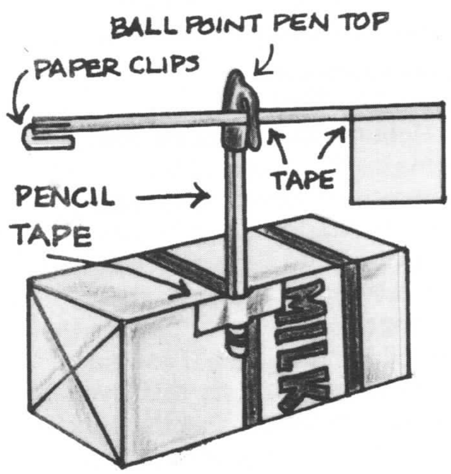
MAPPING AIR CURRENTS AROUND A SCHOOL BUILDING

Introduction

When you walk around the corners of buildings on blustery days, you can notice sudden changes in the wind. On one side there is a strong breeze, while just a few feet away there is none at all. Sometimes the wind blows leaves in just one corner of a building and nowhere else. Especially around extensions and indentations, the wind seems to move in many directions at once.

Investigating how the wind moves around a building can lead to some surprising discoveries. This activity suggests an exciting way of doing this. Blowing bubbles outdoors is always fun. If the wind is not too strong, and the soap solution is right, the bubbles can last long enough as they move with the wind to indicate how the wind makes its way around a structure.



Preparation

In this activity you can use two approaches that complement each other. You can make several simple wind vanes and place them around the building, and blow bubbles. The wind vanes give you a sense of the prevailing wind at one spot or several spots. Airborne bubbles near a building can show how the wind moves along or around it.

Here is one design that can be used to assemble vanes quickly. The more you can make, the more interesting the activity can be.

To Assemble

1. Tape pencil on side of milk carton. If rocks are available, put some inside. This will prevent the carton from being blown around in heavy winds.

2. Make a long straw out of two regular ones by pinching the end of one and inserting it a couple of inches inside the other. Tape index card on one end as shown. Put the top of a ball point pen in middle of the straw, taping it in place. Balance the arm with a few paper clips at the other end so that the arm swings freely. Make sure that the index card does not bump into the milk carton.

You can use several kinds of commercial toys to blow bubbles. What you need is one means of producing lots of little bubbles and another that makes big bubbles larger than a grapefruit. Make soap solution for blowing bubbles of all sizes by mixing about a cup of Joy dishwashing detergent in a gallon of warm water. The less expensive dishwashing detergents give bubbles that break easily.

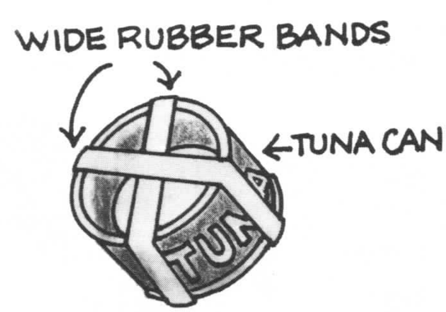
Science Themes
patterns

Science Skills
observing
classifying
recording data

Time Frame
one class period

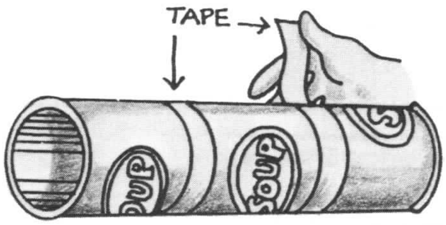
Materials
- ☐ *3 or 4 buckets of water*
- ☐ *Joy dishwashing soap*
- ☐ *3 or 4 trays*
- ☐ *tuna fish cans*
- ☐ *wide rubber bands*
- ☐ *toy bubble blower*
- ☐ *milk cartons*
- ☐ *pencils*
- ☐ *masking tape*
- ☐ *index cards*
- ☐ *paper clips*

Tuna cans that allow both ends to be opened can make grapefruit-sized bubbles. Just cut away the ends of the can and place rubber bands as shown.



- Dip this into the soap solution, then move quickly but not too quickly. You will have to experiment to find the right speed. You should get clumps of bubbles as big as a grapefruit.

Another type of blower will enable you to make bubbles as big as volleyballs. Find three cans of the same diameter such as soup cans. Cut out the tin on both ends and tape together as shown.

