they will be recording all of their observatio that sheet and that before they conduct any trial they should record a prediction on the sheet.

3. Ask them to record the weight of their masses on the activity sheet. Then place the mass on the table and attach the s scale. Each group should record their prediction on how much force it is going to take to slide the mass across the tabl

4. Before they complete the trial, they should record a word that describes the texture of the surface across which they sliding the mass. Brainstorm a list of words that can be considered as texture words to expand their vocabulary. Words *rough, coarse, gritty,* and *bumpy* should be included rather than *soft* or *hard.*

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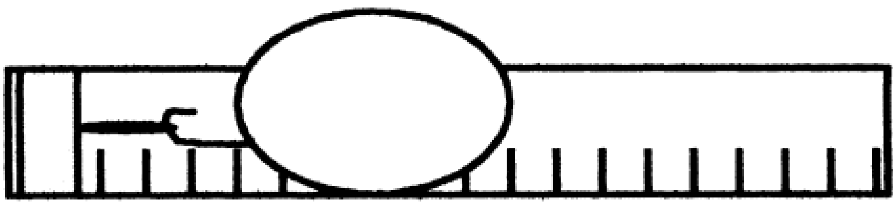
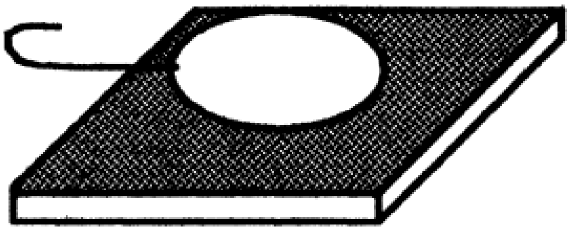
5. Finally, slide the mass across the tabletop and record the force that is required.



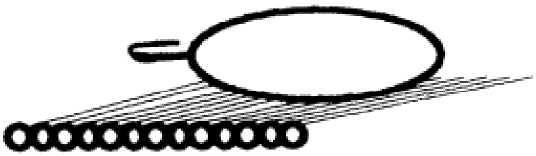
6. Pass out the carpet squares and repeat the steps as before for predicting force and describing texture. Place the carpet fuzzy side down on the table. Then, put a little circle of tape on the back of the carpet and attach the mass to the tape. Hook the spring scale to the mass and pull the assembly across the tabletop.



7. Turn the carpet square over and repeat the process. The back of the carpet square provides a completely different texture to move across the table. Record the results on the activity sheet.

8. Collect the carpet squares and replace them with a small square of sandpaper. Attach the sandpaper to the mass with masking tape, record the prediction and texture on the activity sheet, and complete the trial.

9. Pass out about a dozen drinking straws to each group. Lay them parallel to and touching each other. Place the mass on the bed of straws and push it along the tabletop.



10. Place a square of waxed paper on the tabletop. Attach the 4 corners to the table with small pieces of masking tape. Slide the mass across the waxed surfae, recording the results.

11. Sprinkle cornstarch on the waxed paper. The students should feel the texture of the cornstarch between their fingers before conducting the trial. When this trial is completed, roll up the waxed paper and cornstarch and dispose of it in the trash.

12. Repeat the activity using plastic wrap. The results should be surprising!

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13. With the plastic wrap still in place, put a small quantity of cooking oil on the wrap for the students. Then have them repeat the trial, predicting, determining the texture, and recording the