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Looking Down - Underground Lesson Guide

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Grade Level: 8 - 12
Subject: Geometry

Students will find the volume of geometric solids, allowing them to calculate the porosity of an object.

Wonder How:

Have you ever wondered how people calculate the amount of space in an object?

Goal:

Students will calculate porosity of different geometric solids by finding the dimensions of each object and calculating the volume.

Lesson Guide Agenda:

Lesson Guide | Vocabulary

Volume – The amount of space that a substance or object occupies, or that is enclosed within a container.

Dimensions – A measurable extent of some kind, such as length, width, depth, or height.

Base – The lowest part or edge of something, especially the part on which it rests or is supported.

Width – The measurement or extent of something from side to side.

Height – The measurement from base to top.

Length – The measurement or extent of something from end to end; usually the longest side.

Reservoir - A supply or source of something. A place where fluid collects, especially in rock strata or in the body.

Lesson Guide | Vocabulary

<u>Porosity</u> – The measure of the empty space in a material. It is a fraction of the volume of space over the total volume.

$$\text{Porosity} = \frac{Volume\ of\ Space}{Total\ Volume}$$

<u>Experimental Value</u> – The value that is actually measured from an experiment.

<u>Theoretical Value</u> – The value a scientist expects from an equation, assuming perfect or near-perfect conditions.

Watch the "Looking Down Underground" video before continuing to the challenge!

Get ready for some geometric fun!

If you have any questions throughout this lesson, please email teachers@oerb.com.
We would love to hear from you!

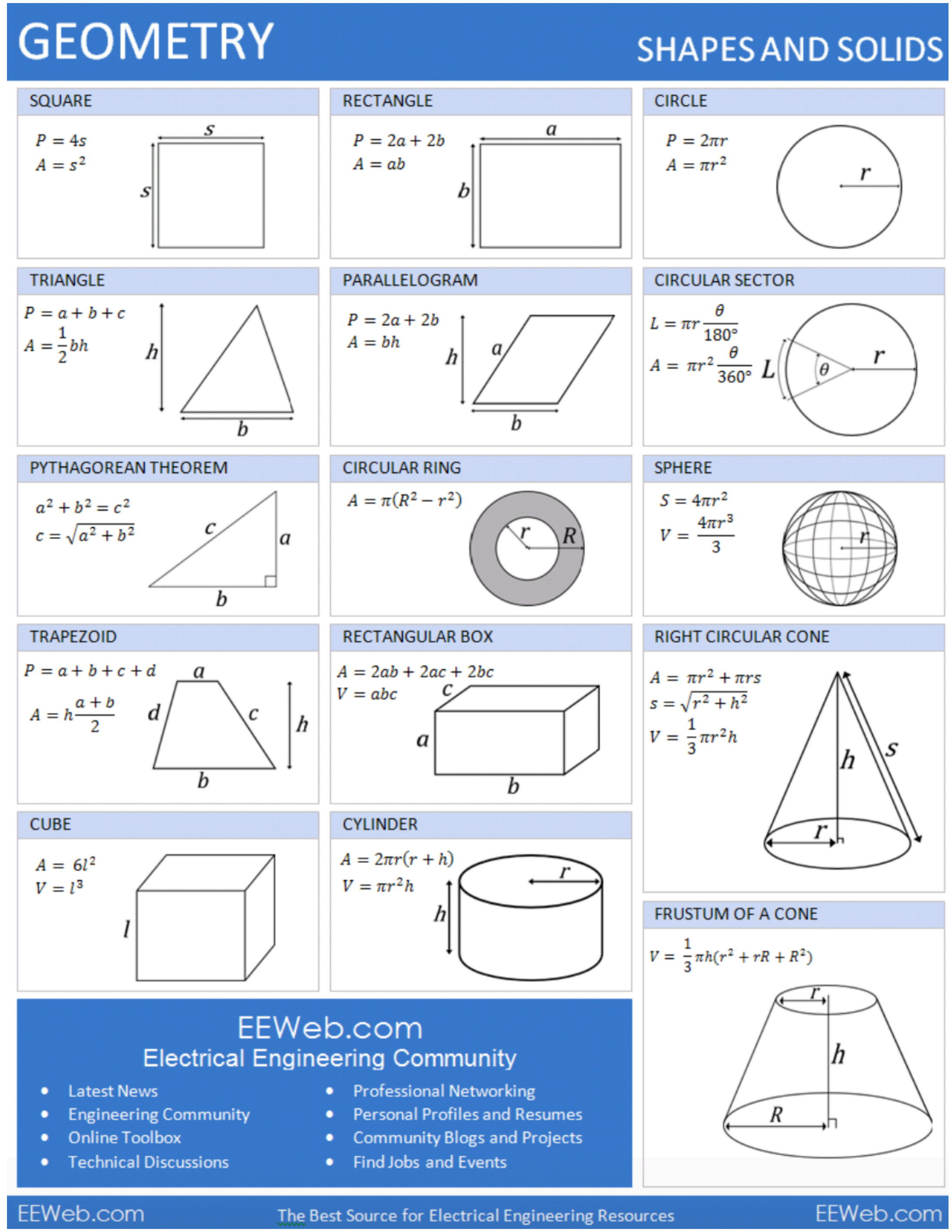
Materials Needed:

Containers from around the house
Tape measure/ruler
Pen
Paper
Calculator
Clear container
Ice cubes
Liquid measuring cup

Lesson Guide | Equation Sheet

Here are equations to find the area and volume for shapes and solids.

