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ACTIVITY : 1 HR 30 MINS

# Investigating Pressure

Students explore the relationship among force, area, and pressure through a variety of examples and models. They compare pressure at different elevations on Earth and create models to illustrate these differences.

**GRADES**

6 - 8

**SUBJECTS**

*Earth Science, Oceanography, Geography, Physical Geography, Mathematics, Physics*

**CONTENTS**

3 PDFs, 1 Video, 1 Link

## OVERVIEW

Students explore the relationship among force, area, and pressure through a variety of examples and models. They compare pressure at different elevations on Earth and create models to illustrate these differences.

For the complete activity with media resources, visit:
http://www.nationalgeographic.org/activity/investigating-pressure/

# Program

DEEPSEA CHALLENGE

## DIRECTIONS

**1. Activate students' prior knowledge with a game of "Would You Rather."**

Designate one wall as "A" and one wall as "B." Have students come to the center of the room. Read each of the questions on the "Would You Rather" Questions handout, and have students indicate their response by moving to the wall that matches their choices. After each question, ask a few students to explain their responses. Use the explanations for each Would You Rather question to focus students' thinking on the concepts being addressed.

**2. Discuss the relationship among force, pressure, and area using the examples from the Would You Rather game.**

Remind students of the cleat example from the previous step. Ask: *What would happen to the pressure you would feel on your foot if the person standing on your foot got heavier? Would the pressure increase or decrease? Why?* Ask students to think about a person pushing a needle into leather. Ask: *If the person were to increase the force with which he or she is pushing the needle, what would happen to the pressure of the needle on the leather?* Draw a simple graph on the board and label the y-axis "pressure" and the x-axis "force." Do not include any numbers. Ask a volunteer to draw a line on the graph illustrating what happens to pressure as force increases. (The slope of the line increases.) Ask another volunteer to draw a line illustrating what happens to pressure as force decreases. (This line will be the same as the previous line.) Remind students again of the example of an elephant on a marble from the previous step. Ask: *What would happen to the pressure of the elephant on your foot if the elephant were to balance on a hockey puck instead of on a marble?* (It would decrease.) *What if the elephant balanced on a dictionary?* (It would decrease even more.) Draw a new graph on the board and label the y-axis "pressure" and the x-axis "area." Have a volunteer draw a line on the graph to show what happens to pressure as area increases. (The slope of the line decreases.) Have another volunteer draw a line to show what happens to pressure as area decreases. (This line will be the same as the previous line.) Ask students to look at the graphs and describe the relationship between force and pressure (directly proportional) and area and pressure (inversely proportional).

**3. Introduce the formula for pressure and apply it to a Would You Rather game example.**

Write the formula for pressure on the board (pressure = force/area). Refer again to the cleat example from the Would You Rather game, this time plugging in actual numbers (a person weighing 50 kilograms (110 pounds) and wearing shoes with cleats that have a total area of 13 square centimeters (2 square inches)) into the formula. Demonstrate how to calculate the pressure. Ask: *What would happen to the pressure if the person wearing the cleats weighed* *only 41 kilograms (90 pounds)?* Write out the formula using the new weight, and calculate the pressure. Ask: *What would happen to the pressure if the 41 kilogram (90 pound) person were wearing shoes with larger cleats that have a total area of 19 square centimeters (3 square inches)?* Again write out the formula using the new numbers, and calculate the pressure.

**4. Divide students into pairs and have them create pressure-related Would You Rather questions for each other.**

Have students come up with scenarios and then manipulate one of the variables in the pressure formula to create Would You Rather questions. Ask each pair to write down at least three questions. Play Would You Rather again, this time inviting a few pairs to ask one of their questions. Collect students' questions for an informal assessment of their understanding of pressure.

**5. Have students model pressure using wooden blocks.**

Distribute a large rectangular wooden block, 10 pennies or washers, and a small container of sand or flour to each pair of students. Challenge students to use these items to model different pressures by changing just one variable (for example, laying a block in the sand on its smallest side will create a slightly deeper impression than laying it on one of its larger sides). Have students describe each trial and what changed during that trial in their science journals. After students have had a few minutes to experiment with the blocks, ask for volunteers to demonstrate their models. Ask students to identify the variable in the pressure formula that changed in each of the models. Ask them to use their models to describe the relationships among pressure, force, and area.

**6. Introduce the *DEEPSEA CHALLENGE* expedition to students.**

Explain that you will watch a brief video describing a historic manned dive to the deepest known part of the ocean. Provide students with the following focus questions:

- Who manned the submersible?
- Where did the submersible dive?
- What effect did pressure have on the submersible under water?
- What did James Cameron do once he reached the bottom of the Mariana Trench?
- Why was the dive important?

