NATIONAL GEOGRAPHIC

RESOURCE LIBRARY
ACTIVITY : 2 HRS 40 MINS

Under Pressure: Defining the Problem

Students will analyze the constraints and considerations associated with the problem of designing a submersible to perform a specific task. After conducting research, students will develop a solution to the problem.

GRADES

9 - 12+

SUBJECTS

Earth Science, Oceanography, Engineering, Geography, Mathematics, Physics

CONTENTS

6 Links, 1 Video, 3 PDFs, 1 Resource

OVERVIEW

Students will analyze the constraints and considerations associated with the problem of designing a submersible to perform a specific task. After conducting research, students will develop a solution to the problem.

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

Program

DEEPSEA CHALLENGE

DIRECTIONS

1. Activate students' prior knowledge by reviewing what they know about pressure.
Ask students to define pressure and to give a formula expressing pressure. Introduce or re-introduce students to James Cameron's *DEEPSEA CHALLENGE* expedition to the Mariana Trench and have students explain how pressure affected the expedition. If necessary, have students visit the provided *DEEPSEA CHALLENGE* website to become familiar with the expedition.

2. Watch a video to introduce one of the design challenges the *DEEPSEA CHALLENGE* team had to address.
Provide students with the following focus questions prior to watching "Cracking the Code": What was the big challenge James Cameron describes? Why was this challenge unexpected? What was the problem with commercially available foam? Have students take notes as they watch the video, and use the questions to launch a discussion at the end of the video. Explain that this was just one of many design challenges the team faced.

3. Distribute the Engineering Process handout and review the steps in the process with students.
Explain that students will use the engineering process to solve a design problem similar to the one James Cameron's team solved. Explain that although the engineering process has seven steps, students will only complete the first four steps in this activity. When reviewing step 1, go over constraints and considerations, and give examples of both. Constraints are absolute requirements or limitations in a design or decision-making process. If a choice or solution doesn't meet the constraints, then it must be eliminated. For example, if you are shopping for new bookshelves for your living room, there will be a size constraint. The bookshelves must be small enough to fit in the available space in your living room. Any bookshelves that are too big must be eliminated as a choice, even if they are otherwise perfect. Considerations are desired, but not necessary, elements in a design, solution, or decision. Considerations can be used to rank choices and solutions. For example, if your living room has a lot of dark wood, the tone of the wood for your bookshelves would be a consideration; you might prefer to have dark wood so that it will match the other wood in the room. However, you wouldn't necessarily eliminate a shelf just because it has lighter wood.

4. Have students redefine the problem description from the Problem Scenario: Design a Submersible handout in their own words.
Read aloud to students the problem description section of the Problem Scenario: Design a Submersible handout. Explain that in this activity students will use the first four steps in the Engineering Process handout they were given earlier to plan and design a solution to the

problem presented in the scenario. Provide students with the Design a Submersible: Design Rubric and review it to be sure students understand the expectations. Divide students into small groups and have each group define the problem in their own words per step 1 of the handout. Invite groups to share their problem definitions with the class, and then go over the problem definition provided on the Problem Scenario: Design a Submersible handout. Briefly review the concepts of constraints and considerations. Have each group list constraints and considerations for the problem. Have groups share their ideas with the class, and then provide the final list of constraints for the problem as listed on the Problem Scenario: Design a Submersible handout.

5. Have students conduct research that will help them solve the problem.
Have groups brainstorm questions they have, information they need, and keywords and topics they could use to conduct research to solve the problem. Have students record their ideas as described in step 2 of the Engineering Process handout. Tell students to consider all aspects of the problem in their research, including dive location and vehicle design. Have students use the provided websites to research basic designs for underwater submersibles and explore different materials available for constructing a submersible. To help them determine a good location for the dive, have them read the National Geographic Education encyclopedic entry about hydrothermal vent communities. Have students record detailed notes and research summaries as described on the Engineering Process handout.

6. Have students propose a solution.
Have students look at their lists of constraints and brainstorm ways to address each constraint in their designs, based on their research. If necessary, have them return to the research step to gather more information. Once students have identified ways to address each constraint, have them plan out their solutions and explain them as described in step 3 of the Engineering Process handout. Tell students that their solutions need to contain profiles of their dive locations, including a map of the location, the maximum depth of the location, the pressure they will need to withstand, the anticipated water temperature, the life forms they might see, etc. Have all students map their locations using the MapMaker Interactive and add labels to record basic information about the dive sites. Their problem solutions should also include basic design information for their vehicles and how the designs will address the constraints of the problem.

7. Have students develop a design.
Have students create detailed concept designs for their submersible vehicles based on their proposed solutions. They should draw and label their designs as described in step 4 of the

Engineering Process handout and write brief reports explaining how their designs will work to solve the problem. Remind them to address the constraints and considerations of the project in their drawings and reports and to be as specific as possible in their drawing and labeling.

8. Have students present their concepts to the class.
Review with students the peer review expectations and the concept of constructive criticism. Give each group time to present its proposed solution and concept design to the class. Allow students to ask questions and to give feedback to each group. Following the presentations, give groups time to make adjustments to their designs based on feedback.

9. Discuss the design process.
Discuss the design process with students. Ask: *What would you have done differently? What worked well? What was most challenging for you?* Note that students should keep all documentation from this activity in preparation for the next activity.