This will be helpful when finding the volumes of the objects.



Geometry Review

Materials Needed:

Containers from around the house
Tape measure/ruler
Pen
Paper
Calculator

Instructions:

1. Collect items from around your home that have simple geometric shapes such as: rectangles, squares, or cylinders.

2. Using the equation sheet, locate the correct volumetric equations that apply to each shape.

3. Measure the dimensions of each shape and plug this information into the appropriate equation.

Continue to the next page to see examples of different shapes

Cereal Box (Rectangle):

1. Find the base. In this case, the base is in a shape of a rectangle.

2. Measure the base length and width, as well as the height of the box.

3. Find the volume by multiplying the length of the base × the width of the base × the height of the box.

$$\boxed{\text{Volume of a rectangular box} = length \times width \times height}$$

Geometry Tip

- When measuring the diameter from a circular object, or a cylinder, trace a pencil or marker and trace the circle on a piece of paper.

- Fold the paper so that the two arcs touch and make a crease. Fold in another way so that the two arcs touch and make another crease. In Geometry, two diameters will cross at the center of the circle. Where the two creases meet is the center of the circle!

- When the center is found, measure the diameter by measuring the distance from one side of the circle to the other, going through the center.

Soup Can (cylinder):

1. In order to find the volume of the cylinder, use the Geometry tip and find the diameter of the circle. The radius is going to be half of the diameter.

2. Find the height of our soup can. Measure the height from the base to the top of the can.

3. To find the volume, multiply π × the radius squared × the height of the soup can.

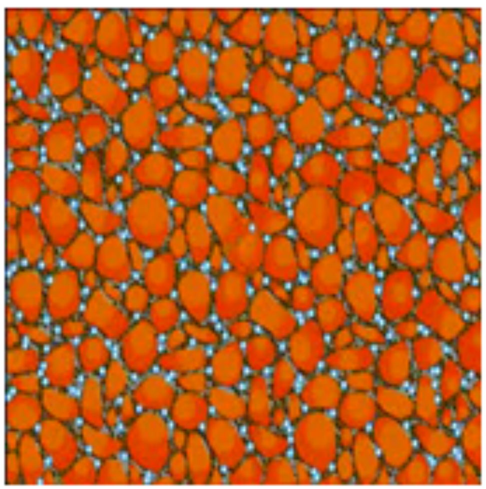
$$\boxed{\text{Volume of a cylinder} = \pi \times r^2 \times h}$$

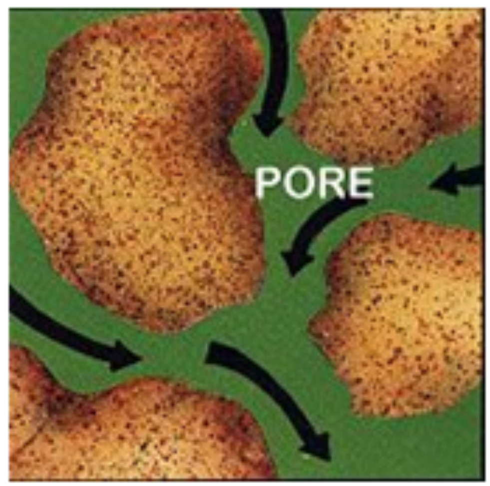
Real Life Concept

Now that you have reviewed how to find volume, apply this information to oil and natural gas.

Oil and natural gas are found in the small spaces between the grains in a sedimentary rock.

Mathematically, porosity is the pore space in a rock divided by the total rock volume.





In good reservoirs the porosity is 10-30%.

Calculating Porosity

Materials Needed:

Tape measure/ruler
Pen
Paper
Calculator
Clear container
Ice cubes
Liquid measuring cup

Now let's use Geometry to find the porosity of an experimental reservoir.

Theoretical Porosity Instructions:

1. Place 12 pieces of ice in a clear cup for the reservoir. Once the container is filled, spaces between the ice cubes will be visible. This will be the porosity!
2. Find the volume of the ice:
   a. Remove 1 cube of ice and measure the length, width, and height of the ice cube, just like the rectangular cereal box.

$$\text{Volume} = length \times width \times height$$

   b. To find the total volume of solid in the reservoir, multiply the volume above by 12 because there is 12 pieces of ice in the cup.

