#SeaworthySTEM

Seaworthy STEM™ in a Box

K-8 Lesson Plans!

Lessons for Grades K-2

Teacher and Student Lesson Books for:

- Anchors Aweigh
- DIY Hydrophone
- Making Waves
- Oh Barnacles!
- Sailor Knots
- Save a Boat
- Sponge Boat

Lessons for Grades 3-5

Teacher and Student Lesson Books for:

- Biofuel Jell-O
- Brace Against the Wind
- Break the Ice
- Glacier Gak
- Glowing Jellyfish
- Morse Telephone

Lessons for Grades 6-8

Teacher and Student Lesson Books for:

- Alka-Seltzer Lava Lamps
- Cartesian Divers
- Comparing Mass and Density
- Density Column Exploration
- Film Canister Boat Float
- Golf Ball Float

Seaworthy STEM™ in a Box Series

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Seaworthy STEM™ in a Box

Lessons for Grades K-2

Teacher and Student Lesson Books for:

- Anchors Aweigh!
- DIY Hydrophone
- Making Waves
- Oh Barnacles!
- Sailor Knots
- Save a Boat
- Sponge Boat

Seaworthy STEM™ in a Box Series

NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

#SeaworthySTEM

Anchors Aweigh!

Grades K-2

Teacher Guide

Seaworthy STEM™ in a Box Series

NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

NAVAL STEM
SCIENCE · TECHNOLOGY · ENGINEERING · MATHEMATICS

Office of Naval Research
Science & Technology

Anchors Aweigh!

Teacher Guide for K-2

Seaworthy STEM™ in a Box Educator Kit description:

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NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

Table of Contents

Lesson Title: Anchors Aweigh!

Time:
45 minutes

Student Objectives:

Students will learn how water vessels are able to remain stationary while on a body of water. Students will explore how anchors function and their importance to ships out on the ocean. Students will experiment with various shapes as well as the amount of weight to determine the effectiveness of different types of anchors.

Lesson Overview:

Students will work in teams to create an anchor for the given toy boat. Students will use iterative design as well as teamwork to create an anchor using a paperclip and different color beads. Students will have to experiment and collect data on the amount of beads needed to park the boat. The goal is for students to discover how many beads does it take to anchor the toy boat in water.

Next Gen Science Standards (NGSS):

K-2-ETS1-1

K-2-ETS1-2

K-2-ETS1-3

Notes

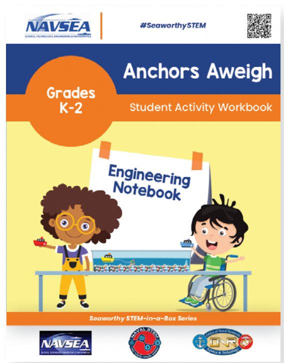
Materials and Equipment List (per group):

Note: Some materials can be shared by the whole class

- ☑ Water
- ☑ Foil pan
- ☑ Toy boat
- ☑ String (2-4 inches) per boat
- ☑ Jumbo butterfly size paperclips
- ☑ Putty
- ☑ Different color beads
- ☑ Marbles
- ☑ Portable 3 speed fan

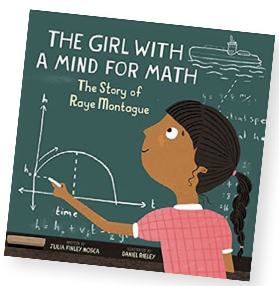
Student Activity Sheets/Handouts:

Anchor's Aweigh Student Activity Workbook



Suggested STEM Related Literacy Book:

The Girl with a Mind for Math
by Julia Finley Mosca



Pre-Activity Setup:

1. Place marbles in the foil pan. The marbles should cover the bottom of the foil pan. The marbles will act as the seabed. Place the fan by the end of the foil pan.

2. Fill the foil pan with water. The pan should be half full with water.

Important!
The amount of water is crucial for the anchor to touch the bottom of the pan.

Procedure:

1. The teacher will give a brief introduction of the importance of an anchor. Students will learn about the crucial role of the anchor's design and weight. The teacher can use the guided introduction questions in the side panel to open a whole class discussion.

2. The teacher will pair students into teams and hand-out materials.

3. Each group will receive 1 toy boat, 1 piece of string, 1 paperclip, variety of beads, and a piece of putty.

4. The teacher will model the activity for students and give students the challenge goal for the activity. The teacher will model the following set up of the design:

    - Attached a piece of string to the toy boat, tie a knot to secure the string.
    - Attached a paperclip to the other end of the string, tie a knot to secure the paperclip.

The teacher can ask these guided questions:

"How does a boat "park" in the water?"

