Fun Ways Scientists Use Math

Ages 8-13

By Susan Kilbride

Also by Susan Kilbride

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Fun Ways Scientists Use Math for Ages 8-13

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Funtastic Unit Studies
USA

http://funtasticunitstudies.com/

Fun Ways Scientists Use Math

Materials Needed for This Unit

Paper and a copier
A stick to use as a fishing pole
String
Magnet
Scissors
Snow (if you don't have any outside, you will need a good blender or snow cone maker and a large cake pan)
A large cooking pot
A ruler that measures centimeters (cm)
Two liquid measuring cups
A calculator
Graph paper
A tape measure
A stick or yardstick
Two jars about 1 pint each that are exactly the same (pint-sized canning jars are perfect for this)
A wide bowl
A tall pot with handles that will fit into the bowl above
Marbles (other items can be substituted for these)
A four-cup measuring cup
A stick of butter
A kitchen scale
Pencil
Paper
100 or more paperclips

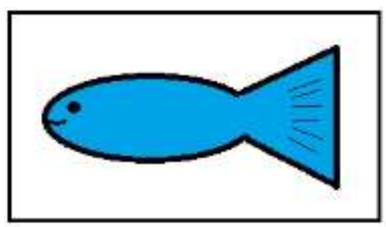
Part 1: Using Math to Estimate Population Size

The purpose of this unit is to show students various ways that math is used by scientists. The point is not to try to teach them math concepts, but to show them in a fun way that math is something that scientists use all of the time.

Activity:
For this activity, you will need: paper and a copier, a pencil, a stick to use as a fishing pole, a magnet, and 100 or more paper clips.

Tell your student(s) that one of the way scientists use math is to estimate the size of a closed population. A closed population is one where the members of the population do not immigrate into the population or emigrate out of it. A perfect example of a closed population is a fish pond where the only changes in the fish population in the pond are due to birth and death of the fish.

Before starting this activity, you will need to cut out some simple fish shapes. On the page following this activity is a pattern that you can copy to make the fish. Copy and cut out as many as you like, but there should be at least 100 of them. If you like, you can just cut the pattern into rectangles with one fish in each rectangle:



Do not tell your student(s) ahead of time how many fish there are. Once you cut out the fish, attach paper clips to their mouths.

When the fish are ready, you will need a stick of some sort to use as a fishing pole. Tie a string with a magnet on one end of it to the pole:

Once you have all of the above items prepared, put up some type of barrier so that your student(s) can't see over it. Scatter the fish behind the barrier. Tell your student(s) that you are going to pretend to be biologists who want to figure out how many fish are in the pond. Have them toss the fishing line with the magnet on the end over the barrier until they have caught 30 fish. Do not put any fish back into the pond until your student(s) have caught 30 of them. Once they have 30 fish, mark them in some way and *then toss them back into the "pond." One way fish are marked in real life is to clip off a tiny piece of their tail fin. You can mark your fish this way if you like.*

From this point on, you will <u>not</u> be marking any fish that you catch. Mix the fish around so that the marked and unmarked fish are randomly spread out. Then have your student(s) catch at least 15 more fish. ***Do not put any of the fish back in the pond until they have caught all 15 of them.*** *Count how many of the 15 fish your student(s) caught were marked. Record the results in a table like the one below. In this table, we are saying that 5 of the 15 fish were marked.*

Test Number	Total Fish Caught	Total Marked Fish Caught	Population Estimate
1	15	5	
2			
3			
4			
5			
6			
7			
8			
9			
10			

Once you have completed Test 1, plug your numbers into the following equation:

$$\text{Population Estimate} = \frac{(\text{Total Number of Fish Caught}) \times (\text{Total Number of Fish Originally Marked})}{(\text{Total Number of Fish Caught with the Mark})}$$