Tip

Check in with groups frequently as they are developing their proposed solutions and concept drawings. Students will need encouragement to push their solutions further and to include more detail.

Modification

During the research phase, check in with students and guide their research as needed to make sure they consider areas where there are hydrothermal vents as potential dive areas. These areas tend to have greater biodiversity than other places in the abyssopelagic zone. Students could select a known hydrothermal vent or pick an area that is likely to contain vents.

Modification

You can simplify the activity by assigning students a dive location instead of having them research to find one.

Alternative Assessment

Observe students and their notes throughout the process and provide feedback as needed to focus their designs. Use the Design a Submersible: Design Rubric to assess students' location profiles, descriptions of the problem, and concept designs and reports.

OBJECTIVES

Subjects & Disciplines

Earth Science

- Oceanography

- Engineering

Geography

- Mathematics
- Physics

Learning Objectives

Students will:

- define and analyze a problem
- identify constraints and considerations for solving a problem
- research parameters related to a problem
- design a solution to a problem using what they know about deep ocean conditions, including pressure

Teaching Approach

- Learning-for-use

Teaching Methods

- Brainstorming
- Cooperative learning
- Discussions
- Reflection

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Learning and Innovation Skills
    - Communication and Collaboration
    - Creativity and Innovation
- Critical Thinking Skills
  - Analyzing
  - Applying
  - Creating
- Geographic Skills
  - Analyzing Geographic Information

National Standards, Principles, and Practices

NATIONAL GEOGRAPHY STANDARDS

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

NATIONAL SCIENCE EDUCATION STANDARDS

• **(9-12) Standard B-2**:
Structure and properties of 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.
• **Principle 7d**:
New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

ISTE STANDARDS FOR STUDENTS (ISTE STANDARDS*S)

• **Standard 1**:

Creativity and Innovation

- **Standard 2**:

Communication and Collaboration

- **Standard 4**:

Critical Thinking, Problem Solving, and Decision Making

Preparation

What You'll Need

MATERIALS YOU PROVIDE

- Drawing paper
- Paper
- Pencils

REQUIRED TECHNOLOGY

- Internet Access: Required
- Tech Setup: 1 computer per small group, Projector, Speakers
- Plug-Ins: Flash

PHYSICAL SPACE

- Classroom

GROUPING

- Large-group instruction

OTHER NOTES

Familiarize yourself with the tips and the problem constraints listed on the Problem Scenario: Design a Submersible to help you guide students during the research phase.

BACKGROUND & VOCABULARY

Background Information

Today, Earth's ocean remains largely unexplored, although new technologies and innovations are increasing our ability to study the ocean depths. James Cameron's record-setting 2012 solo dive to the bottom of the Mariana Trench is one example of how these advances increase our ability to explore. Cameron and his team engineered the submersible *DEEPSEA CHALLENGER* specifically to explore the deepest known parts of the ocean. The only other manned vehicle to reach the bottom of the Mariana Trench was the *Trieste* in 1960. Engineers are problem-solvers. Engineering has given us many of the systems and products we rely on daily. Items such as the cars we drive to school, the computers on which we do research, and even the complex systems that bring water and electricity to our homes were all engineered. Engineers apply a wide range of science knowledge and skills, problem-solving, and mechanical expertise to design and build complex products, machines, systems, and structures. Engineering often involves complex designs that have to be broken down into smaller chunks and problem-solved. For example, the *DEEPSEA CHALLENGER* submersible is made of many parts, including the body design, the mechanics involved in moving the submersible, the communication systems, the cameras and lighting used for exploration, the safety systems, and much more. Cameron and his team had to address each of these parts of the *DEEPSEA CHALLENGER* to optimize it for its mission to explore the deepest known parts of the ocean.

There are many areas of interest in ocean exploration. One area is studying life under deep-sea conditions that are so different than the conditions on Earth's surface or even in shallower ocean zones. The lack of light, the cold, and extreme pressure make the deepest ocean zones —the abyssopelagic and hadalpelagic zones—uniquely challenging environments for life. Hydrothermal vents are mineral-rich geysers on the ocean floor that can provide energy for life. Hydrothermal vent communities in the abyssopelagic zone offer unique opportunities to study life in some of the deepest areas of the ocean.

Prior Knowledge

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Recommended Prior Activities

- Exploring Pressure

Vocabulary

Term	Part of Speech	Definition
abyssopelagic zone	*noun*	zone of the open ocean, starting at 3,962 meters (13,000 feet) below sea level.
buoyancy	*noun*	the power to float or rise in a fluid.
consideration	*noun*	a matter weighed or taken into account when formulating an opinion or plan.
constraint	*noun*	limitation or obstacle.
engineer	*noun*	person who plans the building of things, such as structures (construction engineer) or substances (chemical engineer).
hadalpelagic zone	*noun*	deepest zone of the open ocean, starting at around 6,000 meters (20,000 feet).
hydrothermal vent	*noun*	opening on the seafloor that emits hot, mineral-rich solutions.
pressure	*noun*	force pressed on an object by another object or condition, such as gravity.
submersible	*noun*	small submarine used for research and exploration.
syntactic foam	*noun*	material consisting of tiny hollow "microballoons" made from material such as glass or carbon.

For Further Exploration

Maps

- NOAA/PMEL: Global Exploration—Interactive Map of Hydrothermal Vent Sites

Video

- National Geographic: Deepsea Challenge

FUNDER

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