Objects in water...

(illustration 15-0-9)
(A collage of photos showing students engaged in a selection of the science activities described in this section.)

Materials:

A collection of objects that sink or float for each student work team. A sample list of objects that might be used:

Paper clips	Bottle caps	Beans
Marbles	Paper cups	Aluminum foil
Wooden cubes	Tiles	Nails
Keys	Blank plastic dice	Paper
Buttons	Straws	String
Washers	Crayon	Clay
Scraps of cloth	Pieces of sponge	Corks
Rocks	Wood	Brass fasteners
Rubber bands	Tooth picks	Lids
And so on		

Coffee cans or Tupperware containers in which to store the sets of objects.
Water.
Plastic buckets.
Half-gallon milk cartons.
Desktop containers to hold the water in which the student work teams sink or float the objects. Tupperware or Rubbermaid containers work well.
Pizza trays upon which to place the desktop containers to catch the water spills.
At least two pint or quart size glass jars for each work team with mouths wide enough that a student hand can reach in and retrieve sunken objects.
Salt.
Rubber bands.
Balances or scales (for advanced questioning if advanced questions are asked).
Paper towels and sponges for cleaning up.

Materials considerations:

To select the objects that may sink or float we search our home or our classroom for small objects of which we have at least fifteen. There are no special criteria beyond size. We want the objects to be small enough to fit into the containers we provide. If there are thirty students in our class, we want at least fifteen of each object, since our students work in teams of at least two. More or less than thirty students means more or less than fifteen of each object to be found.

The water is distributed and collected as it was when our students were exploring boats (page 400).

Materials for each team of students available at the start:

A coffee can of objects for each work team.

Questions:

Sort all the objects inside your can into two piles. One pile for what you think will sink. One pile for what you think will float.
Which items are in which piles?
Why?
Do you all agree?

Additional materials:

Water.
Desktop containers to hold the water with which the student work.
Pizza trays for catching drips.

Questions:

Check your predictions.
What floated? Why?
What sunk? Why?
Did each group got the same results? Why?
If an object sunk, can you make it float?
If an object floats, can you make it sink?

Student: Can we put weights on the cork?
Student: Can I tie the marble to a stick?
Student: Can we wad up the aluminum foil and step on it?
Teacher: What was the assignment?
Student: See if we can make it float.
Teacher: Did I set any limits on how you could make it float?
Student: No.
Teacher: Then there aren't any limits to what you might try.

Questions:

What are the variety of ways you found to make things that float sink?
What are the variety of ways you found to make things that sink float?

Additional materials:

Pint or quart size jars filled about two-thirds with regular water and pint or quart size jars filled about two-thirds with salt water. Each work team needs one of each jar. If there is enough salt available, a good ratio of salt to water is about a cup to a cup. The salt water is kept separate from the regular water at both distribution and clean-up.

Questions:

You have a jar with water in it and a jar with salt water. Sink or float your objects in each jar.
Do the same ones sink in both jars?
Do the same ones float?
Do the objects seem to float better in one jar than another? Why? Why not?
Seal off one end of a piece of soda straw with a bit of clay. Float the straw clay end down in one jar then the other. Does it float the same in both jars? Why? Why not?

Additional materials:

Two rubber bands around the outside of each jar to indicate water level. The first indicates the starting level of the water. The second indicates any change to the water level that occur as an object is added in.

If we did not ask the following questions for boats, we can ask them now. If we already asked the questions, we can ask them again with the element of salt water added in. If there are students who found answers to our earlier questions, they may now make the connection that what they learned for boats applies to everything that sinks or floats.

Place one rubber band around the outside of each jar to show where the water level is now.
What happens to the water level when objects are placed in each jar?
Do any objects make the water level rise?
Which objects make the water level fall?
Do the water and the salt water act the same?
Which objects put in the water or the salt water make the level rise the most?
What else can you find out about why the water levels go up or down as you put things in or take things out?

Additional materials:

A balance or a scale.

More advanced questions:

Fill the water to the very top of your jar before you put the object in.
Weigh the water that spills over the side.
Weigh the object.

Which weighs more, the spilled water or the object?
Is the pattern the same for other objects that you place inside your jar?
Does it make a difference if the object sinks or floats?
Does it make a difference if the water is salty or regular?

What other questions will occur to us to ask as we watch our students work?
What does ancient Archimedes and his cry of "Eureka!" have to do with rubber bands around a jar?

Moonshine...

(illustration 15-0-10)
(A collage of photos showing students engaged in a selection of the science activities described in this section.)

Geometry is shape and space. The moon is shape in space.

We want our students to connect school learning with learning that is part of life. Studying the moon at night and discussing observations made the next day in school is one way we can connect school learning to the world outside of school. The moon seen at night is the same moon that can be seen in the daylight hours over school. The moon follows us from school to home and back to school again, just as should all learning that we do.