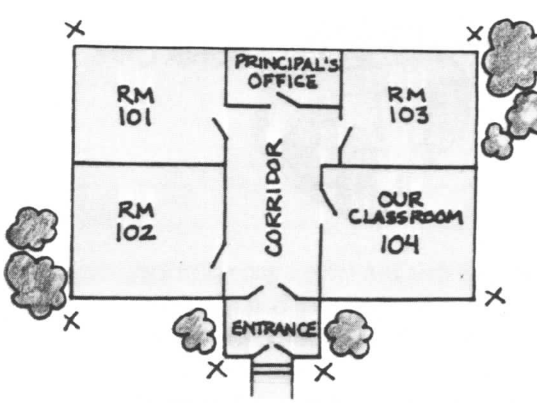


• Dip one end into the soap solution and pull out, making sure a soap film window forms. Blow into the other end till you get a bubble bigger than a volleyball. Move can gently to one side to release the bubble. You will need some practice to release it without breaking.

This last bubble blower will not work well in strong breezes. Practice indoors before going outside.

The Activity

• Before you go outdoors, draw a map of the exterior of the school building, and consider these questions: How will the devices on the preceding pages be useful in showing the direction of the wind? How will the wind move around the building if it is coming from only one direction? What will happen if the wind is blowing directly toward the building? Will the bubbles smash into the wall? What will happen around the corners of a building? Will the bubbles curve around the corner?



For the experiment, you can work either as one large group or in small teams of three or four. Decide before you go outside, and also use the map of the school building to indicate where you would like to test the wind direction.

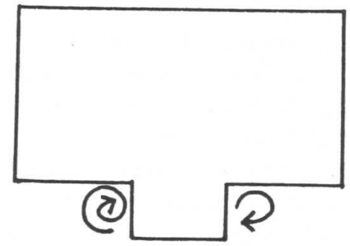
Record each observation immediately on your maps.

• Once outside, first check the wind direction at one location with the wind vanes. Several of them in a row should give a good idea of how wind is behaving at that location. Note that the wind direction can change dramatically within a distance of a few feet around corners or at indentations in the building.

• Blow large and small bubbles. On very windy days you will find it easier to follow the smaller bubbles, while on calmer days the bigger ones will sometimes last a minute. The bigger ones will help you see how the air moves around and over a building. You will have to blow bubbles for several minutes at each location to see whether they always travel in the same direction. If a steady wind is blowing, and you observe carefully, you should be able to see the bubbles following the same lines of movement. At some locations they will always move in a straight direction while at others they will either spiral upward or move in a circle. Don't forget to draw arrows on your map to indicate in which directions the bubbles floated.

Thinking About and Analyzing Your Results

Did your results agree with those of other students? If not, why not? On very windy days, the wind blows in gusts and tends sometimes to switch directions very suddenly. On calmer days, the wind tends to blow in a prevailing direction, giving similar results. However, at extensions or indentations in the building, bubbles may travel in circles, or opposite to the direction of the prevailing wind. The results here may be confusing and the observations should be repeated in the next class. For instance, the diagram shows how bubbles moved when wind blew near an elevator shaft sticking out from the building.



Some of the bubbles circled around the shaft in the opposite direction to that of the prevailing wind. If you have a similar situation with your school building, why does this happen?

You should blow bubbles outdoors more than once. The second and third times need not take the entire class period, but should be done when the wind conditions are very different from those of the first session, such as on stormy days or very calm days. You can also do repeat experiments in different locations in your own neighborhood, testing to see how bubbles move around houses or apartment buildings.

Going Further

Helium-filled balloons, sold in some novelty stores, add an extra dimension to the activity. Bright colored balloons, visible over long distances, show the direction that the wind is moving a short distance above the building and at several hundred feet. If you can get more balloons, try this several times to check whether the winds above the buildings always blow in the same direction.

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MAPPING AIR CURRENTS INSIDE A SCHOOL BUILDING

Introduction

Indoor circulation is hard to spot unless an open window brings in a chilling breeze. It often seems that there is no air movement at all in a very still room. In fact, in even the quietest and most isolated rooms, it is possible to detect air currents. For instance, heat from radiators sets up convection currents, or the air conditioning vents circulate cooler air in a warm atmosphere.