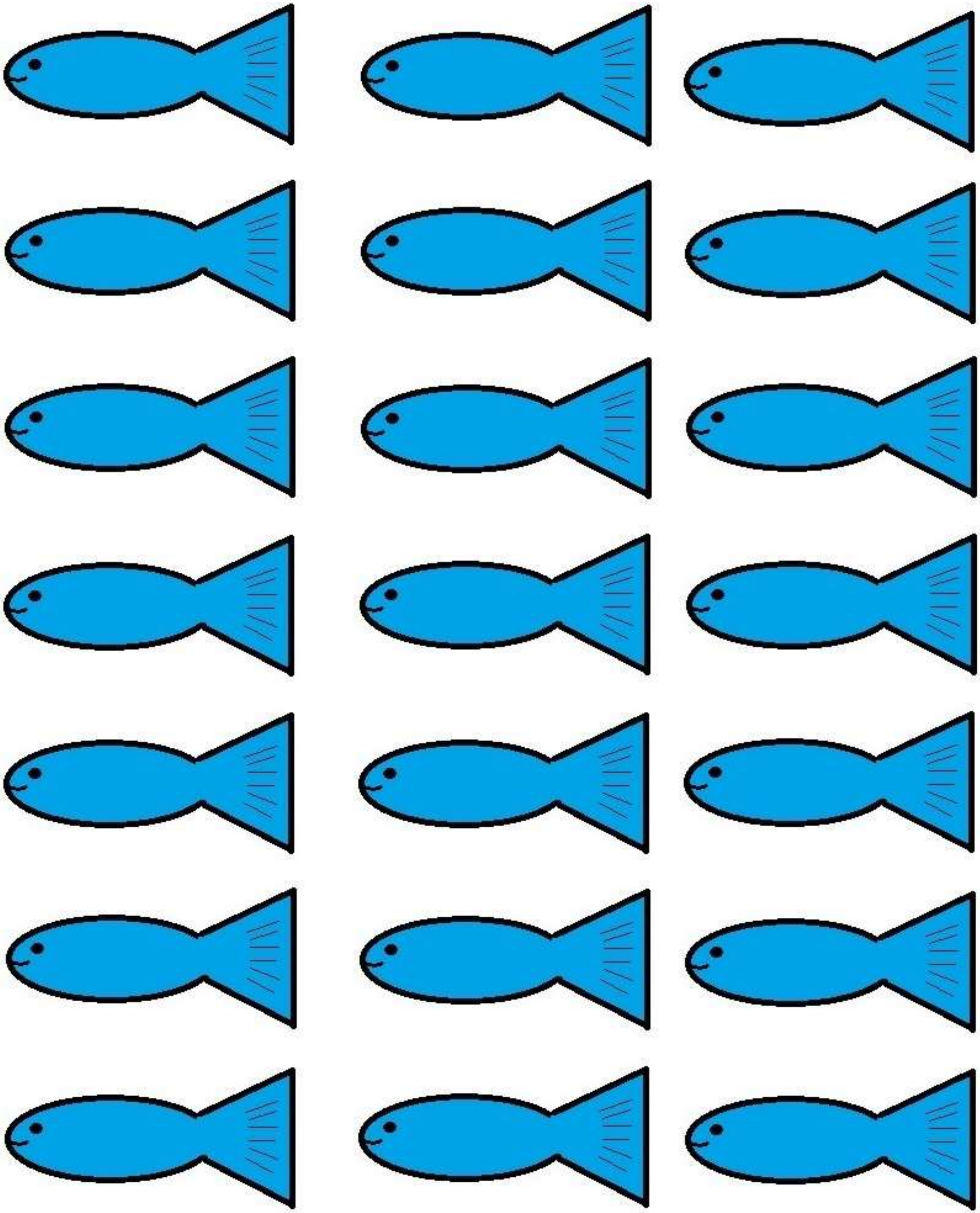
The total number of fish originally marked is 30, since that is how many you marked from the first capture. In the example above, the equation would look like this:

$$\text{Population Estimate} = \frac{(15) \times (30)}{5}$$

The answer to the equation above is 90. This number should go in the Population Estimate column in the table.

At this point, don't tell your student(s) how many fish you started with. Instead, toss all of the fish back into the pond, spread them out randomly, and have them do nine more tests. Tell your student(s) that the more total fish they catch for each test, the more accurate their results will be. Once they have done all the tests and calculated the population estimates for each test, add the 10 population estimates you calculated together and divide the answer by 10 to find the average population estimate.

Now tell your student(s) how many fish they started with and compare it with the average you calculated. Look at the table and see which of the tests were the closest to the real answer. In general, the more tests you do and the larger numbers you use, the more accurate your results will be. This is true for all scientific testing.



Part 2: Using Math to Estimate Flood Danger

Activity:
For this activity, you will need: a measuring cup, snow, and two pots to melt the snow in. If you don't have any snow, you can make some by grinding up ice in a good blender or snow cone maker.