Materials:

Sky.
Moon.
Drawing paper for drawing moon and sky.
Compasses or other means of knowing north, south, east and west.
Street maps.
Clocks at home for telling observation times.
A calendar for measuring days and dates.

Materials considerations:

We ask our students look into the sky and find the moon. The moon is in the sky both day and night. We tell our students that, while they may stare at the moon, they must not look directly at the sun. We begin our questions when the sky is clear and the moon is visible during the day.

Materials for each team of students available at the start:

The sky above with the moon visible.

Questions:

What do you know about the moon?
Is it ever visible during the day?
Let's go outside and see if we can find it now.
What shape is it?
What different shapes have you seen the moon become?
Why do you think the moon has so many different shapes?
Will the moon still be visible tonight when the sky is dark?
Look for the moon tonight when you are home. If you see it, write down the time you looked and where it was when you found it.

After the first evening's observations and the discussion in class that follows the next day, we begin introducing our students to materials and methods for observing and recording that permit them make and record their observations in ways that facilitate sharing more effectively. We determine the kinds of methods and materials to introduce and the rate of introduction based on the needs we see and the abilities of our students.

The following materials and procedures may be of assistance to our students in organizing their information for sharing:

Compasses or any other means of determining north, south, east and west that we and our students can devise.
Our shadow points north at noon standard time. If we stand outside at noon and use our shadows to indicate north, can we determine south, east and west? if students learn the shadow-

pointing-north technique at school, they can create their own north indicator at home at noon on any weekend day. If they know north at home, can they find south and east and west as well?

Street maps might be used as an aid in indicating the direction of the moon. Street maps indicate north, south, east and west. How might they be used to help our students know north and all the other directions from their homes?

Astronomers use devises that measure angles for determining height above the horizon. We can make formal angle measuring devises if our students are familiar with protractors, or we can use fists to measure moon height.

To use a fist to measure degrees of height above the horizon, each student holds his or her arm out straight, hand made into a fist—the fist is turned up, not sideways, with its bottom edge on the horizon. The top of the fist is roughly 10° above the horizon. Keeping his or her back and arms straight, the other hand's fist is placed above the first. Assuming the bottom of the first fist is still lined up with the horizon, the top of the second fist is now 20° above the horizon. Keeping the second fist where it is, the first fist can now be placed above the second, for a measure that is 30° above the horizon. Each time a fist is moved above its mate—assuming the mate fist is held in its old position and the student's back is still straight—the newly placed fist adds 10° to the height measured.

(illustration 15-0-11)
(Illustrate the use of a person's fists as a measuring devise for angles. The illustration shows the arm being kept straight as a single person's fist is placed fist upon fist, while describing a 90° arc. Emphasize that the student's back must be kept straight. Show what happens when it is not.)

Once our students can determine both direction and height above the horizon, we can ask them:

When you go home tonight, find the moon. Record the time you found it, and where it was, by direction and height above the horizon.

Questions that follow from our students' nightly observations:

Where was the moon last night?
What was the time when the moon was there?
Can we make a summary drawing in class now of the moon's path across the sky from the time anyone first saw it until you all should have been in bed?
Was the moon changing places in the sky according to a pattern from which we might predict where the moon would have been after you had gone to bed?
Where do you think the moon will be tonight?
Will the moon follow the same path this evening as it did last night?
What might you find out about the moon's path if you plotted the moon's location every half-hour or hour for an evening?
Would your chart for the moon look the same on a different night?
What was the moon's shape last night?
What will the moon's shape be this evening?
Are the moon's shapes each evening in a pattern that will let you predict the moon's shape for future evenings?
When will the moon be full? When will it be full again?
What are all the shapes the moon takes between the times that it is full?
Is the moon ever visible in the morning and not at night, or at night and not the morning?
Is the moon ever not visible during the day and during the evening?
How long will it take the moon to return to the same place in the sky that it was the first time that you observed it, or will it ever?
What might we find about the moon's monthly path if we charted its location in the sky each evening at the same time?
Why would I say to make the observation at the same time each evening?
What causes the different moon shapes?
What do you think the earth looks like from the moon?

Drawings used to keep track of observations of the moon should include:

The date(s) and time(s) of the observation(s).
What the moon looked like.
Where it was—height in direction and degrees.

More advanced questions:

Where are the planets? Can we see them?

Why is Venus often in the same place each night when the moon is not?
What is the difference between a planet and a star?
Do the movements of the planets and the stars follow any kind of pattern?

Studying the moon may lead to studying the planets and the stars. Studying the planets and the stars may interest our students in watching something else at night besides television.

Building...

(illustration 15-0-12)
(A collage of photos showing students engaged in a selection of the science activities described in this section.)

Materials:

Straws.
Pins.
Metal washers or weights.
Toothpicks.
Clay.