Designers of the buildings concern themselves with how air circulates through a building. They try to design systems that continually move the stale air full of smoke and odors out of the building or purify it and recirculate it. They carry out tests on models and sometimes on the building itself to determine how well this is happening.

This activity will demonstrate that air currents swirl around inside your school building. It will also show that, even though the air speed is much slower than outdoors similar patterns of motion exist indoors.

Preparation

Indoor movements of air can be detected. First, try the wind vanes and bubbles that you used outdoors. You will find that wind vanes don't move at all in a classroom; and that, unless there is a strong draft from an open window or from a heat duct, even bubbles sink directly to the floor. What you need is something very light that is produced continuously—smoke, for example. With a lighted match*, set a piece of string burning, and then blow out the flame. If the string is cotton, it should smolder slowly, producing a small amount of smoke. (Strings made of synthetic fiber will not smolder.) You can also use mosquito coils or incense.

Science Themes

patterns

Science Skills

observing
experimenting

Time Frame

one class period

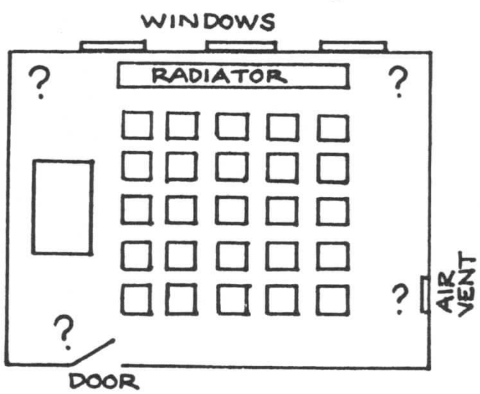
Materials

- ☐ *matches*
- ☐ *cotton string or mosquito coils or incense*

* *Caution:* Students should use care in using a lighted match. Keep it away from flammable materials. Be sure it is completely out before throwing it away. The same care should be shown for the smoldering string.

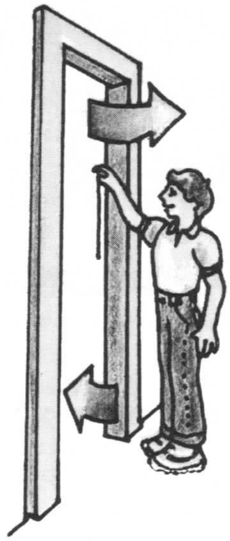
The Activity

Before testing locations in your classroom and around the school building, first observe what happens to the smoke from the smoldering string when you and everything else around you are very still. The smoke should rise straight up a little way before diffusing. If you blow gently, the smoke should move in the direction in which you blew. Move to different parts of the classroom and watch how the smoke moves. Since any kind of movement affects the smoke, you will have to stay very still, not moving the string at all, and not even talking. As you check various spots, write down your results. Make a drawing of the classroom indicating where windows, doors, radiators and ventilator openings are. Draw arrows to show which ways the smoke moves at different spots.

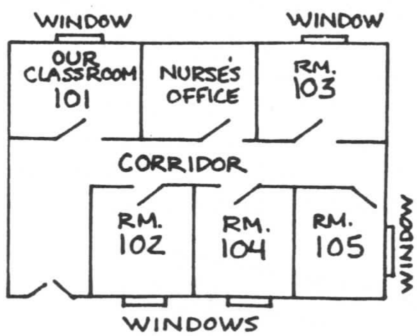


When testing near windows watch how the smoke moves with the window open and closed. Also hold the string a foot or two from the window and observe how the smoke moves. The movement at doorways sometimes gives surprising results. Watch how the smoke moves at several different levels above the floors.

You may find that the air is traveling into the classroom at one level and moving out at a different level.



Do the same kind of testing for the entire school building. First, draw a map of the entire school building that marks where there are doors, windows and entrances. Then check all these locations. Remember to record your results.



Discussion

After you have tested the various points in the building, compare your results with those of other students. Do the arrows on the maps point in the same direction as yours? If they don't, discuss why this may have happened. If you find real discrepancies, you may want to go back to check a certain spot. Perhaps you were moving near the smoldering cord as you recorded your results.

Here are some questions to consider: Were there areas where the smoke moved in a horizontal line without any disturbance in it? What does this indicate about the air movement at this point? Were there places where the smoke rose up in a straight line at first smoothly then in a spiral fashion? What does that show? Were there places where the smoke was not smooth? How can you interpret all of these results? A horizontal stream of smoke indicates a continuous, smooth, flowing stream of air. Smoke that rises vertically indicates no circulation at all, and situations where smoke moves in all directions at once usually indicates a heavy draft.