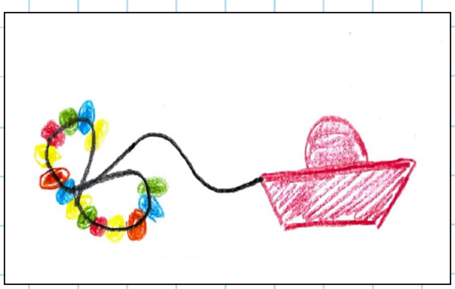
"Why would sailors and crew members need to stop in the water?"

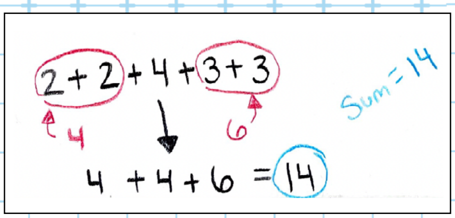
"Do you think an anchor is heavy? (Why or why not?)"

- Experiment on the amount and size of beads needed on the paperclip.
- Place a piece of putty at the end of the paperclip to prevent beads falling off the paperclip.
- Place boat in the water and turn on the fan. Observe if the boat stays parked in the water.
- If the boat is still moving, repeat steps 4 and 5.

5. During the activity, students will use the guided worksheet to complete their math data.
6. To conclude, the teacher can guide students in a whole group discussion. The teacher can use the following guided conclusion questions below.
    - "How many beads did it take to anchor your boat?"
    - "Did you have to use different size and color beads?"
    - "What were some challenges you had with building your anchor?"
7. The teacher will guide students into clean-up procedures. The teacher can use the reading resource as an extension to the activity.
8. **Extension:** Have the students manipulate the shape of the anchor to determine if they can park their boat using less weight (beads). If so, add a teacher conversation prompt about discussing failures/successes of specific designs (a round table share out) prior to the final drawing.

Check out these great examples of a student's observation!





Vocabulary Terms:

- Anchor: A heavy object attached to a rope or chain and used to moor a vessel to the sea bottom
- Fluke: The part of an anchor that fastens in the ground
- Rode: Is what connects your anchor to the boat
- Force: A push or pull on an object
- Resistance: An opposing or slowing force

Misconceptions/ Science information:

An anchor is a device that is attached to a ship by cable or chain. The anchor is lowered to reach the bottom of the seabed and to hold the boat in a particular place without drifting in the ocean. When the anchor is dropped in the water, the heavy mental anchor will sink to the bottom of the seabed. The reason an anchor is shaped in a "U" with two flukes is to dig into the seabed and when the boat pulls the anchor chain, also known as the rode, it digs deeper into the surface which creates resistance. To retrieve the anchor, the boat will be positioned directly over the anchor and will retrieve the anchor by pulling out the rode. When the flukes are pointing upward, there will be less resistance. This will allow less force needed to pull the anchor out of the seabed. This activity was created to give students an introduction of anchors and the job of an anchor.

STEM Related Career:

- Ship Design Engineer
- Ship Captain
- Structural Engineer

Fun Fact!

Contrary to what many people assume, it is not the ANCHOR that stops a vessel moving, but in fact the cable connecting the two. Due to it's length and weight, it forms a natural 'catenary' (curve), which acts as a 'spring' to absorb shocks.

Fun Fact!
The word anchor is Greek in origin, meaning "crooked" or "hook."

Reference Photos:

NAVSEA

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

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#SeaworthySTEM

Anchors Aweigh! Teacher Guide

Seaworthy STEM™ in a Box Series

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

#SeaworthySTEM

Anchors Aweigh

Grades K-2

Student Activity Workbook

Name: ______________________________

Date: ______________________________

Seaworthy STEM™ in a Box Series

Anchors Aweigh!

1 After building your anchor, draw the model of your anchor. Use different colors to represent the beads on your anchor . (Don't forget to count and draw the same amount on your anchor!)

Fun Fact!

Contrary to what many people assume, it is not the ANCHOR that stops a vessel moving, but in fact the cable connecting the two. Due to it's length and weight, it forms a natural 'catenary' (curve), which acts as a 'spring' to absorb shocks.

2 Let's do some math! Look at the different color beads on your anchor. Look at the different colors and count each color.

Red: ___________

Orange: ___________

Yellow: ___________

Green: ___________

Blue: ___________

Purple: ___________

White: ___________

Black: ___________

Pink: ___________

3 Count and add all the beads and give the sum total below.

Total number of beads:

____

Fun Fact!
The word anchor is Greek in origin, meaning "crooked" or "hook."

4 **Engineering Design Challenge:** Now change the shape of your anchor to see if you can use fewer beads on your anchor to park your boat. Draw your design.

Experiment with your design!