Ask students to take notes on these questions as they watch the video. Show the National Geographic News video "James Cameron Breaks Solo Dive Record." At the end of the video, discuss the focus questions. Ask students if they were surprised to hear how much the submersible shrank due to the pressure of the water. Ask: *Why was the pressure on the submersible so great in the Mariana Trench? Which variable from the pressure formula changed as the submersible went deeper? How did it change? Why?*

**7. Use a model to introduce the idea that pressure can vary greatly depending on where you are on the planet.**

Remind students that molecules in the air and water molecules have mass and therefore exert force. The force applied by the molecules over a specific area equals the pressure of the molecules on the area. Explain that air pressure and water pressure vary based on your elevation above sea level or your depth in the water; note that other variables such as volume and temperature can also influence pressure calculations. Place a marshmallow in the bottom of a test tube, and fill the test tube with cotton balls. Explain that the marshmallow represents a person, and the cotton balls represent molecules in the air. Explain that this model shows a person at sea level. Remove the marshmallow and cotton balls. Replace half of the cotton balls, then place the marshmallow on top of them and fill the test tube with additional cotton balls. Explain that this model shows a person on a mountaintop. Ask: *At which location will air pressure likely be greater?* (Air pressure will likely be greater at sea level because the air is denser there than at the top of a mountain. There are more molecules in the air, each of which has mass, pressing down on a person at sea level than on the top of a mountain.) Explain that, in general, air pressure decreases as you go up in elevation, although other factors such as temperature and humidity can also affect air pressure. Empty the test tube and place the marshmallow at the bottom again. This time, fill the test tube with marbles and explain that they represent water molecules. Ask students what they think the model represents (a person under water). Rearrange the items in the test tube so the marshmallow is close to the middle of the test tube. Ask students to explain this new model in relation to the previous one. (The person is now in water that is less deep). Ask: *In which of these two models would the person be under more pressure?* (The model showing the person in deeper water.) *Why?* (Pressure on a person increases in deeper water because there is more water and thus more mass above the person.)

**8. Have students locate Mount Everest and the Mariana Trench using a wall map or the MapMaker Interactive.**

Have students place a marker to indicate each location. Give students the elevation of each location and have them add that information to the map as well. Ask: *In which location would the pressure exerted on a person be greater? Why?* Ask students to predict how much greater the pressure would be at one location versus the other. Distribute the Comparing Pressure handout to each pair of students and ask students to compare their predictions to the actual pressure difference between Mount Everest and the Mariana Trench. Review the handout with students. Explain that the pressures listed on the handout are averages since other factors can also influence air pressure.

**9. Explain that students will use the data from the Comparing Pressure handout to create a visual model showing the general differences in pressure at different locations on Earth.** Distribute poster board, pens, beans, rulers, glue, and the Modeling Pressure handout to each pair. Review the handout with students and answer any questions they might have about the activity. Allow time for students to create their models. When students have finished, have them reference their models to write a brief explanation of why pressure is different at different places on Earth. Use the answer key provided in the Assessment section to assess students' explanations.

# Tip

In step 8, check students' progress as they finish step 5 to be sure they understand how to use the scale to measure and mark the elevation of the *Titanic* wreckage relative to the Mariana Trench before they move on to the other items on the Comparing Pressure handout.

# Tip

In step 8, note that students will need to glue beans on top of each other to fit enough in the one-inch square to represent the pressure at the *Titanic* wreckage and the bottom of the Mariana Trench.

# Informal Assessment

Observe students as they create their own Would You Rather questions and explore the block and sand models. Check that students can accurately explain the examples they come up with and how the blocks demonstrate the relationships among force, area, and pressure.

Students' explanations of their models of pressure at different elevations should include the following information:

- Pressure is force applied over a specific area.
- Pressure increases as force increases.
- Pressure decreases as area increases.
- Molecules in air and water have mass and therefore exert force.
- In general, air pressure decreases as elevation increases because there are fewer molecules above any given point (less force).
- Pressure increases as water depth increases because there are more water molecules above any given point (more force).

# Extending the Learning

Have half the class investigate how pressure affects deep-sea divers and half the class investigate how pressure affects mountain climbers. Pair students from each group and have them create Venn diagrams comparing and contrasting the pressures experienced by these two groups of people.

Conduct an additional demonstration of pressure: Using a dry syringe, remove the plunger and place a miniature marshmallow in the barrel of the syringe. Choose a second marshmallow of the same size to use as a control. Place the plunger back in the syringe barrel, and push the plunger down to force out as much air as possible without squeezing the marshmallow. Cover the open tip of the syringe with a finger. Pull the plunger back as far as possible without pulling it out of the syringe, hold it in this position, and observe. Compare the size of the marshmallow in the syringe with the control. Predict what will happen if the plunger is released. Release the plunger and observe. (As the plunger is pulled back, the volume of air inside the syringe increases; the pressure decreases; the air trapped in the marshmallow expands; and the volume of the marshmallow increases. When the plunger is released, the volume of air inside the syringe decreases; the pressure increases; the air inside the marshmallow compresses; and the volume of the marshmallow decreases.) The marshmallow might appear shrunken after the demonstration since some of the air initially trapped inside might escape when the marshmallow expands. As an alternative to using a marshmallow for this demonstration, you can also use a small water balloon inflated with a little puff of air and tied off.