Tell your student(s) that every spring meteorologists need to be able to warn people about possible flood dangers from snow that will melt and run into lakes and rivers. They estimate this danger by finding something called the "Snow-Water Equivalent" or SWE. This is a fancy way of saying the amount of water snow makes when it melts. This number will vary depending on how tightly packed the snow is. Snow that is tightly packed will melt into more water than snow that is loosely packed. If you live in a place that has snow, you can test this by melting two cups of snow that are tightly packed and two cups of snow that are loosely packed and comparing how much water they each make. If you don't have any snow handy, you can make snow by grinding up ice in a good blender or snow cone maker. Don't heat the snow on a stove, just let it melt naturally. You should get more water from the snow that was tightly packed. We say that snow that is tightly packed is denser than snow that is loosely packed. Density is a scientific term that basically is a measurement of how tightly packed something is.

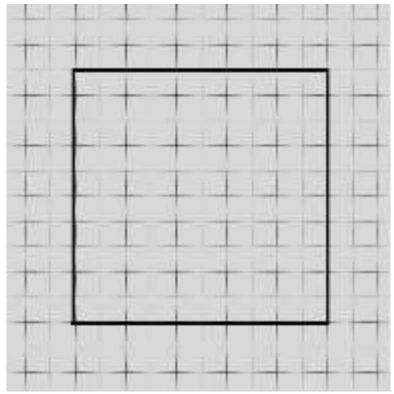
Activity:
For this activity, you will need: a large cooking pot, a ruler that measures centimeters, paper, a pencil, and graph paper. If you don't have snow outside, you will need a cake pan, ice, and a good blender or snow cone maker.

If you live in a place that has snow, you can estimate the SWE of the snow in your yard. If you don't have any snow, you can make some as you did in the activity above and put it in a large cake pan. Pretend that the cake pan is outside in your yard and take the measurements below.

First, take a large cooking pot, a ruler that measures centimeters (cm), paper, and a pencil outside. Then, find a flat area of snow and draw a square in the snow that is ten centimeters on each side. Measure the depth of the snow in the middle of the square and record it on the paper. Next, dig out all of the snow inside the square and put it into the cooking pot. Take it inside and melt the snow by letting it sit inside (don't heat it or you'll lose too much to evaporation). Once it's done melting, measure how much water it converts into. If you can measure this in cm^3, that would be more scientific, but you can also just use a regular liquid measuring cup.

For a more accurate measurement, you should do this a few times and find the average water volume and average snow depth. However, this may not be practical and your student(s) might start losing interest. You could just point out to them that taking more samples and finding the average would give you a more accurate result.

While you are waiting for the liquid to melt, give your student(s) a piece of graph paper and have them pretend that each little square on the paper is 1 centimeter long. Have them draw a square that is 10 pretend-centimeters on each side, like the picture on the following page.



Tell them that the square they drew on the graph paper represents the square they drew in the snow that was 10 centimeters long on each side. Next, tell them that the number of centimeters inside the square equals the 10 centimeters along the top of the square times the 10 centimeters along the side of the square, or 100 cm^2 (10 cm x 10 cm = 100 cm^2). The little "2" is called an exponent and stands for the 2 cm in 10 cm x 10 cm. Now tell them they can check this by counting the little squares inside the big square they drew. Point out to them that this means that the square they drew in the snow had 100 cm^2 in it. If they have a hard time understanding this, you could take them outside and draw the graph directly onto the snow with your ruler. Tell your student(s) that when you multiply the top and side of something to find out how big it is inside, you are finding the "area" of it. So 100 cm^2 is the area of your snow square.

Once your snow has melted and you have your volume of water, you will know that for the depth you measured, you would get that many cups of water for every 100 cm^2 of snow on the surface. For example, if your snow depth is 70 cm and you got 3 cups of water when you melted the snow,[1] you will know that at a snow depth of 70 cm, for every 100 cm^2 of snow at the surface (the number of centimeters in the square you drew), you would get about 3 cups of water.

Save your results for the next activity.

Activity:
For the next activity, you will need: a calculator.

From the previous activity, you now know how many cups of water a 100 cm^2 block of snow in your yard at its current depth contains. Using a calculator, you can easily convert this measurement to the actual SWE number that a scientist would use. To do this, you first need to convert your cup measurement to cm^3 (unless you used a measuring cup or beaker that measured in ml, then you already have this number. A ml is the same as a cm^3). You do this by multiplying your number of cups by 236.588237 to find the number of cm^3. For example, if your snow block melted into 3 cups of water:

$$3\ C \times 236.588237 = 709.764711 cm^3$$

[1] I made these numbers up, so don't worry if yours don't relate to them.