Here are some definitions: Smoothly moving air is called laminar flow; erratic and irregular flow is known as turbulence. Laminar flow is especially noticeable at doors or open windows. A long thin stream of smoke from the burning string often continues for two or three feet. In such situations, the air moving past that point has a steady speed and a constant direction. Turbulent flow by contrast is random motion involving mixing of air at that point.

Going Further

If you can create conditions where everything is still in the room, you can observe the various formations that smoke makes as it rises from the burning string or incense. There are a large variety of flowing changing curves and spirals that are beautiful to watch but only last a few seconds. Close all windows and doors and shut off any fans that might be in your classroom. Place the smoking string on something that will not burn and will be steady. Try to draw the different shapes that are repeated. Do they always look the same? If a slide projector is available, shine the light from the lens onto the smoke. It will make it more visible.

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PATTERNS IN MOVING WATER: PART I

Science Themes
patterns

DS-3

Science Skills
observing
experimenting

Time Frame
one or two class periods

Materials
- ☐ *trays*
- ☐ *water*
- ☐ *starch*
- ☐ *food colors: red, blue, yellow*
- ☐ *sticks*
- ☐ *drinking straws*

Introduction

The two previous activities made air movement visible by using bubbles or smoke. Similar techniques make it possible to see movement in water. One way is adding food color to the water.

You may have noticed that certain kinds of movements were repeated in the air mapping. The smoke may have revealed various kinds of spiral movements. The bubbles outside showed certain kinds of circular motions when they came near extensions of buildings. Because of the short observation time, it is hard to see what this pattern actually looks like. With the arrangement in this new activity, you can see some very definite patterns. Although they happen in a liquid, they are quite similar to those that occur with certain kinds of air movement. In fact, scientists treat movement of air and water as the same effect, under the general term "fluid motion."

The Activity

If you are not careful, this can be very messy. So put newspaper down on all the workplaces and near the sink, and fill the trays from buckets rather than at the sink.

Fill a tray with water to about a depth of 3 cm. Then add enough starch to give a white background when completely stirred. If you use a cat litter tray this is about 5-6 tablespoons. Or you can use cafeteria type trays as long as the sides are tall enough to keep the water from splashing out. Continue stirring the water until the starch is evenly distributed, without any lumps on the bottom. The starch is added to give a white background to the color added to the water. Once you have stirred the starch into the water you are ready to explore. Try to form small groups of students at each tray, if you have enough trays. Ideally, there should be one or two students per tray.

The idea is to move the water *slowly* in different ways, drop in a *few* drops of food color, and observe how the color moves.

There are several different ways you can explore with the food color, starch and water. Try them all, and make up your own.

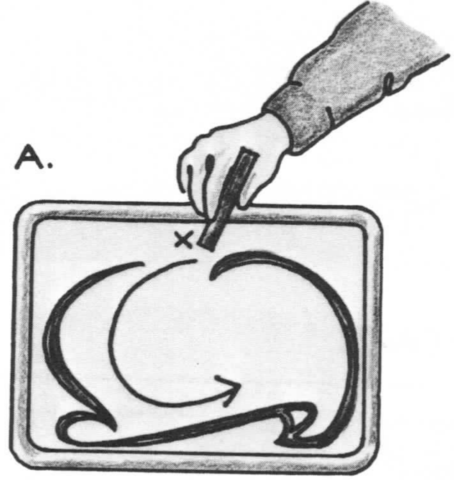
A. Use a stick or your hand to move the water in a circular fashion in the direction shown in the drawing. Carefully place a drop or two at the points indicated. Do it first at one point, then wait a minute or longer. Do the same again at another point. Note especially what happens at the corners. It may surprise you.

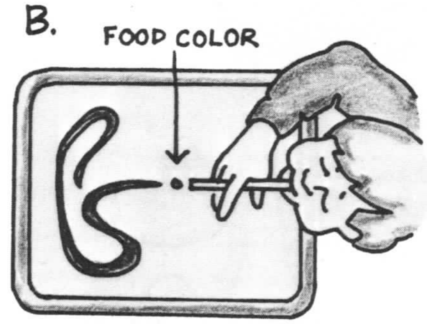
B. First, place a few drops of color using a drinking straw or eye dropper. Blow gently in front of the color, and watch how water moves for a while. Alternatively, blow for a while on the water and then carefully place a few drops of color in the water. Does this pattern differ from the other ones?