## OBJECTIVES

# Subjects & Disciplines

**Earth Science**

- Oceanography

**Geography**

- Physical Geography

- Mathematics
- Physics

# Learning Objectives

Students will:

- use models to illustrate the concept of pressure

# Teaching Approach

- Learning-for-use

# Teaching Methods

- Cooperative learning
- Discussions
- Hands-on learning
- Modeling

# Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Learning and Innovation Skills
    - Communication and Collaboration
    - Critical Thinking and Problem Solving
- Critical Thinking Skills
  - Applying
  - Understanding

# National Standards, Principles, and Practices

### NATIONAL GEOGRAPHY STANDARDS

• **Standard 4**:
The physical and human characteristics of places

### NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard B-1**:
Properties and changes of properties in matter

### OCEAN LITERACY ESSENTIAL PRINCIPLES AND FUNDAMENTAL CONCEPTS

• **Principle 7a**:
The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.

### ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

• **Standard 2**:
Communication and Collaboration

**Preparation**

**What You'll Need**

### MATERIALS YOU PROVIDE

- Glue
- Black beans (or similar)
- Cleat (or photo of cleat)
- Cotton balls
- Fine point pens
- Large test tube
- Marbles

- Marshmallow
- Pennies or washers
- Poster board
- Small containers of sand or flour
- Tennis shoe (or photo of tennis shoe)
- Wall map (optional)
- Wooden blocks
- Rulers

### REQUIRED TECHNOLOGY

- Internet Access: Optional
- Tech Setup: 1 computer per classroom, Projector, Speakers

### PHYSICAL SPACE

- Classroom

### GROUPING

- Large-group instruction

## BACKGROUND & VOCABULARY

# Background Information

Pressure is force over a specific area (pressure = force/area). As force increases, pressure increases proportionally. As area increases, pressure decreases proportionally. Pressure can be measured in a variety of units including pascals (Pa), which is the standard international (SI) unit equivalent to one newton per square meter, or in pounds per square inch (psi). Pressure can be important in describing the behavior of fluids such as air or water. Though we can't see the individual molecules in air or water, they have mass and therefore exert force. Air or water pressure describes that force acting over a specific area. The pressure on an object that is under water is proportional to the weight of the water above the object. Liquid pressure also depends on the density of the liquid. However, liquids are practically incompressible, so, except for small changes produced by temperature, the density of a given liquid is almost the same at all depths. Therefore, the deeper an object goes under water, the more pressure it is under.

As a rule of thumb calculation, pressure under seawater increases at a rate of 0.445 psi per foot of depth. So an object under 10 feet (3 meters) of seawater would be under 4.45 psi of pressure. Just as water pressure is caused by the weight of water, atmospheric pressure is caused by the weight of air. However, air pressure generally decreases with elevation. The air at higher elevations is generally less dense than at sea level, and the pressure is lower since there are fewer "layers" of molecules in the air above pressing down. The lower density of the air at higher elevations also explains why mountain climbers can have trouble getting enough oxygen as they ascend higher and higher. Since there are fewer molecules of oxygen and other gases that make up air at high elevations, mountain climbers have to breathe faster to take in the oxygen they need. Other factors can influence air pressure, making it possible that the air pressure at two different locations at the same elevation, or the air pressure at the same elevation at two different times, can be different. Temperature is one of the factors that can affect air pressure. As air warms up, thermal energy is transferred to the gas molecules in the air; the molecules begin to move faster, moving farther away from each other. This can decrease the density of the air and lower the air pressure. Lower temperatures can increase the density of the molecules in the air, leading to an increase in air pressure.

# Prior Knowledge

["An understanding that density is mass per unit volume", "An understanding that weight is the force of gravity on a mass", "A basic understanding of force, including the knowledge that force = mass x acceleration (Newton's Second Law)"]

# Recommended Prior Activities

- None

# Vocabulary

| Term | Part of Speech | Definition |
|---|---|---|
| **DEEPSEA CHALLENGE** | *noun* | ongoing expedition to study the deepest point in the ocean, with a record-breaking descent to the Challenger Deep in March 2012. |
| **exert** | *verb* | to force or pressure. |
| **pressure** | *noun* | force pressed on an object by another object or condition, such as gravity. |

## For Further Exploration

### Interactives

- University of Colorado at Boulder: Interactive Simulations—Gas Properties

### Websites

- National Geographic: DEEPSEA CHALLENGE

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