5 Did your new design work better or did it do worse? Why?

6 If you had to make a new anchor what would it look like? Draw below.

Notes

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Anchors Aweigh! Engineering Notebook

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

DIY Hydrophone

Grades K-2

Teacher Guide

Seaworthy STEM™ in a Box Series

DIY Hydrophone

Teacher Guide for K-2

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SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

Table of Contents

Lesson Title: DIY Hydrophone

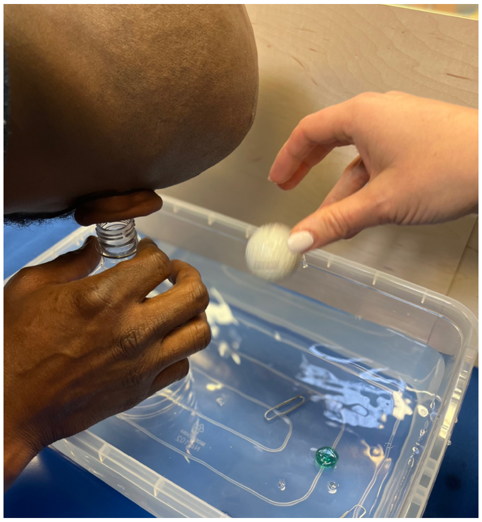
Time:
1 Class period (30-45 minutes)

Student Objectives:

Students will learn about sound waves and build a simple version of a hydrophone. Students will explore different types of sounds created by a variety of objects dropped in water. Students will collect data on their own personal assessment of sounds the objects produced.

Lesson Overview:

Students will create a hydrophone. A microphone which detects sound waves underwater. Students will use the empty soda liter and place it in a container of water. The mouthpiece of the soda liter will be used as an earpiece for listening. Students will work in teams by taking turns and listening to objects being dropped into the container. Students will collaborate and discuss the similarities and differences of sounds created by dropped objects.



Next Gen Science Standards (NGSS):

K-PS2-1
1-PS4-1
1-PS4-4
K-2-ETS1-1
K-2-ETS1-3

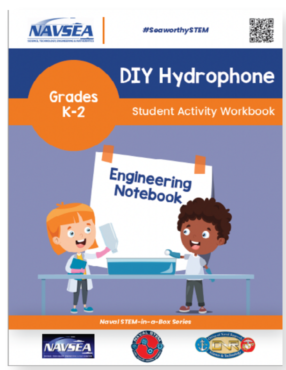
Notes

Materials and Equipment List (Per Team):

- 1 precut empty soda liter bottle
- Water
- 1 Fish tank or Clear container w/ depth
- Fishing line
- 2 solo cups
- Materials to drop in water, items within the classroom such as:
  - Corks
  - Paperclips
  - Ping pong balls

Student Activity Sheets/Handouts:

Hydrophone Graph Student Activity Workbook



Suggested STEM Related Literacy Book:

Sounds All Around
by Ellen Rooley

Fun Fact!

The first hydrophone was invented in 1914. It was designed as a way to locate icebergs following the Titanic disaster.

Pre-Activity Setup:

Make sure to cut off the bottom of the empty liter bottle.

Procedure:

1. The teacher will give a brief introduction/ review about sound waves. The teacher will ask students, **"Do you think sound can travel in water?"** The teacher will let students discuss and provide short answers to the discussion.

2. After discussion, explain to students that they will be split into teams and will work together to listen to sound waves in water.

3. The teacher will split the class into small groups, (3-4 students).

4. The teacher will give each team 1 liter bottle, objects to test, and water container.

5. The teacher will then guide students to use the objects to test and observe sound traveling in water. The teacher will model an example of dropping an object in the water while listening.

"Supplies"

"Dropping an object in water while listening"

(Helpful tip: This will be easier for students to achieve if one student listens while another student drops the object, students should take turns.)

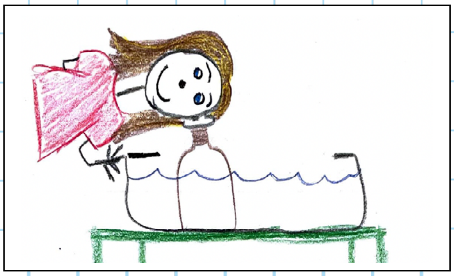
6 Give students 10-15 minutes to discover and explore how they can listen to sound waves using the liter bottle. During this time, the teacher will walk around to help guide groups that may need help.

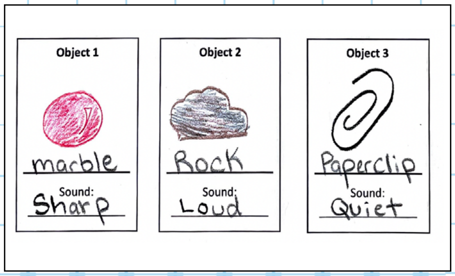
7 When students have completed dropping an object and observing with their ears, students should record their observations in the engineering notebook. The teacher should give students time to complete the activity and guided questions.