This means that 3 cups equals 709.76471 cm^3. Once you have your answer, divide it by 100cm^2, which is the size of the square you measured in the snow. Using our example above this would be:

$$\frac{709.76471\ cm^3}{100\ cm^2} = 7.0976471\ cm$$

The answer, 7.0976471 cm, is the SWE (Snow-Water Equivalent) for our example. This number tells us what the depth of the water in the yard would be if the snow in the yard instantly melted and stayed in one place. This is the number that scientists use to help them calculate flood danger in the spring when the snow melts.

Part 3: Using Math to Estimate Tree Height

Activity:

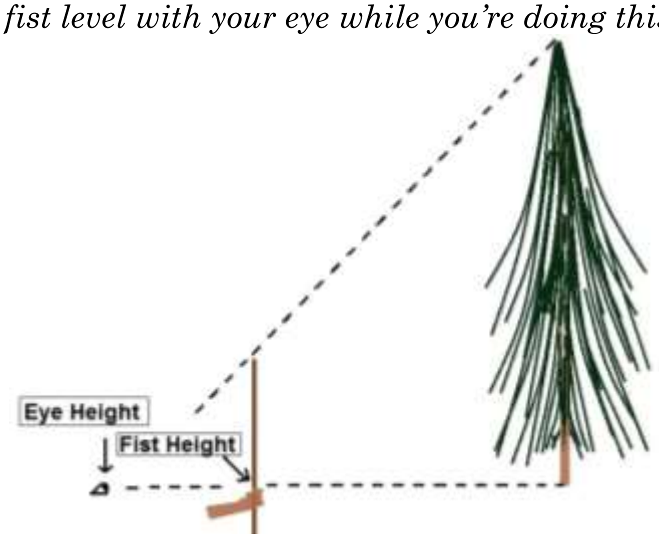
For this activity, you will need: a tape measure, a yardstick or a similar-sized stick, access to a tree that is on level ground and has its top directly over its base.

This measuring trick doesn't actually involve a lot of math, but it is based on a geometry concept. Foresters have a number of ways to measure tree heights, but this simple method only needs a tape measure, a stick, and some way of marking the stick. (And it doesn't involve climbing the tree!) It only works on trees where the very top of the tree is directly over its base, and both you and the tree are on level ground.

Take any stick or yardstick and mark on it the distance from your eye (use your cheekbone, so you don't poke your eye) to the middle of your fist when your arm is stretched straight out at eye level in front of you (with no bends in the elbow).

Now, go in front of the tree you want to measure and grasp the stick with your fist so that the mark you made on the stick is in line with the top of your fist. Extend your arm all the way out (no bends in your elbow), parallel to the ground. The stick should be straight up and down with the part of the stick that you measured ***above your fist*** *(i.e. the "1" should be on the highest part of the stick).*

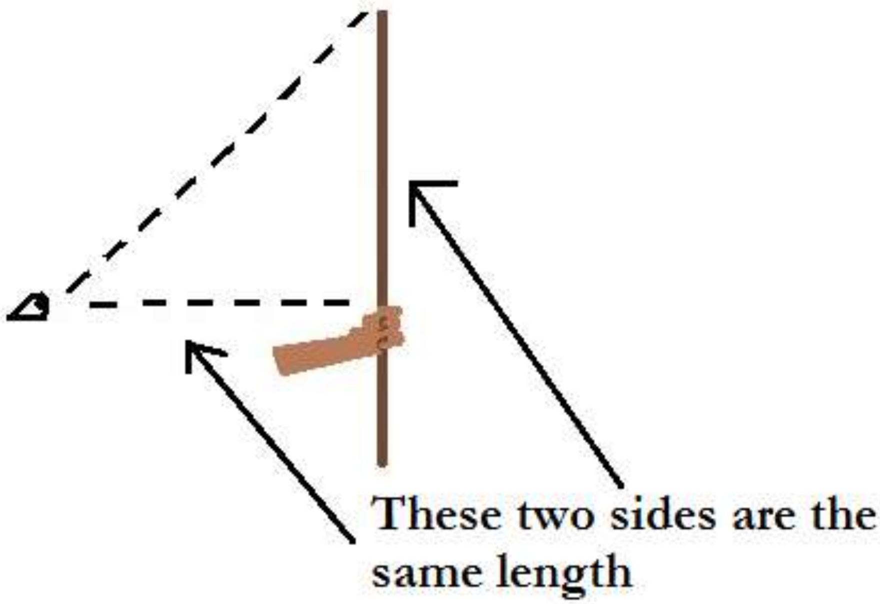
Next, keep holding the stick in front of you and, ***with your fist at eye level,*** *move either closer to the tree or farther from it until the top of the stick lines up with the very top of the tree and the top of your fist lines up with the very bottom of the tree. Don't forget to keep the top of your fist level with your eye while you're doing this.*