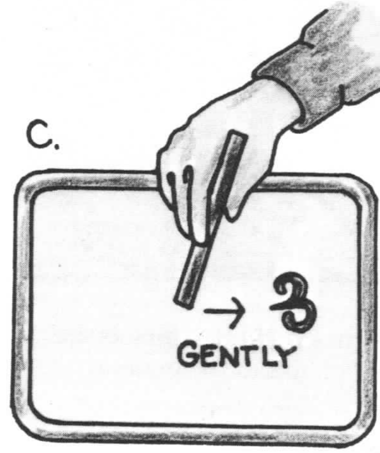
C. After stirring the starch into the water, let it come to a complete rest. Place a *few* drops in the center of the tray. Move the color very gently with a flat stick. If you have moved it at the right speed, a mushroom pattern will emerge with the colors.

Try dropping two different colors near each other about 1 cm apart. Move the stick as before between the two colors. If you do it carefully, you should get a spiral containing two different colors.

Continue to add drops to different parts of the tray, and to move the stick different ways. Observe carefully the patterns that are created. Do similar shapes occur each time the water is moved? How much does the color mix rather than forming into moving layers? After a while the water will become muddy, diminishing the effect of the color. At that point, it is best to dump this water out and start all over again.





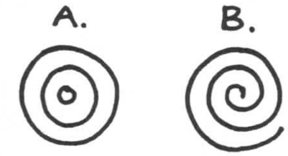


Note well: Don't dump the starch solution into the sink. The starch will clog up the drain. Instead, pour the solution into buckets. Let them sit overnight; next day, pour off the top layer and discard the settled starch into a waste can.

Discussion

Share your results with other students who have done this activity. Did you observe recurring patterns? The one that does occur often can be drawn as a spiral.

Sometimes, it is hard to draw these patterns. For instance, "A" and "B" are not the same pattern.



"A" is a series of concentric circles, while "B," which appears when the food color is moved gently, is a vortex—a shape that occurs frequently in nature. Have you seen similar forms? The hole in the water of a draining tub, the shapes created by boat paddles, and small "dust devils" on windy days are among the examples.

When moved slowly near each other, two colors will form a vortex in which the two colors don't mix. It looks as if the water were separated into layers. Although this isn't strictly true, it serves as a useful way of understanding what is happening.

Going Further

One class period may not give you enough time to observe fully what occurs with food color in water. Try this activity again or several times, inventing other ways to move the water and food color. Remember to record your results each time.

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PATTERNS IN MOVING WATER: PART II

Introduction

In the previous activity, you must continually add food color to the water to see how the water is moving. In an alternative approach, you don't have to add food coloring each time. Instead of starch, you use Ivory dishwashing detergent, which contains very fine particles. Added to a tray of colored water, these particles show up patterns of disturbance when the water is moved by air or when an object moves through it.

The Activity

Ideally it is best if each student has his or her own tray. If that is impossible, students should work in small groups at each tray. Fill the tray with water to a depth of 5 cm (2 inches). Pour Ivory dishwashing detergent into the tray and stir slowly to dissolve all of it. One cup of detergent per gallon of water is a good proportion. Blue food color provides the best contrast with the white particles. Add enough color to show movement clearly when the water is disturbed.

There are a number of ways to experiment with the solution. You can blow on the surface with a drinking straw and watch what happens as the water moves. Alternatively, you can move objects of different sizes and shapes through the solution. Before starting each time, blow over the whole surface with your mouth, instead of the straw to smooth out the surface of the solution. That will enable you to see your next attempt better.