8 When completed, the teacher can guide students on clean-up and have guided whole group discussion. The teacher can ask the following questions:

- "Which object made the loudest noise? (Softest?)"
- "Why do you think that object was quiet? (Loud?)"
- "Do you think sound can travel in water? (Why?)"
- Why do you think this happened?

Check out these great examples of a student's observation!

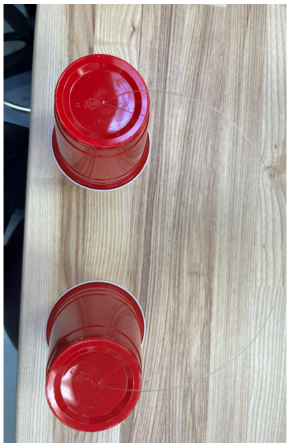




Extension Activity:

9 Have the students test their homemade telephone system made of two solo cups and a fishing line.

Make sure the students are touching the string between the cups and that the string is pulled tight. Having a string long enough to go across the room is the most effective.



10 After discussion, the teacher can extend the lesson by using the following STEM literacy book.

Vocabulary Terms:

- Density: The amount of matter in an object.
- Hydrophone: An underwater device that detects and records sounds in the water
- Reflect: When light waves or sound waves bounce off of a surface
- Sonar: A device for detecting objects underwater using reflected sound waves
- Sound Waves: A special kind of wave that can be detected by the human ear or specialized devices

Misconceptions/ Science information:

The purpose of this activity is to introduce students to sound waves and how they can travel in air and water. Sound waves travel faster in denser substances such as liquid. Sound waves will travel faster in water than they do in air. When an object hits the bottom of the seabed, the reflection of that energy will produce a sound. The sound will bounce off the bottom of the seabed and the sound wave will travel throughout the water. Students are using the one liter bottle as a "headphone" to listen to the different sounds being created when the objects are dropped, hit the bottom of the water container, and being reflected out. The Navy will use the same concept but on a much larger scale using sonar. Sonar is used to detect objects underwater and for measuring the water's depth by producing sound and detecting when the sound is reflected. Sonar can be used as a way to communicate underwater as well as a tool to locate marine life or other vessels in the surrounding area.

STEM Related Career:

- Sonar/Electronics Technician
- Engineering Technician
- Oceanographer

Fun Fact!

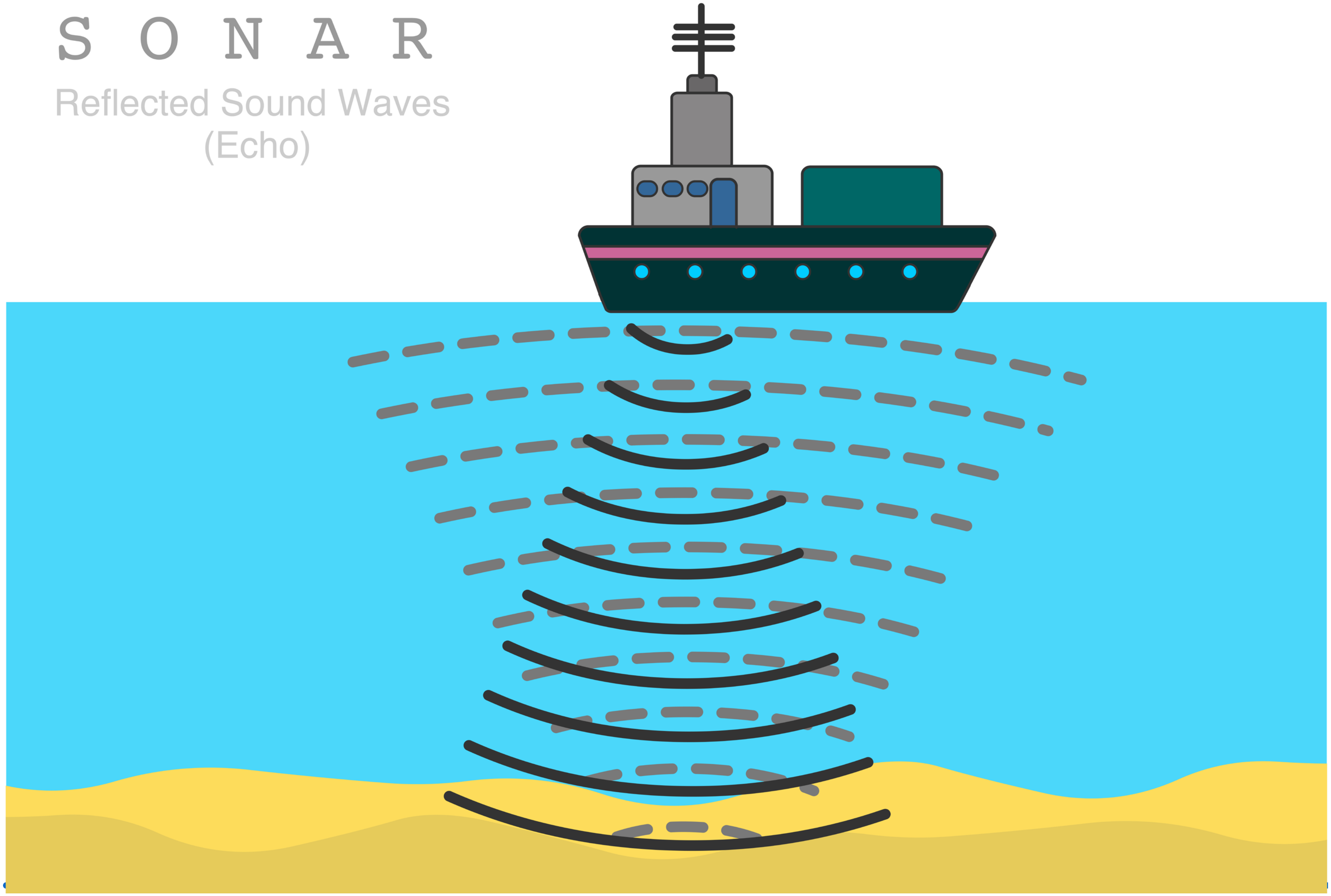
The DDG 1000 is one of the newest naval ships! Its sleek shape is not only cool to look at but purposefully designed this way! The composite superstructure significantly reduces radar cross section and other signatures, making the ship harder to detect by enemies at sea.

