INDIANA UPLANDS | PROUD PARTNER

Grade 6-8 STEM Challenge

Spuds to Subs

Inspired by Matt, a Mechanical Engineer in the Indiana Uplands.

Published by Regional Opportunity Initiatives

GRADE 6-8 STEM CHALLENGE

Spuds to Subs

Inspired by Matt, a Mechanical Engineer in the Indiana Uplands.

Students will design a system to make a potato neutrally buoyant.

LESSON TIMELINE

DAY 1

- Show the inspiration video, "Matt - Mechanical Engineer" (5 minutes)
- Introduce the Engineering Design Process (10 minutes)
- Introduce the challenge (5 minutes)
- Brainstorm, Design, and Build (30 minutes)

DAY 2

- Finish submarine designs (if not done on day one)
- Test and refine designs (one 50-minute period)

DAY 3

- Final design performance evaluation (50 minutes)

Recommended Supplies

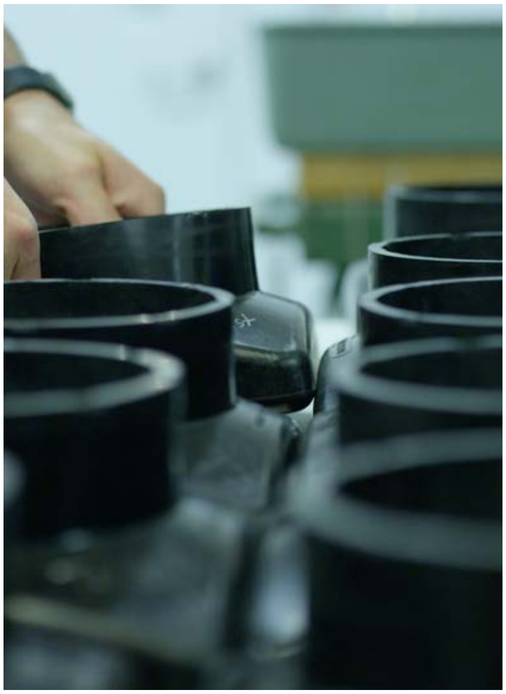
For each group of 3-4 students:

- 1 large potato
- Straw
- Ziploc bag
- Metal Washers (various sizes)
- 2 balloons
- Rubber bands
- Tub or pool of water to test designs

CAREER CONNECTION AND LESSON OVERVIEW

Engineers who work for the Navy, like Matt, are given unique challenges to solve every day. Engineers use the engineering design process as a blueprint for solving problems and devising solutions. Matt is often given complex mechanical challenges that require him to design and prototype new sensor systems and the tools to install and repair them. Matt uses 3D printing and prototyping to create and test new designs, ensuring that the final products work correctly before they are sent into the field.

Like real engineers, students will be given criteria (what the design must do) and constraints (resources and limitations) when creating a design. Here, they will need to use a collection of materials to make a potato neutrally buoyant. That is, it must neither float to the top of the water nor sink to the bottom. While Matt's challenges are a lot more complex than making a potato float, he uses the same processes to create and test sensor systems before the Navy installs them on their ships.



IN THIS CHALLENGE, STUDENTS WILL:

- Design a system that will make a potato neutrally buoyant, i.e. it will neither float nor sink in water.
- Refine their designs to fit criteria and constraints.
- Communicate their designs and revisions.

Standards

Science & Engineering Process Standards

SEPS.1 Posing Questions (for science) and defining problems (for engineering)
SEPS.2 Developing and using models and tools
SEPS.4 Analyzing and interpreting data
SEPS.6 Constructing explanations (for science) and designing solutions (for engineering)
SEPS.8 Obtaining, evaluating, and communicating information

Preparing for College and Careers

PCC-2.1 Determine roles, functions, education, and training requirements of various career options within one or more career clusters and pathways
PCC-2.2 Analyze career trends, options and opportunities for employment and entrepreneurial endeavors for selected career clusters and pathways
PCC-2.3 Evaluate selected careers and pathways for education requirements, working conditions, benefits, and opportunities for growth and change
PCC-2.4 Use appropriate technology and resources to research and organize information about careers

Engineering Design and Development

ETE 4.1 Apply the steps of the design process
ETE 4.2 Use the design process to create a product that addresses a real world problem
ETE 4.3 Create a technical sketch of a design with appropriate notation
ETE 4.4 Develop a product using the design process, while maintaining appropriate documentation
ETE 4.5 Develop various types of models (graphical, physical, or mathematical) that help communicate solutions to peers

Engineering

6-8.E.1 Identify the criteria and constraints of a design to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions
6-8.E.2 Evaluate competing design solutions using a systematic process to identify how well they meet the criteria and constraints of the problem
6-8.E.3 Analyze data from investigations to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success
6-8.E.4 Develop a prototype to generate data for repeated investigations and modify a proposed object, tool, or process such that an optimal design can be achieved