By requiring every boy and girl in class to build during math, we ensure that all our students—male and female, rich and poor—gain the geometric and mathematical background that building can provide. Our requirement that all our students build does not stop with math. Our science activities also include building opportunities.

For free exploration, we said:

Let's see what you can make.

For geometry we said:

Let's see what you can build.

For science we say:

Let's see what answers you can find to the questions that I ask.

Materials for each team of students available at the start:

Straws.
Pins.

Questions:

What is the highest structure you can make with fifty straws and fifty pins?
Your structure must be free-standing, which means you cannot hold it up and it is not to lean against the wall.
Can you make a bridge from one desk to another using the same fifty straws and pins?
What is the strongest bridge that you can make?
How shall we measure strength?

If students have difficulty thinking of ways to measure bridge strength, we can suggest hanging metal washers on the bridge and seeing how many washers the bridge will support before it collapses.

What is the highest structure you can make with a limit to the straws and pins you may use?
Can you make a tower that will touch the ceiling?
What other building challenges might we pose?

Additional materials:

Toothpicks.
Clay.

The same questions asked for straws and pins can be asked for toothpicks and clay. The questions are the same. Will the answers be the same, as well?

We use straws and pins or toothpicks and clay and not Lego blocks or Tinker Toys for the questions that we ask. Straws and toothpicks are commonly available in greater classroom quantities than Lego blocks or Tinker Toys. If we have Tinker Toys or Lego blocks in quantities that permit every child in our room to be actively engaged, then Lego blocks and Tinker Toys can be a part of science, too. The difference between science and math is not the materials used, it is the questions asked and the direction that the explorations take.

Paper planes and kites...

(illustration 15-0-13)
(A collage of photos showing students engaged in a selection of the science activities described in this section.)

Children have been making paper airplanes since before men and women first learned to fly. Do the children making planes know they are using geometric skills as they experiment with the aerodynamics of flight? Do they know that folding paper into planes is so common in our world that there are books displaying the most advanced designs from the many paper airplane flying contests? Do they know that folding paper into planes counts as science in our class?

Materials:

Paper.
Scissors, crayons, paper clips, tape, or whatever else our students think to use to make their planes fly farther, or longer, or more decoratively.
Books on paper airplane contests from the school or local library.
Straws.
String.
Tissue paper.
Glue.
Kite sticks.
Newspapers.
Fabric for making kite tails.

Materials for each team of students available at the start:

Paper.
Whatever else our students need to turn their paper into an effective flying devise.
Books on paper airplanes.

Questions:

Can you fold your piece of paper into a paper airplane that will fly?
Which plane made will fly the farthest?
Which plane will stay the longest in the air?
Is the plane that flies the farthest also the plane that stays the longest in the air?
Will more paper make the plane stay longer in the air, or will less paper mean a longer flight?
What else seems to matter for having a paper plane fly farther or stay longer in the air?
How do planes that are made of steel stay up in the air?
What other questions might we ask about our planes?

Materials available for each team of students for making kites:

Straws.
String—for building and for flying kites.
Tissue paper.
Glue.
Kite sticks.
Newspapers for kite paper.
Fabric for making kite tails.
Books on kites from the school or local library.

Instructions:

Teacher: Here is a pyramid I have made with string and straws. You may use it as a visual guide as you make pyramids of your own.

(illustration 15-0-14)
(Show the process of running string through each straw length to form triangles and hooking series of triangles together to form the pyramid.)

Teacher: When you have made one pyramid, make some more. When you and your workmates have made at least ten, you can add tissue paper, and connect your pyramids to make a kite.

(illustration 15-0-15)
(Show the process of adding tissue paper to the straw pyramid and then show ten pyramids connected together to form a pyramid kite.)

Questions:

Will the kite fly?
What other straw constructions might you make that will fly as well?

If our students have kite sticks left over from kites they have flown at home, they can bring the sticks to school and see what new kinds of kites they might make. Books on kites might give our students clues as to the wide variety of shapes that have flown before. What new varieties of shapes might our students try?

Paper airplanes and kites are a part of every child's life. Paper airplanes and kites are also examples of how easy it is to connect school learning to a child's life.

Pendulums...

(illustration 15-0-16)
(A collage of photos showing students engaged in a selection of the science activities described in this section.)

Materials:

Tongue depressors.
Fishing line or heavy duty nylon thread.
Masking tape.
Assorted objects of various weights and materials to serve as pendulum bobs: fishing sinkers, metal washers, Styrofoam balls, wooden balls and blocks, and clay.
Metronome or any other device students might use for timing.
Graph paper.
Golf tees.
Thin dowels, or long unsharpened pencils.

Materials considerations:

Before our students begin answering questions, we show them how to make a base from which to swing their pendulums. To make a base, crack the end of a tongue depressor. The end may be cut with a sharp knife, but cracking works as well and is something our students can do for themselves. Slide a length of fishing line in the crack. On one end of the line, tie the weight that is to be the pendulum bob. Use masking tape to tape the tongue depressor to the desk from which the pendulum is to swing.