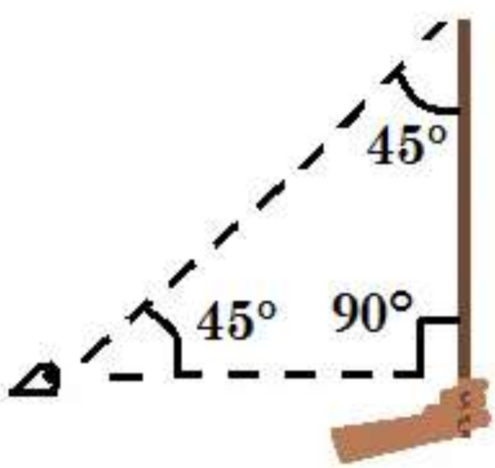
Once you have the stick in the proper place, stop there. Mark the ground straight down from your eye and then take a tape measure and measure from your mark on the ground to the base of the tree. This measurement is the tree's height.

You can show your student(s) why this works using simple geometry. If your student(s) haven't learned geometry yet, you can skip this explanation, or just tell them that the reason this works has to do with rules about triangles.

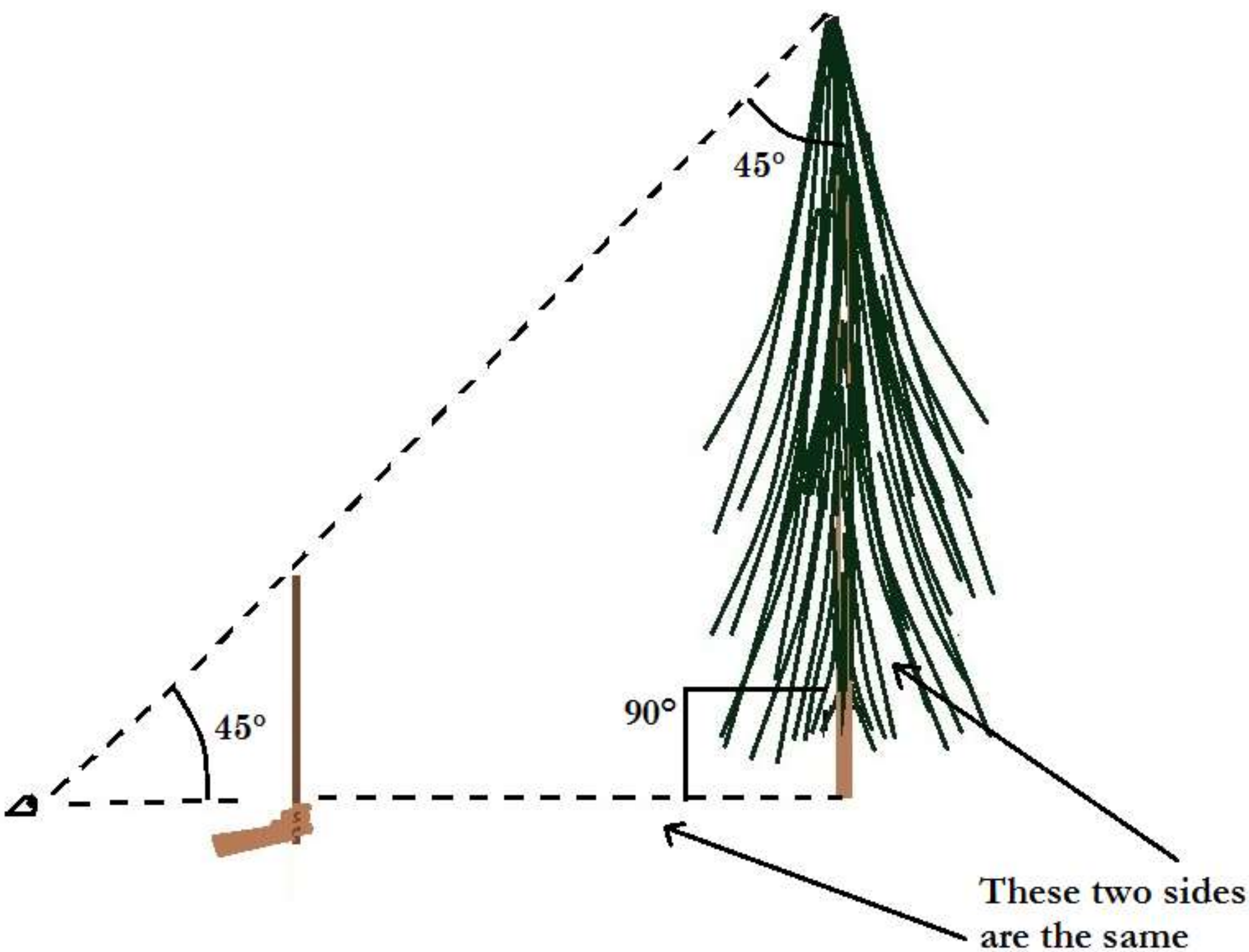
To start, look at the diagram below. Notice that the dotted lines form a triangle with the stick. Remember, the line across the bottom between the eye and the stick is the same height as the stick from the fist to the top (because you measured the stick and marked it this length).