7th Grade Science Standards

7.PS.2 Describe the properties of solids, liquids, and gases. Develop models that predict and describe changes in particle motion, density, temperature, and state of a pure substance when thermal energy is added or removed

8th Grade Science Standards

8.PS 5 Investigate the property of density and provide evidence that properties, such as density, do not change for a pure substance

Grade 6-8 Employability Standards

6-8.M.2 Engage in feedback with peers to seek growth and learning opportunities from others
6-8.WE.4 Understand failure as an opportunity for growth
6-8.LS.1 Communicate information to audiences in a variety of formats (i.e., large and small group presentations, e-mail communication, interview setting, etc.)
6-8.LS.2 Speak to and have conversations with peers and adults to express ideas while respecting differing opinions
6-8.LS.12 Use prediction and evaluation skills to develop potential solutions

Planning and Implementation

SPUDS TO SUBS

Essential Vocabulary

- ENGINEERING DESIGN PROCESS: A series of steps that a student or engineer follows to come up with an optimal solution to a problem.
- MASS: The amount of matter in an object. How much “stuff” it is made of.
- WEIGHT: The force exerted on the mass of an object by gravity.
- GRAVITY: Attraction between two objects with mass, i.e. a marble and the Earth.
- NEUTRAL BUOYANCY: A state where an object’s overall density is the same as the water it is in. It neither sinks nor floats.
- BALLAST: Heavy material placed on a floating object to make it more stable.
- CRITERIA: The standards a design or solution must meet.
- CONSTRAINTS: The limitations on a design due to materials, time, space, etc.

In this challenge, students will:

- Design a system that will make a potato neutrally buoyant. When something has neutral buoyancy, it should float in the middle of the tank and neither rise to the surface nor sink to the bottom. The buoyancy system should completely encase the potato and keep the potato dry.

Before Class:

- Read the activity outline sheet and leader notes to become familiar with the activity.
- Gather necessary materials. Be sure that you have enough materials and space for students to work in groups of 3-4.
- Go over relevant vocabulary for students.
- Set up a testing tank for students. The testing tanks should be at least a foot deep and preferably clear (clear plastic storage bins work well.) You will most likely need more than one to ensure that students can test before their final evaluation.
- The social aspect of this activity is critical as it is a group undertaking. Be sure students understand their responsibilities within their group and divide work equitably. Giving students roles within their group can help with this.

Guiding Questions

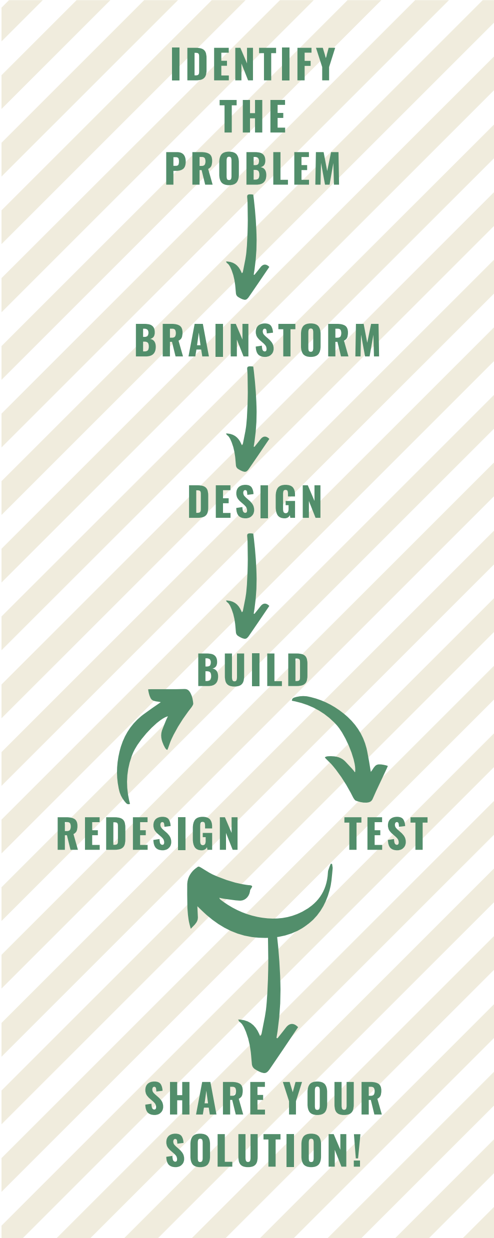
1. Why do some objects float in water while others sink?
2. What is density? How is it related to mass?
3. What determines whether an object floats or sinks in water? In air?
4. How can you affect the buoyancy of an item?
5. What could you do to an object to make it "hover" in a tank of water without sinking to the bottom or floating to the top?