Fun Fact!

Sonar is used to identify, track, and navigate safely in the ocean. With advances in technology, newer-generation submarines are extremely quiet and hard to detect in the noisy ocean environment due to new technology in engineering design.

SONAR

Reflected Sound Waves
(Echo)



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DIY Hydrophone Teacher Guide

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

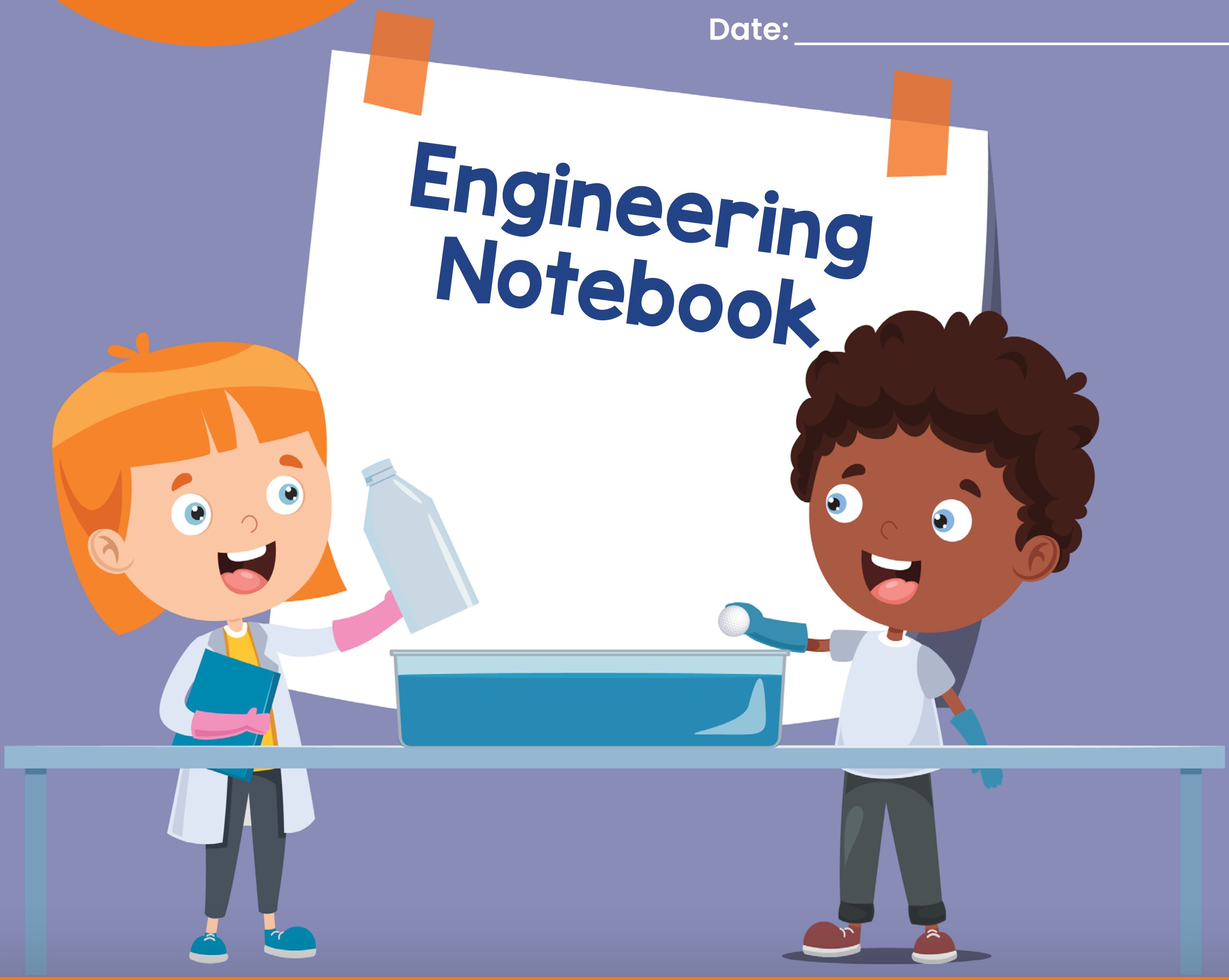
DIY Hydrophone

Grades K-2

Student Activity Workbook

Name: ______________________________

Date: ______________________________



Seaworthy STEM™ in a Box Series

DIY Hydrophone

Fun Fact!

Sonar is used to identify, track, and navigate safely in the ocean. With advances in technology, newer-generation submarines are extremely quiet and hard to detect in the noisy ocean environment due to new technology in engineering design.

1 Before starting your experiment, draw your DIY hydrophone and how you have placed the hydrophone in the water.

Fun Fact!

The DDG 1000 is one of the newest naval ships! Its sleek shape is not only cool to look at but purposefully designed this way! The composite superstructure significantly reduces radar cross section and other signatures, making the ship harder to detect by enemies at sea.

2 Inside each box, draw and label what objects you tested with your hydrophone. Under sound, use the text box below and describe the sound you heard when the object hit the bottom of the container.

Object 1	Object 2	Object 3
Sound:	Sound:	Sound:

Text Box:

Soft Quiet Loud Gentle Silent

High Low Explosive Faint Sharp

Fun Fact!
The first hydrophone was invented in 1914. It was designed as a way to locate icebergs following the Titanic disaster.