This means that two of the sides of the triangle in the picture are the same. And since the stick is being held perpendicular to the bottom line, the angle where the stick meets the bottom line makes a right angle. If a triangle has a right angle (90°) and the two sides on either side of the right angle are equal, this means that the other two angles in the triangle are each 45°:



Next, look at the diagram below. Notice the large triangle formed by the tree and the two lines coming off of it. You now know from the previous diagram that the angle near the eye is 45°. The angle formed by the tree and the bottom line is going to be 90°, just like the angle formed by the stick and the bottom line (because they are perpendicular to each other). This means that the remaining angle also has to be 45°, because all of the angles of a triangle must add up to 180° and 45 + 45 + 90 = 180.



This large triangle is similar to the small one on the previous page. They both have one 90° angle and two 45° angles. Because of this, the larger triangle, like the smaller one, will have two equal sides—the sides on either side of the 90° angle are the same. The bottom line is the one you measured with a tape measure from your eye to the tree, and it is the same length as the height of the tree!

Part 4: Floating or Sinking?

Activity:

Tell your student(s) the following story: Way back in 287 BC, a man named Archimedes was born. He grew up to be a famous inventor and mathematician. There is a famous story about him that may or may not have actually happened. It seems that Hiero, the king of Sicily, had commissioned a crown to be made of gold. When the crown was finished, Hiero suspected that the goldsmith had taken some of the gold and replaced it with silver. But since the crown weighed exactly the same as the gold, Hiero couldn't be sure. He asked Archimedes to solve the problem.

Archimedes was thinking about the problem Hiero had given him when his bath time came around. He climbed into the full tub, and as he did, some of the water overflowed onto the ground. "Eureka!" Archimedes cried and jumped out of the tub. Some accounts say he ran through town naked to tell Hiero he'd solved the problem. This story has been told for over two thousand years!

What Archimedes realized was that the water that poured out of the tub when he climbed in took up the same amount of space or volume as he did. So if he could measure how much water the crown displaced, he would know its volume. As we'll see in a moment, knowing the crown's volume is just the first step to solving the puzzle.

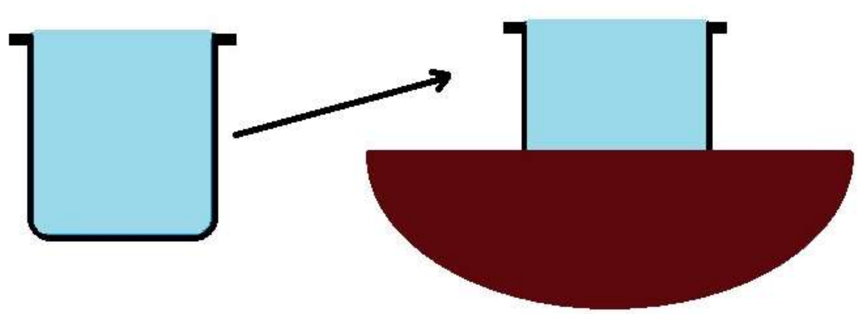
Activity:

For this activity, you will need: Two jars about 1 pint each that are exactly the same (pint-sized canning jars are perfect for this), a wide bowl, a tall pot with handles that will fit in the bowl, string, marbles, (other items can be substituted for these), a four-cup measuring cup, another cup, a pencil and paper.