Day 1

Introduction

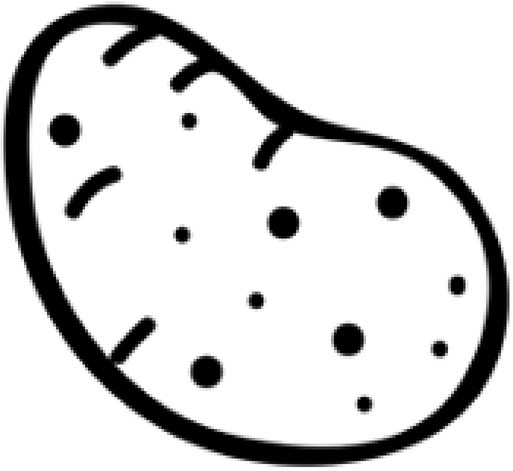
Show students Matt's career shadow video. Talk about what engineers do and outline the engineering design process. There are many versions of the EDP that include more or fewer steps but each should include some variation of:

- Identify the Problem
- Brainstorm
- Design
- Build
- Test & Evaluate
- Redesign (if needed)
- Communicate solutions



Explain to students the challenge and outline what materials they will have. Explain the criteria for successful designs (potato hovers in the middle of the tank) and constraints (it must use the materials provided and keep the potato dry.)

> *"Today you'll be designing a system that will make a potato neutrally buoyant. If something is 'neutrally buoyant,' it means that it neither sinks to the bottom nor floats to the surface of a body of water."*



Criteria:

1. Students will build a submarine hull for their potato.
2. The potato must float in the middle of the tank. It should not rise to the top nor should it sink to the bottom.

Constraints:

1. Student engineers may use only the materials provided. They do not have to use all the materials.
2. The potato must remain dry.

Submarines have to not only be able to sink in a controlled way but also resurface when needed. Submarines do this through the use of ballast tanks. These tanks contain air and water, the amounts of each allow the ship to control its depth by changing its buoyancy. To stay on the surface, the ballast tanks fill with air. Air is less dense than water so if there's enough of it in the tanks, the sub will float.

When it's time to submerge valves are opened, allowing the air to escape and sea water to enter the tank. To return to the surface, compressed air (stored in different tanks) is blown into the ballast tanks, forcing out the sea water and causing the sub to rise. Often the sub will need to stay at a constant depth while cruising. They must be able to maintain neutral buoyancy to travel efficiently and without being seen.

The engineers that design submarines have to balance all of these forces and make sure that the interior of the sub is safe for humans. When designing subs, engineers have to think about what materials are appropriate to make sure it will not only float but also be hydrodynamic, or able to move easily through the water.

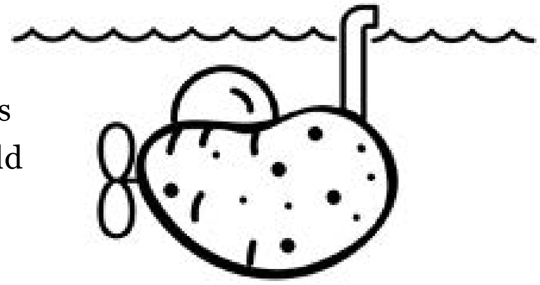
Brainstorm, Design, and Build

Share the challenge and give your student engineers time to think through and plan, both on their own and in small groups. Discuss the questions as well as the criteria and constraints of the challenge. Encourage students to think about:

- What is density? How do you tell how dense something is? How is that related to phases of matter?
- What is buoyancy? How can you affect it?
- What role do mass and weight play in this system? Are mass and weight the same thing?

Day 2: Refinement

Test, Evaluate, and Redesign



Students should be fairly self-directed once they get started building but be prepared to help your engineers trouble shoot their designs. The test pool or tank should be available to them throughout their testing time. Encourage them to plan, test, evaluate, and redesign frequently before submitting their design for a final assessment.

Day 3: Communication

Share, Discuss, and Report

Each student group should share out their initial designs as well as any revisions or modification. Ask them to describe their approach either verbally or in writing.

At the end of day 3, set aside at least 20 minutes for all groups to be able to demonstrate their final designs in the tank.

Invite students to think about the STEM connections in this activity:

- What is the relationship between mass, weight, and density?
- What does gravity have to do with buoyancy?
- What are the real-world analogs for the things you used to make your potato buoyant? What do real submarines use to float and sink?

Career Exploration and Extension

Prompt students to think about and research what a career as a mechanical engineer might entail.