3 Listen to the sounds being made when objects are dropped. How do you think sound waves move in the water and through the hydrophone? In the box below, sketch you listening to the sounds in the water. Then draw how you think the sound waves travel to your ear.

Extension Activity:

4 Use your plastic cup telephone with a partner. Say “telephone” softly into the cup. Then say “telephone” in a normal volume into your cup. Could your partner hear you? Which was louder: the first word or the second word? Why do you think this happened?

5 Do you think the sound waves from your first or second word had more energy? Why?

Notes

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DIY Hydrophone Engineering Notebook

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Making Waves

Grades K-2

Teacher Guide

Seaworthy STEM™ in a Box Series

Making Waves

Teacher Guide for K-2

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Lesson Title: Making Waves

Time:

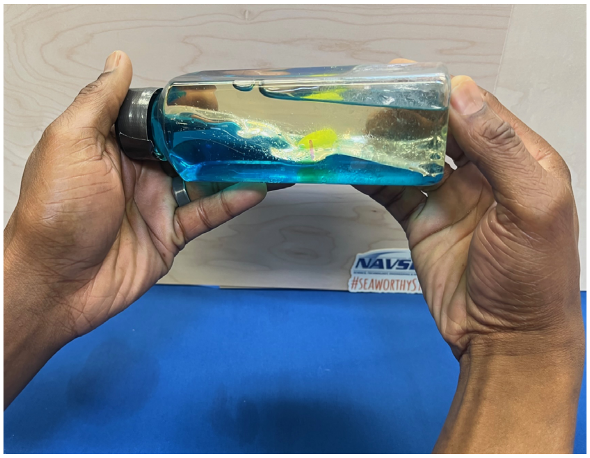
1 Class period (30-45 minutes)

Student Objectives:

Students will learn about energy and how the amount of energy can decrease the frequency and/or magnitude of the waves in the ocean. Students will explore making different types of waves by the amount of energy used. Students will observe the different types of waves created.

Lesson Overview:

Students will create an ocean in a bottle. Students will fill up the bottle with water, blue dye, and cooking oil. The water and oil will naturally separate. When the student tilts the bottle back and forth, “water” waves will be created. The waves are produced by the amount of energy student’s give. Students can observe the change in the wave by the amount of energy given. With this activity, students should understand the amount of energy will change the outcome of a wave.