Science Themes

patterns

Science Skills

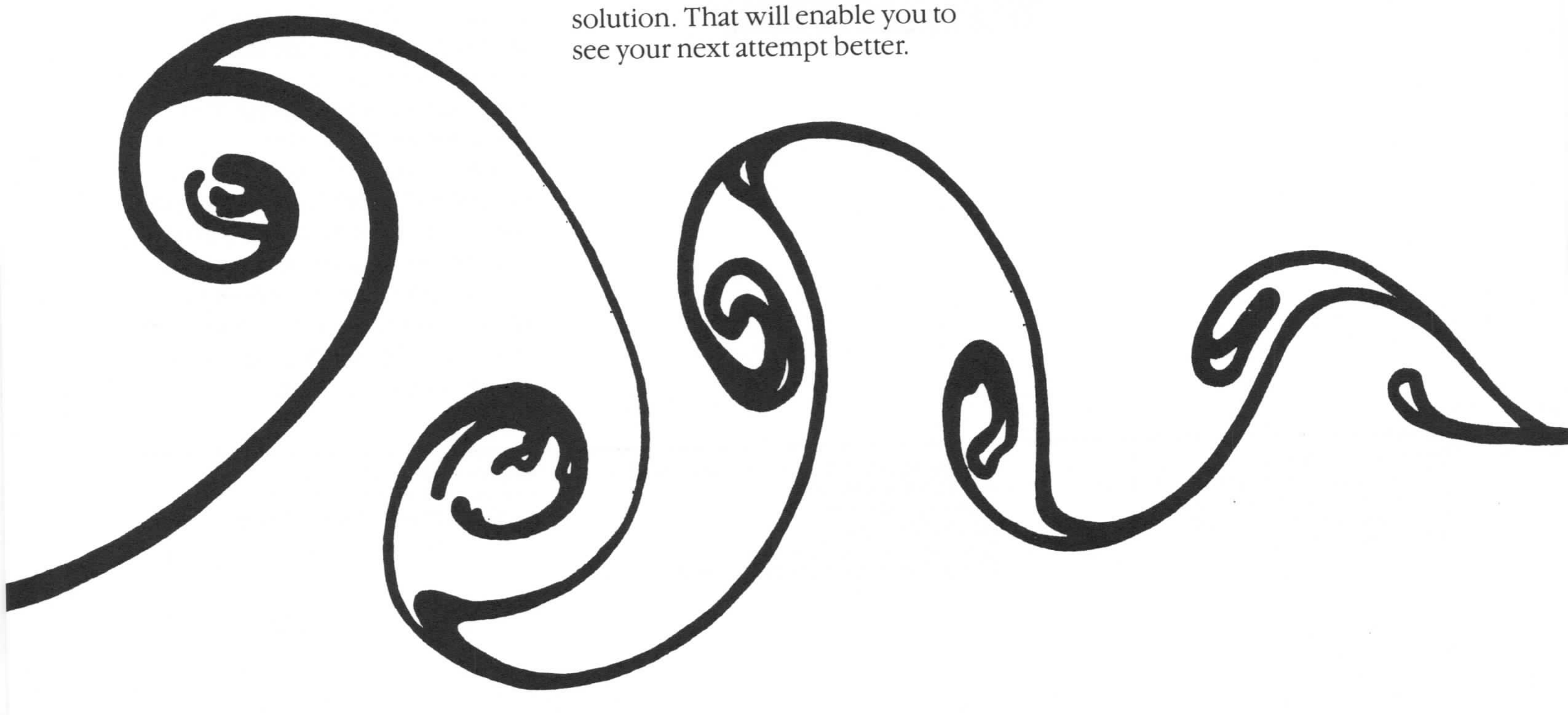
observing
experimenting

Time Frame

one or two class periods

Materials

- ☐ *trays*
- ☐ *water*
- ☐ *Ivory dishwashing liquid*
- ☐ *food color: blue*
- ☐ *sticks*
- ☐ *drinking straws*



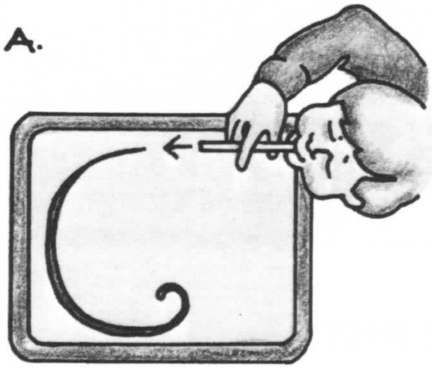
A. Blow through a straw along the sides of the tray and note how the water moves. Do these patterns look any different from those in the experiments with food color and starch?