(illustration 15-0-17)
(Show how to make a pendulum base with a cracked tongue depressor taped to a desk top.)

This base allows the length of the pendulums line to be adjusted with a minimum of fuss. To make the line longer or shorter, the tape is lifted, the line pulled one way or the other through the tongue depressor crack, and then the tape is put back down again.

Materials for each team of students available at the start:

Pendulum stands made from tongue depressors, fishing line and tape.
Pendulum bobs made from a variety of things.
Metronome or any other device students might use for timing.
Graph paper.

Questions:

Can you get two pendulums taped side-by-side to swing together for ten swings? For twenty?

Can you get three pendulums taped side-by-side to swing together?
Can you make one pendulum swing twenty times while another only swings ten times?
What can you do to a pendulum to change the way it swings?
How long will it swing straight?
Can you make it swing in a circle?
What makes a pendulum swing faster?
Does the length of the line from which it swings make any difference?
Does the weight of the pendulum bob make any difference?
Does the materials out of which the pendulum bob is made make any difference?
What does make a difference? What does not?
When you let the pendulum bob go to begin its first swing, can you tell how far it will swing over on the other side? Will it swing back to the same point from which you let it go?
Can you make the pendulum swing farther on its second swing than on its first?
How long will the pendulum swing without stopping if you don't touch it? Can you make a graph to show how long it will swing?

If we ask our students to use a graph to help them predict when the pendulum will stop, we suggest to them the data they might graph. They might count the number of times the pendulum swings in, say, ten seconds then wait thirty seconds and count the swings in ten seconds once again. This "waiting thirty seconds then counting for ten" cycle is repeated as often as needed. The data from the waiting-counting cycles can then be graphed coordinately, with the coordinate points being the first, second, third and so, on cycles of counting paired with the number of swings counted in that cycle.

How far does a pendulum go on each successive swing? Can you find a way to measure how far it swings and graph your measurements?
Make a pendulum swing in a big circle. How long does it take to go around once?
Make the same pendulum swing in a little circle. How long does it take to go around once?
How long does it take a pendulum to go back and forth once, on a long swing?
How long does it take the same pendulum to go back and forth once on a short swing?

Additional materials:

Golf tees.

Questions:

Stand a golf tee so that your pendulum bob can knock it down. Can you have your pendulum bob leave the tee standing as it swings over and knock it down as it swings back?
Stand two tees side by side. Can you knock them down one at a time on two different back swings?
Set up ten tees. Can you knock them all down with five back and forth swings of your pendulum?
Can you put your ten golf tees in a circle and predict which one will be knocked over last?

Additional materials:

Thin dowels or long pencils.

(illustration 15-0-18)
(Show two pendulum strings wrapped around the same thin dowel or pencil half way down their length.)

Questions:

Start one pendulum while you hold the other one still. When the first one is started, let the second one go. What happens? Why?
Start both pendulums swinging at the same time in the same direction. What happens? Why?
Start one pendulum swinging one way and the other swinging in the opposite direction. What happens? Why?
Try moving the dowel up or down the lines and then releasing the pendulums.
What happens if you slant the dowel instead of having it go straight across?
What would happen if you hung three pendulums from the dowel?

The pendulum supports that students have taped to their desks can be hand held as well.

If you hold your tongue depressor in your hand, can you make your pendulum swing back and forth without giving it a push?
Can you make your pendulum stop without touching it with your hand?
Can you control the speed of your pendulum?

Does your pendulum swing in the same way when you hold it in your hand as when you had it taped to your desk?

Students may be interested in exploring what effect a very long line has on the actions of a pendulum. To create a very long pendulum we may hang a line from our class ceiling, or from the branch of a tree outside our room.

All the questions asked of the shorter pendulums may be asked again for a pendulum of extraordinary length. We may also ask our students to contemplate:

Where are pendulums used in life outside of school? Why?

Candles...

(illustration 15-0-19)
(A collage of photos showing students engaged in a selection of the science activities described in this section.)

Materials:

Coffee cans, one pound and two pound sizes.
Glass jars of assorted sizes. Quart mayonnaise jars. Pint jelly or peanut butter jars, and so on.
Birthday candles—one pack per student team.
Small boxes of matches.
Baby food jars half filled with water for burned matches.
Sheets of aluminum foil.
Modeling clay.
Pie tins.
Water supply.
Metronome or water clock or any other device students might use for timing.

Materials considerations:

A metronome can be used to count candle burning time. If no metronome is available, a water clock can be made by putting a small hole in the bottom of a coffee can, filling the coffee can with water and allowing the dripping water to strike an aluminum or metal pie tin placed below. The sound of the dripping water striking the pie tin can be counted and used as time intervals much as can the ticking of a metronome.