Next Gen Science Standards (NGSS):

K-ESS3-2

2-ESS1-1

2-ESS2-2

2-ESS2-3

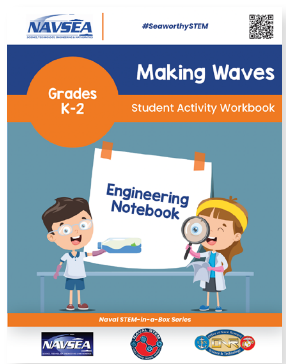
Notes

Materials and Equipment List (Per Student):

- 1 Smooth Plastic Bottle
- Food Coloring (Blue)
- Cooking Oil
- Water
- Funnel
- Tape
- 1 Pony Boat Bead
- Portable 3 speed fan

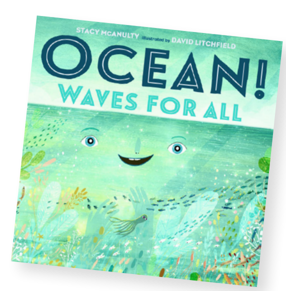
Student Activity Sheets/Handouts:

Making Waves Student Activity Workbook



Suggested STEM Related Literacy Book:

Ocean! Waves for All
by Stacey McAnulty



Procedure:

1 The teacher will give students an overview on energy and how waves are created by the given force of wind. The main concept on the lesson is for students to understand the amount of energy driven into a wave will increase or decrease the size of the wave. The teacher can lead a whole class discussion with the following introduction questions.

- What is energy?
- What is a wave?
- Is water a living thing?
- How do waves get bigger or smaller?

2 Each student will receive 1 empty bottle w/ lid, 1 funnel, blue coloring dye, water, cooking oil, and a boat bead.

3 The teacher will guide students in creating a wave bottle. *(Please note- depending on age level, teacher will scaffold the directions with building of the wave bottle.)*

1. Fill the container 1/3 way with water.

2. Add 2-4 drops of blue food dye coloring and have the student drop 1 boat bead inside the bottle.

Fun Fact!

The wind is the driving force of weather at sea, as wind generates local wind waves, long ocean swells, and its flow around the subtropical ridge helps maintain warm water currents such as the Gulf Stream. Weather ships were established by various nations during World War II for forecasting purposes, and were maintained through 1985 to help with transoceanic plane navigation.

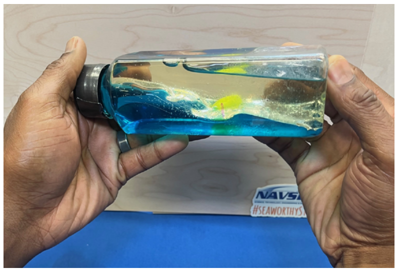
(Helpful tip: Use a funnel!)

3. Fill the remaining bottle with cooking oil.

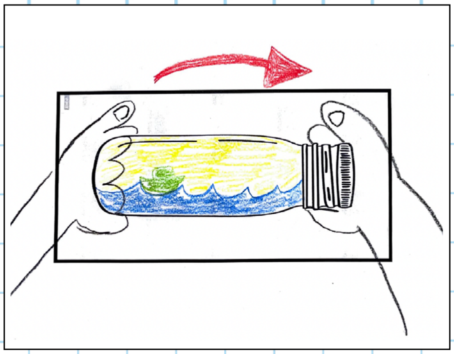
4. Close the lid, tightly!

5. Use the tape to secure the lid.

4 When students have completed creating the wave bottle. Have students gently tilt the bottle back and forth to make waves.



Check out these great examples of a student's observation!



5 Have students observe the waves inside the bottle. Give students 5-10 minutes to explore and observe creating different size waves.

6 After observing, have each student fill in the student engineering notebook.

7 To finish the activity, the teacher will ask guided concluding questions to students.

- How did you make a wave?
- Where did the energy come from?
- How can you create bigger/smaller waves?
- How do you think waves form in the ocean?

8 The teacher will model the way in which the wind helps with the formation of waves.

- Set up your container of water and have a portable 3 speed fan ready. Ask the question "What is wind?" Discuss with the class.

- Ask the students to predict which of the 3 fan settings will generate the most wind- Low, Medium or High. Have them record their prediction in their journals.

- Proceed through the demonstration with the class by angling the fan towards the water then turning the fan to its lowest setting, followed by the medium setting, followed by the highest setting.

- Have the students record in the workbook the answer to "Why did the highest setting on the fan create the strongest waves?"