Take the two jars and fill one with marbles and one with water. Screw the lids on tightly and tie pieces of string around the top of each jar so that there is a tail of string that is about a foot long hanging off each jar.

Before you start, ask your student(s) which jar do they think will displace the most water from the pot, the one with the marbles or the one with the water.

Next, take the cooking pot and fill it with water. Then, place the pot inside the bowl and, using the cup, carefully pour more water into the pot until it is so full that the water is about to spill out. (But be careful not to let any spill out yet.)



Gently pick up one of the jars and slowly lower it by the string into the pot until it touches the bottom. Be careful not to let your hands touch the water. Water will pour out of the pot into the bowl. Once the water has stopped pouring out, use the string to slowly pull the jar out of the pot, being careful not to create any waves that would cause more water to pour out of the pot. Again, make sure that your hands don't touch the water.

Next, grab the pot by its handles and carefully remove it from the bowl, making sure not to spill any water into the bowl in the process. Set it aside. The water remaining in the bowl is the water that was displaced by the jar when you lowered it into the pot. (i.e. it's the water that the jar took the place of in the pot.)

Now, carefully pour the water from the bowl into the 4-cup measuring cup. Write down how much water was in the bowl. When you take measurements, make sure that your eyes are directly in line with the water line that you are measuring. If you are above or below it, you will get a different measurement.

Once you have finished with this, follow the same procedure with the other jar. Compare your measurements. They both should be the same. There may be some slight differences due to extra drips of water here or there, but they should have pretty much the same measurement. Try putting other items in the jars and test this. However, make sure that whatever you put in the jars is heavy enough to sink the jars until they are completely covered by water, or the experiment won't work properly. Tell your student(s) what you are measuring is the <u>volume</u> of the jars, or how much space they take up in the water. It doesn't matter how much they weigh, they still take up the same amount of space in the water.

The next activity will show how Archimedes could have used this number to solve his gold crown problem.

<u>Activity</u>

For this activity, you will need a calculator, the pot from the previous experiment, a 1-cup measuring cup, a stick of butter, a ruler that measures centimeters, a kitchen scale, a pencil, and paper.

Once Archimedes knew the volume of the crown, he could figure out its density. A simple way to think of density is to think of how much "stuff" is packed into an area. For example, if you have two suitcases exactly the same size, but you pack twice as many clothes into one of them, the suitcase with more clothes is denser.[2]

The density of gold is different than the density of silver, so if Hiero's crown had the same density as gold, then the goldsmith did not cheat the king. If the crown had a different density than gold, then he did cheat the king. In the story, it turns out that the goldsmith did cheat the king.

On the following page is the equation for calculating density.

$$\textbf{Density} = \frac{\textbf{Mass}}{\textbf{Volume}}$$

[2] This explanation is taken from the author's book, *Science Unit Studies for Homeschoolers and Teachers*.

The mass in the equation is measured in grams and the volume is measured in cubic centimeters. For this application of the equation, you can use the weight in grams of an object as its mass. Once Archimedes knew the volume of the crown, all he had to do was divide it into the weight in grams to find the density.

*By now, your student(s) may be wondering what any of this has to do with the title of this section (*Floating or Sinking*). Well, it turns out that items with a density greater than water sink and items with a density less than water float. The density of water is about 1.0 g/cm*^{3}.

Tell your student(s) that you are going to test this by calculating the density of a stick of butter and then observing if it sinks or floats in your pot. Leave the paper on the stick of butter for now (to keep it from getting messy) and measure the height, width, and length of the stick in centimeters. Using your calculator, multiply these three numbers together to find the volume of the stick of butter. Next, weigh the butter on a kitchen scale. The weight will need to be in grams, but if your scale isn't metric, weigh it in ounces and multiply your answer by 28.3495 to get the weight in grams. Finally, to calculate the density of the butter, just divide the weight you found by the volume. If you did everything correctly, the density will be less than 1.0 g/cm^3*, meaning that the butter will float. Take the paper off the butter and place it in a <u>tall</u> pot of water to test this. Make sure that the water is not too warm or the butter will melt.*

Ask your student(s) why an engineer might want to know if a material could sink or float. (For ship building or other types of water-related structures).

Below are four more density problems for you to try. The answers and explanations on how to do the problems are on the following pages.

Will it Sink or Float?