B. Blow directly overhead and observe the motion created in the wake.

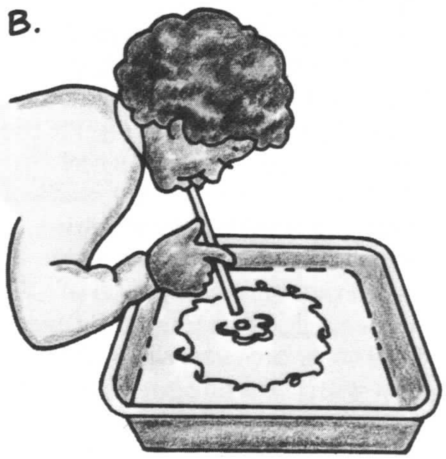
C. Try moving different sized sticks slowly through the water at different speeds. The sticks can be as thin as a drinking straw and as wide as a 4-inch piece of wood. Are the patterns in each case similar or different? Move differently shaped objects such as small cylindrical bottles and oval ones through the solution.

In all of these situations, you should make drawings and write very brief descriptions of how the patterns were created.

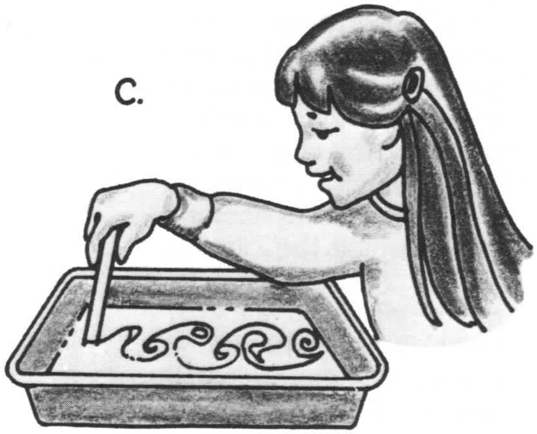
A.



B.



C.



Discussion

Compare your results with those of other students who have done this activity. How did the water circulate when you blew with the straw?

What kind of pattern kept recurring when objects of different sizes moved through the solution? The wake created behind a moving object in water tends to be of this form.

If an object is moved at the appropriate speed, the vortices it produces alternate and grow as they move away from the object. In some special circumstances, they can be quite regular. You can observe this in the everyday world. Vortices sometimes peel off behind a rock in a slow moving stream or the abutment of a bridge in a fast moving river. This situation with alternate vortices in different directions is called a vortex street. As the drawing shows, it can be quite beautiful.

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MOVING WATER AROUND OBJECTS

Introduction

Bubbles give some indication of how the wind moves around a building. Smoke from a burning string or incense shows how air moves on a smaller scale indoors. Food color and dishwashing detergent on a much smaller scale demonstrate movement in a tray of water. Many careful observations will show that similar patterns occur in each environment.

Specialists in fluid dynamics have developed careful procedures and mathematical calculations that justify comparing movements of air and water on a small scale to that on a large scale. Models of cars, planes and boats are tested in wind tunnels or water tanks as if they were moving in the real world. The results help in making final designs for these vehicles.

This activity gives you an approximate picture of what happens in these tests. Scientists and engineers are mostly interested in what happens to the air or water as it moves past an object. The disturbance behind the object gives an indication of how much resistance the object presents to the moving fluid. The pattern created behind the object shows how much the objects resist the flow of the fluid. Some shapes move more smoothly in fluids than others. Compare older automobiles with their flat windshields and bulging fenders with today's cars, that feature slanted windshields and smooth lines along the body. Modern automobiles have been designed to offer minimal resistance to air flow. Stick your hand out of a fast-moving car with the palm facing the wind and with it parallel to the ground. The effect of the wind is quite different in each situation.

By experimenting with food color and detergent solution, you can get an approximate picture of what happens as a liquid flows past a small object such as a popsicle stick. Different sizes and shapes of objects induce different forms of flow.

Preparation

The equipment and set-up are the same as in the previous activity. Spread newspapers under the tray and on the floor to absorb any spillage, and mix the detergent and the food color in the same proportions with the water in the tray.

The Activity

As already seen the particles in the detergent show how water moves when air is blown on the solution. By placing small objects in this solution, you can explore how water moves around them.

- Stand a ruler or a small piece of wood such as a popsicle stick in the middle of the tray as shown in the drawing. Blow through a straw at one end of the tray to create a moving current of water. Blow slowly so that a steady stream moves toward the object. Observe what happens when the water reaches the object and moves around it.
- Try different sizes of wood, starting with a width of half an inch, and moving up to 3 to 4 inches across. Do the patterns of water movement in front of and behind the object change as you increase the size?