If a water clock is to be used, it design should be tested in advance to make sure that its sound is loud enough to be heard in class, and to make sure it leaks slowly enough to drip countable drops.

For ease of distribution, we put each work team's materials in a two pound coffee can, and tape a strip of masking tape to the can so that students may label which can is theirs.

Before any material is handed out, we state the rules for working with fire in our room, and demonstrate how the matches and candles are to be used safely. The candles used in the experiments go out constantly. To conserve matches each team of students may wish to keep one candle lit continuously. This candle may be placed in a clay base and kept safely away from any place a student might inadvertently lean over it.

Clay is also used to hold the candles that are the subject of the experiments. A small amount of clay rolled into a ball and pressed to the working surface makes an excellent candle support. Students protect the tops of their desks or tables by conducting all their experiments on sheets of aluminum foil.

Materials for each team of students available at the start:

Coffee cans.
Glass jars.
Aluminum foils sheets.
Baby food jars half filled with water.
Candles.
Matches.
Modeling clay.
A metronome or other timing devise.

Questions:

Put your candle in a clay base to hold it, then light it.
Describe to your partners everything you can about what you observe happening.
Now share with all of us in class what you have observed so far.
Put a large glass jar over your candle.
Predict how long you think your candle will burn inside the jar.
Will it burn until it has all burned up?

At this point, we introduce the metronome or water clock so our students have a timing device.

If you re-light your candle after it has gone out and put the glass jar over it again, will it take more or less time for it to go out this time, or will it be the same? Predict and then find out.
Can you make your candle go out in your jar in the same amount of time three times in a row? When you can, call me and I'll come over and watch you do it for a fourth.
How come your candle does not always go out in the same amount of time? What do you think affects candle burning time?
Can you make your candle burn longer in the jar? How?
Can you make your candle burn shorter? How?
Burn two candles in your jar at the same time. What happens? Why?
Do two candles burn out twice as fast as one?
Can you burn two candles in your jar and have one candle burn out before the other one?
What would happen if you burned three candles in your jar?
Do three candles burn out three times as fast as one?
Does a single candle burn a longer or shorter time in a smaller glass jar?
What difference does jar size make? Why?
Can you put three jars of different sizes over three different candles so that all three candles will go out at the same time?

Additional materials:

Pie tins about half filled with water, one tin per work group.
Initially, one candle in its clay holder is placed in the center of the water filled pie tin.

Questions:

Light your candle. Put a glass jar over it in the water. What happens? Why?
Use a rubber band to mark how high the water went. Can you get the water to rise that high again?
Can you get the water to rise higher?
What's the highest you can get the water to rise?
Can you get the water to rise higher than the candle?
Will two candles make the water rise higher? Faster?
What will three candles do?
Try wetting the rim of your jar and putting your jar over a candle that isn't in water.
What happens to the jar?
Why does your jar stick to the desk?
What else can you find out about candles and water, or candles and air?

For some students, the water will rise in their glass jar once their candle has burned out. For others, the glass jar may stick to the pie tin instead. In either situation, the question is always "Why?"

Students may say that the candle has burned up the oxygen, so the water has rushed in to take its place. We might even offer this explanation ourselves. But, apart from nuclear reactions, matter can neither be created nor destroyed. The oxygen may burn, but it does not burn up. It merely changes to a different gaseous state. The burning of the oxygen is not the explanation for water rising in the jar.

If we observe carefully as the jar is placed over the candle, bubbles can be seen escaping up through the water as the candle burns the air. We tell our students to observe carefully every aspect of their experiment. Perhaps with careful observation, they will see the bubbles there.

What do the bubbles mean? And what do the bubbles have to do with water rushing into the jar? Do we always have to know the answer before we ask our students to explore? Or, can we allow ourselves to wonder and to speculate as our students do?

Ice cubes...

(illustration 15-0-20)
(A collage of photos showing students engaged in a selection of the science activities described in this section.)

As materials approach freezing, they either maintain their shape, or they shrink in size. Water is the only material that expands when frozen. Imagine what our world might be like if, as it froze, water shrank. In winter time, the shrinking ice too dense to float would sink to the bottom of ponds and lakes, where the sun's warmth could not reach it in the spring. With no thawing of the ice, the ponds and lakes would eventually become frozen into solid blocks of ice, as each succeeding winter sank succeeding layers of ice.

Ice more dense than water would sink in oceans, too. The polar cap would not be a floating mass of ice—it would be a steadily growing glacier beneath the sea, not reachable by the sun's warming rays. If water froze and shrank, there would still be life on earth, but it would be an entirely different kind than what we see today. We should all be pleased that water is an exception to the freezing rule. The fact that frozen water expands and floats has made the earth quite a different place than it would have been if frozen water sank.