> Note: This works well for rectangular shaped ice. If you have moon shaped ice, you will need your parent's permission to go online and look up the volumetric equation for an ellipse. The volume of the moon shaped ice cube will be half of that.

3. Find the volume of the container:
    a. Trace the circle onto a piece of paper. If the cup is larger on one end than the other, trace the circle of the larger side. This will overestimate the volume rather than underestimate the volume.
    b. Find the center of the circle, just like the soup can.
    c. Measure the diameter through the center of the circle. The radius is half of the diameter.
    d. Measure the height of the cup.
    e. Calculate the volume by multiplying $\pi \times$ the radius squared $\times$ the height of the cup

$$\text{Volume} = \pi \times r^2 \times h$$

4. To determine the porosity of the experimental reservoir, compare the volume of the space with the volume of the container.
5. To find the total volume of space, take the volume of the container (Step 3) and subtract it by the volume of the ice cubes (Step 2):

Total Volume of Space = $Total\ Volume\ of\ the\ container\ - volume\ of\ the\ ice\ cubes$

6. Now that the total volume of space is known, find the porosity:

Porosity = $\frac{Total\ Volume\ of\ the\ Container\ - Volume\ of\ the\ Ice\ Cubes}{Total\ volume\ of\ the\ Container} \times 100$

Or

Porosity = $\frac{Total\ Volume\ of\ Space}{Total\ volume\ of\ the\ Container} \times 100$

Note: Multiple these equations by 100 to get the percent porosity.

You have just calculated the theoretical percent porosity. This is the percentage of space in the cup based on the equations used!

Experimental Porosity Instructions:

1. Set the cup of ice aside and allow it to melt completely.
2. Measure the volume of water from the melted ice cubes by carefully pouring the water into a measuring cup. Take a note of this measurement before disposing of the water.
3. To find the volume of water in a full cup, use a similar cup to the reservoir and completely fill it with water. Measure this volume by carefully pouring the water into a measuring cup.
4. To calculate the experimental porosity, take the volume of the melted ice water and divide it by the total amount of water held in the cup.

$$\text{Porosity} = \frac{Volume\ of\ Total\ Water\ in\ Cup - Volume\ of\ Melted\ Ice\ Cube\ Water}{Volume\ of\ Total\ Water\ Held\ in\ Cup} \times 100$$

You have just calculated the experimental percent porosity. This is the percentage of space in the cup based on actual measurement!

Percent Error:

Calculate the percent error between the theoretical and experimental porosities.

To do this, take the theoretical porosity minus the experimental porosity and divide that by the theoretical porosity. Multiply by 100 to get a percentage. This is the percent error!

$$\text{Percent Error} = \frac{theoretical\ porosity - experimental\ porosity}{theoretical\ porosity}$$

Wrapping Up

Reservoirs with different sized objects will have different porosities.

The reservoir with the smaller objects tend to have a smaller percent porosity because they fill up more of the space, whereas the reservoir with the larger objects have a larger percent porosity.

Challenge:

Find geometric solids around your home, measure the dimensions, and calculate the volume.

Using this skill, design and create your own reservoir and calculate the porosity.

WANT TO WIN A PRIZE?

Share a picture of your homemade reservoir and calculations with us by emailing teachers@oerb.com and on Facebook/Instagram by tagging us @oerbok.

Be sure to include your name, grade, school, and teacher!

The teacher with the most student submissions will win a $100 Amazon Gift Card!

Lesson Guide | Oklahoma Academic Standards

A1.A.1 Represent and solve mathematical and real-world problems using linear equations, absolute value equations, and systems of equations; interpret solutions in the original context.

A1.A.1.1 Use knowledge of solving equations with rational values to represent and solve mathematical and real-world problems (e.g., angle measures, geometric formulas, science, or statistics) and interpret the solutions in the original context.

G.3D.1 Solve real-world and mathematical problems involving three-dimensional figures.

G.3D.1.1 Solve real-world and mathematical problems using the surface area and volume of prisms, cylinders, pyramids, cones, spheres, and composites of these figures. Use nets, measuring devices, or formulas as appropriate.

G3D.1.2 Use ratios derived from similar three-dimensional figures to make conjectures, generalize, and to solve for unknown values such as angles, side lengths, perimeter or circumference of a face, area of a face, and volume.

G.C.1 Solve real-world and mathematical problems using the properties of circles.

G.C.1.1 Apply the properties of circles to solve problems involving circumference and areas, approximate values and in terms of π, using algebraic and logical reasoning.

G.C.1.2 Apply the properties of circles and relationships among angles, arcs, and distances in a circle amount radii, chords, secants, and tangents to solve problems using algebraic and logical reasoning.