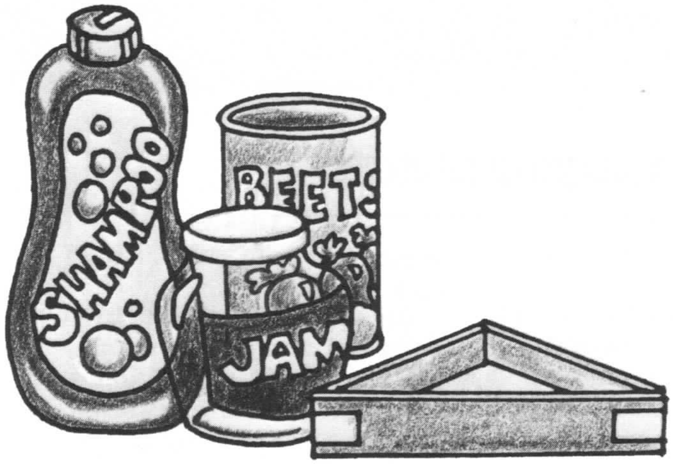
Science Themes
patterns

Science Skills
observing
experimenting

Time Frame
one or two class periods

Materials
- ☐ *trays*
- ☐ *water*
- ☐ *Ivory dishwashing liquid*
- ☐ *food color: blue*
- ☐ *sticks*
- ☐ *drinking straws*

• Place different shapes such as hair shampoo bottles, small cans and jars, in the middle of the tray. Make a triangular shape by taping pieces of wood or cardboard together.
• Before you test each size or shape, wait until the liquid has stopped moving. Then blow very gently several inches in front of the object. You can make the flow more visible by placing a few drops of food color in front of the object just before blowing.
• Don't forget to record your observations by making drawings of each experiment.



Discussion

The wider the piece of wood in the moving water, the greater the angle of the flow pattern past the object. This can be seen easily in the soap solution. There are other disturbances next to and behind the stick which require close observation to notice.

If you look very carefully in front of the object you can see a slight movement of the water as it tries to get around it. If you blow very gently, you can also see that vortices sometimes form just off the edges of the object.

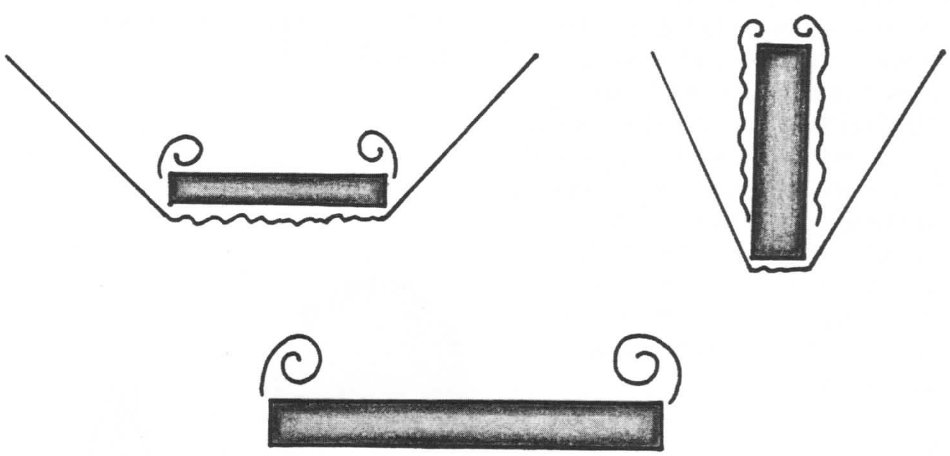
As you change the size of the pieces of the wood you should notice that the overall pattern remains the same.

The greater the diversion of the flowing water and the more vortices or turbulences behind the object, the greater the object's resistance to the movement of the water. This resistance is called drag. Engineers try to design automobiles, boats and airplanes to minimize their drag.

By experimenting with different shaped objects, you can see that the flow differs greatly depending on how the object is shaped.

Going Further

To get a much better picture of what is happening, use a larger tray and a continuously flowing stream of water. You can do this using a framed box made out of wood with a drop cloth placed in it. A hair dryer provides constant air source to keep the solution moving. In this way you can investigate the effect of larger objects on the flow of water.



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