Materials:

Water.
Plastic portion cups.
Plastic sandwich bags.
Ice chest.
Bags of ice.
Pie tins or Tupperware containers to capture the water from the melted ice.
Thermometers.
Insulating materials.
Glasses or jars.
Rubber bands.
Salt.
Towels and sponges for cleaning up.

Materials considerations:

As we first ask our students questions about ice we provide them ice that we have prepared in advance by freezing water in plastic portion cups. As our students begin to pursue answers to a greater variety of questions, the ice we provide can come from the bags of ice cubes available at the local grocery store.

To learn about ice, our students need ice. Although ice is easily provided, it is also equally easily melted, so in class we provide receptacles, such as pie tins or Tupperware containers into which the dripping ice can melt.

Materials for each team of students available at the start:

Ice in plastic portion cups.
Plastic sandwich bags.

Questions:

We ask the first question just before our students leave school for the day. The first assignment is to be carried out at home or on the way. We give each student a plastic portion cup filled with ice that we have earlier frozen in a cup and a plastic sandwich bag in which to transport the ice.

Predict how long it will take your cube of ice to melt. What time is it now? What time do you think it will be when the ice in your portion cup has melted all the way. How much time is that?

Take your ice with you as homework tonight. When you come back to school tomorrow morning, let me know how close your prediction was to the actual time it took.

We could just as easily have handed the portion cups out at the start of the school day and measured the melting time at school. But if the ice were melted in our class, the melting time for each portion cup would be just about the same. Sending the ice home guarantees a wide variety of results.

The next day in class we ask:

How many minutes or hours did it take for your ice to melt?
Why are you all telling me so many different times?

Our students discuss with us the different factors they think might have contributed to all the different times. As they offer their suggestions, we may offer ours, as well.

Additional materials:

A bag of ice cubes.
An ice chest.
Pie tins or Tupperware containers.
A source of heat—the room heater, or hot water from a tap, or maybe even human hands.
Thermometers.
Towels for mopping up.
Whatever else our students need to carry out the experiments they devise.

Questions:

Can we get everybody's ice to melt in closer to the same amount of time?
What are the variables? What things make a difference in how quickly or slowly ice melts?
Will twice as big a piece of ice take twice as long to melt?
How can you get an ice cube to melt faster than it does in air? Keep a record of the things you try.
Is there a faster way?
What factors can you find that affect the melting rate of the ice cubes that we have in class?
Will ice melt faster in water or in air if both the water and the air are at the same temperature?
Will the ice melt faster in a larger container of water?
Does the temperature of the water affect the melting time?
Can you make the ice melt faster in cold water than in warm or hot?
What effect would crushing the ice have on its melting time?
What else can you find out?

Additional materials:

Insulating materials. Samples of the kinds of materials that might be tried:

Water	Salt water	Alcohol
Aluminum foil	Air	Sand
Paper	Shredded paper	Sawdust
Styrofoam	Pencil shavings	Rags
Cotton	Dirt	Leaves
Anything at hand		

Questions:

How long can you keep your ice cube from melting, without putting it into a refrigerator, or freezer, or cooler, or taking it outside our room? Keep notes on the ways you try. If you find a way that slows your cube's melting time, your notes must be clear enough to let others in our class replicate what you have done.
What else can you find out?

Additional materials:

Things to put upon the ice, like paper clips or coins or bits of rock. The things used may be any item that our students choose to try that will not be harmed by the experience.

Questions:

What happens when you put objects on the top of an ice cube?
Why do some objects sink into the ice and some remain on top?
What attributes do the sinking objects have that the non-sinking objects do not?
Will a pile of two or three or four washers placed on top of an ice cube sink farther in than the just one of the same sized washer?
What else can you find out?

Additional materials:

Glasses or jars for floating cubes.
Rubber bands for marking water level on the glass or jar.
Salt.

Questions:

Why does ice float in water?
What happens to the water level as you add the ice?
What happens to the water level as the ice melts?
Will the ice float higher or lower in salt water than in regular?

Starting at the start again. We give each student a plastic portion cup filled with ice that we have earlier frozen in the cup and a plastic sandwich bag in which to transport the ice.

Predict how long it will take your cube of ice to melt. What time is it now? What time do you think it will be when the ice in your portion cup has melted all the way. How much time is that?
What things might all of you do this time so that the melting times you all get for your portion cups filled with ice are closer to each other's times than they were when you first took your ice home?

Shadows...

(illustration 15-0-21)
(A collage of photos showing students engaged in a selection of the science activities described in this section.)

The study of shadows was first discussed in the ratio section of the fractions chapter (page 264). Studying shadows offers another opportunity to connect mathematics to science and science to mathematics. We can start the exploration of shadows in math and continue it in science, or we can start the explorations in science and draw upon the experiences in math.

Materials:

Source(s) of light.
Objects of various kinds.
Chalk.
Timing devise.