- What does a mechanical engineer do all day? What does Matt do?
- What kind of training would a student need to become a mechanical engineer? What about an engineer in general? What other types of engineers are there?
- Are jobs like Matt's in high demand? Will more people be hired to be engineers in the future?
- What kind of education is needed to be an engineer? Where could a student be trained locally for a career in engineering? What types of classes are important?

Name: ____________

Spuds to Subs

Student Data Sheet

IDENTIFY THE PROBLEM What are we trying to do?
BRAINSTORM Imagine solutions to the problem above. Record your ideas in words or pictures.

Name: ______________

DESIGN
Create a blueprint of the prototype you will build. What materials will you use?

BUILD
You will have ________minutes. Use this time to build the prototype you planned.

Name: ________________

TEST AND REDESIGN

Improve the prototype that you created. How can you make it better?

SHARE AND COMMUNICATE

Share your spud sub with the class or a classmate

What was the most difficult part of this challenge?

What was your biggest success?

ACKNOWLEDGEMENTS

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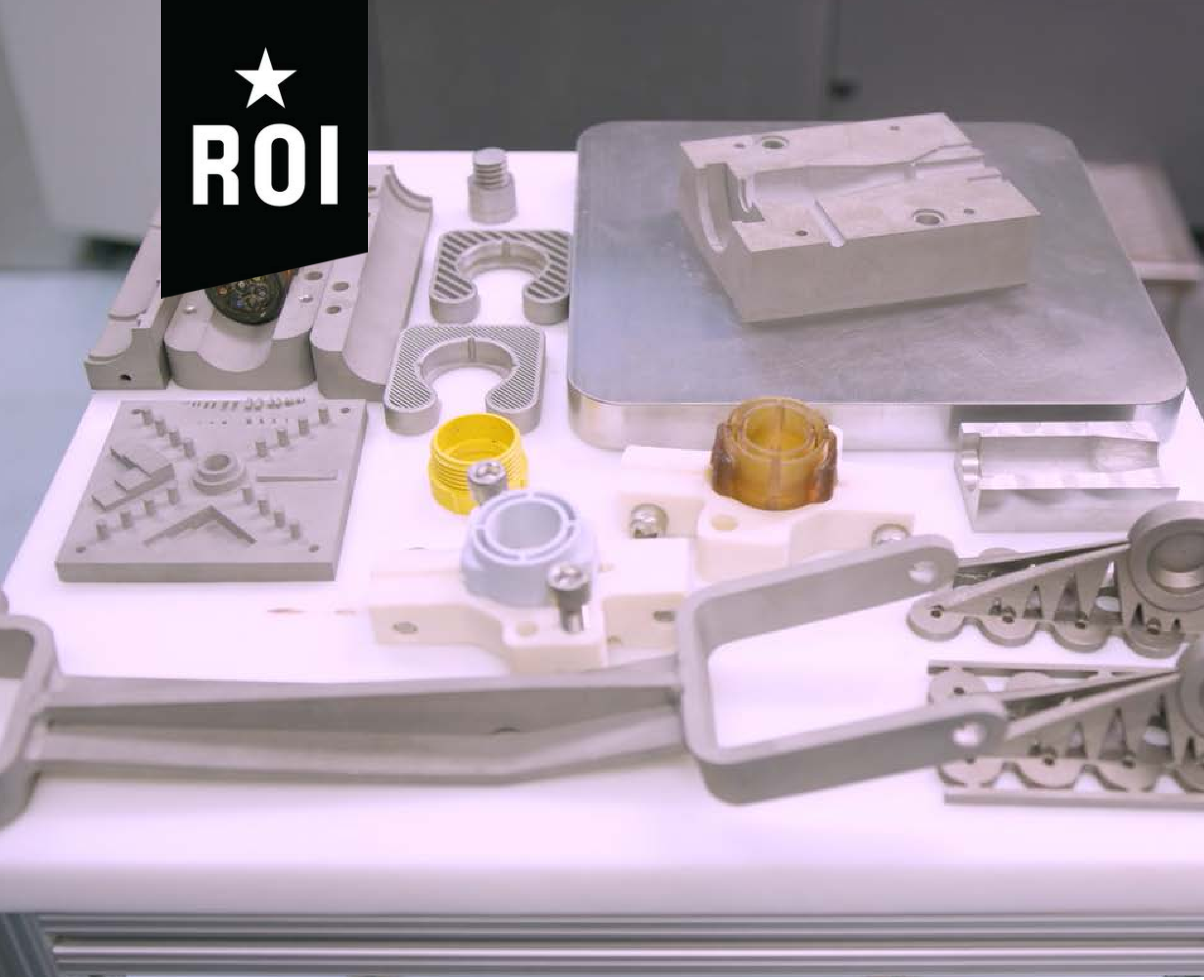
potato by montatip from the Noun Project

Submarine by Made from the Noun Project



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