A block of wood that is 10 cm long by 10 cm tall by 10 cm high (find the volume by multiplying 10x10x10 to get cm^3) and weighs 530 grams

A bowling ball that has a volume of 5452 cm^3 and weighs 8 pounds (8 pounds is the same as 3628.739 grams).

A brick of gold that is 2 cm long by 2 cm tall by 2 cm high and weighs 154.4 grams

A cup of honey that weighs 336 grams. 1 cup equals 236.588 cm^3.

Will it Sink or Float?

A block of wood that is 10 cm long by 10 cm tall by 10 cm high (find the volume by multiplying 10x10x10 to get cm^3) and weighs 530 grams

To solve this, first multiply 10 cm x 10 cm x 10 cm to get 1000 cm^3, which is the volume of the wood. Then plug the numbers into the density equation:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{Density} = \frac{530\ gm}{1000\ cm^3}$$

$$\text{Density} = 0.53\ g/cm^3$$

Since 0.53 g/cm^3 is less than the density of water (1.0 g/cm^3), then the block of wood will float.

A bowling ball that has a volume of 5452 cm^3 and weighs 8 pounds (8 pounds is the same as 3628.739 grams).

To solve this, plug the numbers into the density equation, making sure to use the weight in grams, not pounds:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{Density} = \frac{3628.739\ gm}{5452\ cm^3}$$

$$\text{Density} = 0.66557942\ g/cm^3$$

Since 0.66557942 g/cm^3 is less than the density of water (1.0 g/cm^3), then the 8-pound bowling ball will float! I bet you didn't guess that one!

A brick of gold that is 2 cm long by 2 cm tall by 2 cm high and weighs 154.4 grams

To solve this, first multiply 2 cm x 2 cm x 2cm to get 8 cm^3, which is the volume of the gold. Then plug the numbers into the density equation:

$$Density = \frac{Mass}{Volume}$$

$$Density = \frac{154.4\ gm}{8\ cm^3}$$

$$Density = 19.3\ g/cm^3$$

Since 19.3 g/cm^3 is greater than the density of water (1.0 g/cm^3), then the brick of gold will sink.

A cup of honey that weighs 336 grams. 1 cup equals 236.588 cm^3.

To solve this, just plug the numbers into the density equation:

$$Density = \frac{Mass}{Volume}$$

$$Density = \frac{336\ gm}{236.588\ cm^3}$$

$$Density = 1.420190373\ g/cm^3$$

Since 1.420190373 g/cm^3 is greater than the density of water (1.0 g/cm^3), then the cup of honey will sink.

Praise for Susan Kilbride's
Science Unit Studies for Homeschoolers and Teachers

If you are looking for quality science units, but simply don't have the time to put a unit together, Susan's book is perfect for you. If you want to supplement your existing science program, I definitely recommend taking a close look at the book. Those of you who might be a little scared of trying to put together your own science lessons for fear you might get something wrong, fear no more. . . .

Jackie from Quaint Scribbles

This collection of fun science lessons and activities are designed to offer hands on experiments that will satisfy the curious nature of children, while making it easier for parents to teach science.

Kathy Davis of HomeschoolBuzz.com

If you're looking for a science unit study homeschool program that is easy to use and is comprehensive and worth using, then you should check out Science Unit Studies for Homeschoolers and Teachers. *I recently read through the book and really liked what I saw.*

Heidi Johnson of Homeschool-how-to.com

. . . .the conversational style and logical, easy-to-follow instructions certainly make this a recommended and useful tool for any parent; especially those that may be uncomfortable or unfamiliar with teaching science.

Jeanie Frias of California Homeschooler

I think Science Unit Studies for Homeschoolers and Teachers *is a good value and provides a lot of fun, hands-on science for homeschoolers.*

Courtney Larson, *The Old Schoolhouse® Magazine*

The wealth of information included therein is amazing and the material is novice friendly. I would definitely recommend Science Unit Studies for Homeschoolers and Teachers.

Bridgette Taylor with Hearts at Home Curriculum

Susan's book is full of so many activities that one would have a very full study of general science over the course of a school year if every activity was completed. I teach a General Science class at a local homeschool co-op and I am implementing a lot of the activities in this book into my class this year. I highly recommend this book for any science teacher or student. It really makes the teaching of science quite simple and fun.

Heart of the Matter Online

We used Science Unit Studies for Homeschoolers and Teachers *at home as part of our homeschooling science lessons. My children, ages 5, 7 and 9 became excited about learning science, actually jumping up and down when it was time to start science lessons!*

Ilya Perry, mother of three with a degree in elementary education