Materials considerations:

There are no special materials necessary for exploring shadows made by the sun, we just go outside when the sun is shining. If we find it more convenient to study shadows inside our room, then we provide the light source(s). Clear light bulbs, filmless film strip projectors, or even flash lights make good indoor shadows for our students to study.

Materials for each team of students available at the start:

Source of light.
Our students themselves.
Chalk.

Questions:

What kinds of shadows do you make?
What is the biggest shadow you can make with yourself?
The smallest?
The widest?
The narrowest?
Can you get your shadow to do what you want it to?
Can you stand on your shadow's head?
Can you not touch your shadow at all?
Can you make your shadow get in front of you? Behind you?
Touch shadows with someone else.
Can your shadow's hand shake someone else's shadow's hand without your own hands touching?
Make a mark on the ground with chalk. Can you touch the mark with the shadow of your finger without having your finger touch the mark? How about with your foot? Your nose?
Can you circle your mark on the ground with the shadow from both your hands?

Trace around the shadow of your hand with chalk. Does your shadow get bigger or smaller or stay the same as you raise your hand while keeping your shadow in the same place?
Does the size of your hand's shadow act differently in sunlight than it does inside our room?
Is your shadow just on the ground or is it also between you and the ground?
What shadow puppets can you make upon the wall?
How do you think you play shadow tag?
What else can you discover about the shadow that your body makes?

Additional materials:

Assorted objects.
Timing devise.

Questions:

What kinds of shadows do different objects make?
Take one object like, say, a book. What is the biggest shadow you can have it make?
The smallest?
The flattest?
What is the biggest shadow you can make with any object that you can hold?
The roundest?
The flattest?
The smallest?
Are there objects that always make the same kind of shadow regardless of how they are held?
Watch the shadow of a bouncing ball. Does the shadow's size change as the ball goes higher?
Find a shadow outside our classroom for a tree or the roof of a building. Mark the end of the shadow. Look at your mark in five minutes. Has the shadow moved? Which way? How far?
Will the shadow ever come back to your first mark?
Will this shadow be at the same place at the same time tomorrow?
If you mark the shadow every five minutes, could you use your marks to tell where the shadow would be five minutes in the future? Ten minutes? Fifteen?
Do all shadows for standing things move at the same speed?
Why do objects that are standing still have shadows that move?
What objects do not have shadows?
Do clouds have shadows?
Does air?
Does a bubble?
Does a window?
Does the moon have a shadow?
Does the sun?
What happens to shadows at night?
What makes some shadows dark and some shadows light?
What else can we find out about shadows?

Friction, force and motion...

(illustration 15-0-22)
(A collage of photos showing students engaged in a selection of the science activities described in this section.)

Formulas for friction, force and motion are taught in physics. We do not have to teach our students formulas to give them experiences that they will find useful when they study physics in some later year. All we have to do is give them blocks of wood and small carts and ask them to observe.

Materials:

Blocks of wood the same size.
Boards down which to slide the blocks—12" by 24" masonite works well.
Masking tape.
Felt pads, wax paper, aluminum foil, rubber bands, flat headed thumbtacks, and so on—for adding to the blocks of wood as sliding surfaces.
Yard or meter sticks.
Protractors.
Small carts—any cart-like devise with wheels on it, that can carry weights, and that will roll down a board. Carts might be small toy dump trucks or Lego block creations, or flat pieces of wood with wheels attached.

- Weights to be added to the carts—any object of uniform size available in quantity, like washers or nails or Power Block S-1 squares.
- Devices for measuring time.
- Tape measures.

Materials considerations:

The purpose of our lessons is to introduce our students to the study of friction, force and motion. The materials we provide need not be elaborate. The motion we examine can be produced by sliding anything down a board or ramp.

The initial motion our students study is created by placing their block of wood on their board, lifting the board until the block slides, and then measuring the amount of lift necessary to produce the slide. The measurements can be the height to which the board is raised or the angle of the board's incline.

Questions:

- What is the slipperiest surface in the world?
- What is the least slippery?
- What makes these surfaces slippery or not?

Materials for each team of students available at the start:

- A block of wood for each student team.
- Boards down which to slide the blocks.
- Yard sticks, or meter sticks, or protractors.

Questions:

- How high do you need to raise your board to get your block to slide?
- Does it matter if you raise your board slowly or quickly?

Additional materials:

- Additional blocks of wood the same size as the blocks already in use.
- Masking tape.

Questions:

- If you tape two blocks together, so that you now have a block twice as big, will you have to raise your board more or less to get the larger block to slide? Or, will the height you need to raise the board not change at all?
- Does it make any difference if you tape the blocks side by side or one atop the other?

(illustration 15-0-23)
(Show two blocks taped side by side (twice the surface area) and two blocks taped one atop the other (same sliding surface area). Note that it is important not to let the tape be placed on the sliding surface.)

- What happens if you tape more blocks together?
- Which do you think has a greater effect on your block's ability to slide down your board, weight or surface area?

Additional materials:

- Felt pads.
- Wax paper.
- Aluminum foil.
- Rubber bands.
- Flat headed thumb tacks.
- And so on.

We now ask our students to add different materials to the sliding surface of their original single block.

- What effect will wrapping rubber bands around your block have on its sliding ability? Will the block now begin sliding at a lower height? Will you have to raise your board higher before your block will slide? Or will the block start sliding at the same height as it did before?

What effect would adding felt pads to the sliding surface of your block have on the height at which the block begins its journey down your board?
What is the sliding effect of wrapping aluminum foil around your block?
What happens if you wrap your block in wax paper?
Will thumb tacks pushed into the sliding surface of your block speed its slide or slow it down?
What other changes to the sliding surface might we try?
Why do some surfaces slide faster down the board than others? What makes a surface fast? What makes a surface slow?

Additional materials:

Small carts—anything with wheels on that will roll down a board.
Protractors—to measure the angle of incline.
Timer of some kind and/or yard sticks and/or tape measures.

The motion studied by our students now is the motion of a rolling cart. Wheelless blocks slide off the board and stop. Carts roll off the board and keep on rolling until they stop. The measure made for the wheelless block is the height of the board or the angle of the board's incline as the block begins its slide. The measure of the rolling cart is the speed of its roll, or the distance the cart travels before it comes to rest, or both.

Will your cart slide down the board sooner than your block did?
Will your cart slide sooner than any of the surfaces you added caused your block to slide?
Why does adding wheels cause the sliding to speed up?
How fast will your cart roll down the board when the board is at a 10° incline?
Shall we measure speed from when the cart begins to roll until the cart is off the board? Or, shall we give ourselves longer to mark the time, by measuring time from when the cart first begins to roll until the cart reaches a finish line we draw a foot or two or three from the board?
Will the cart roll at the same speed or a faster one if the incline is raised to 20°?
How much faster is the roll at 20° than it was at 10°?
What will the speed of the roll be at 30°? 40°? 50°?

If our students cannot measure angles with their protractors, we can change the degrees to inches high.

How fast will your cart roll down the board when the top of the board is a 10 inches off the floor?
Will the cart roll at the same speed or a faster one if the incline is raised to 15 inches?
How much faster is the roll at 15 inches than it was at 10 inches?
What will the speed of the roll be at 20 inches? 25 inches? 30 inches?

If we choose, we can ask our students to measure the distance the cart rolls before it stops instead of measuring time. Or, we can measure both time and distance at each height and see if there is a correlation between the two.

How far will your cart roll after it leaves the board when the top of the board is 10 inches high?
Will the cart roll the same distance or a farther one if the incline is raised to 15 inches?
How much farther is the roll at 15 inches than it was at 10 inches?
What will the distance of the roll be at 20 inches? 25 inches? 30 inches?
Is there any correlation between the distance that your cart rolls and its speed?

Additional materials:

Weights to put on or in the carts.

Questions:

If you add weights to your cart, will it roll faster or slower down your board?
Will it roll farther?
If there is a change in speed or distance with added weight, how is it affected by the height or angle of the board?
Can you predict the change in speed or distance for each new weight you add?
What else do you think you can find out?

Questions we can ask our students to think about in class and think about at home:

Will you slide down a hill faster in a cardboard box or in a wagon?

Assuming you just roll and do not push, would a wagon get you down the same hill faster than a skateboard would?
Would the wagon or the skateboard be faster or slower if you were in it or on it or if it just went down by itself?
If you do not push with your foot or take a running start, what could you do to make your skateboard go faster down the hill? (If you expect to find the answer to this question after school, make sure that you have your helmet on and that your ride does not end up with you in front of a passing car.)
Assuming you just roll and do not push, is a skate board faster or slower than roller blades for getting down the hill?
What might you do to make the roller blades speed up while going down a hill?
Would a wagon be as fast a way to slide across the ice as using ice skates?
Which is a faster way to get down a snowy hill, using a snowboard or using skis?
Which is faster to slide down, a playground slide or a water slide? Why do you think so?
Which of these questions have answers that relate to the blocks and carts we have been studying?

And for ourselves, we ask:

Who is Galileo?
What uses did he make of simple observations that changed our scientific world?

Summary

Wondering…

We present questions to our students in science to encourage them to wonder why things happen, and then we help our students create experiments that they can use to find answers to the questions that their wonderings produce. The fifteen areas of exploration described in this chapter are examples of topics we might use as catalysts for wondering. We can also use the wonderings our students bring with them to school as a source of topics to investigate.

What do our students want to know about that we can make a part of the science that we teach? If we want to know, we ask:

What do you wonder about?
What can we do to find answers to your wonderings?
What materials do we need to help you know?

Teachers with a passion for a subject often pass their passion on to the students in their care. We can also encourage our students pass their passions on to us.