Vocabulary Terms:

- Density: the mass of an object divided by its volume
- Energy: The ability to work
- Force: A push or pull on an object
- Wind: The movement of air

Misconceptions/ Science information:

Ocean waves are created by energy. Waves are created by wind that is disturbing the surface of the ocean. Small amounts of wind/energy will create ripples on top of the water surface. When energy is passing through the water, the ripples in the water will build upon each other and create bigger waves. If there is a gust of wind or severe storm, the waves will be increase in size due to increase of wind.

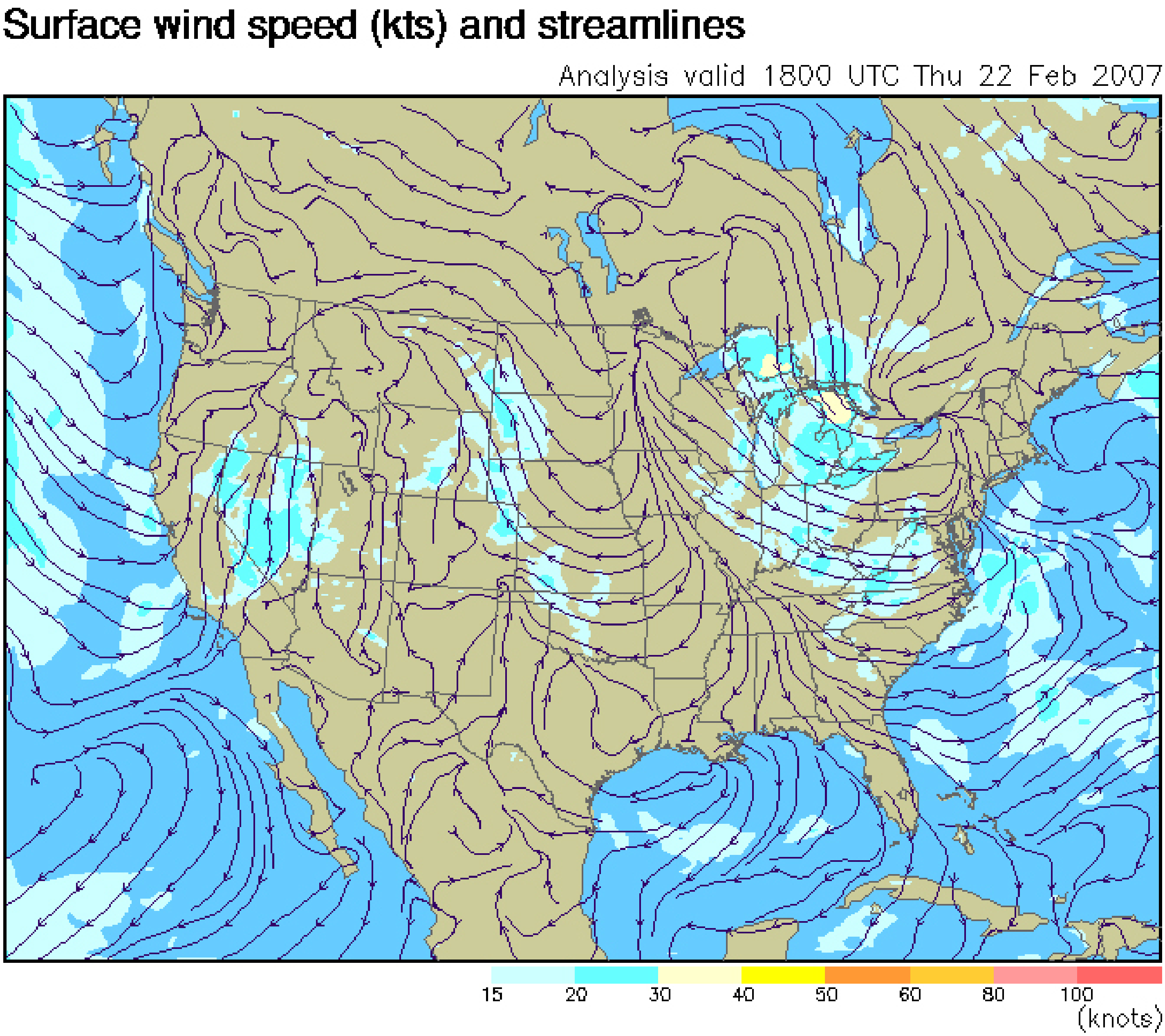
Fun Fact!

Today, the Navy relies on weather forecasting with the help of technology and meteorologists. A series of Meteorology and Oceanography Centers—Naval Meteorology & Oceanography Command—provide weather-related information to the fleet.

STEM Related Career:

- Ocean Engineering
- Marine Biology
- Marine Researcher
- Meteorologist

Reference Photo:



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#SeaworthySTEM

Making Waves Teacher Guide

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

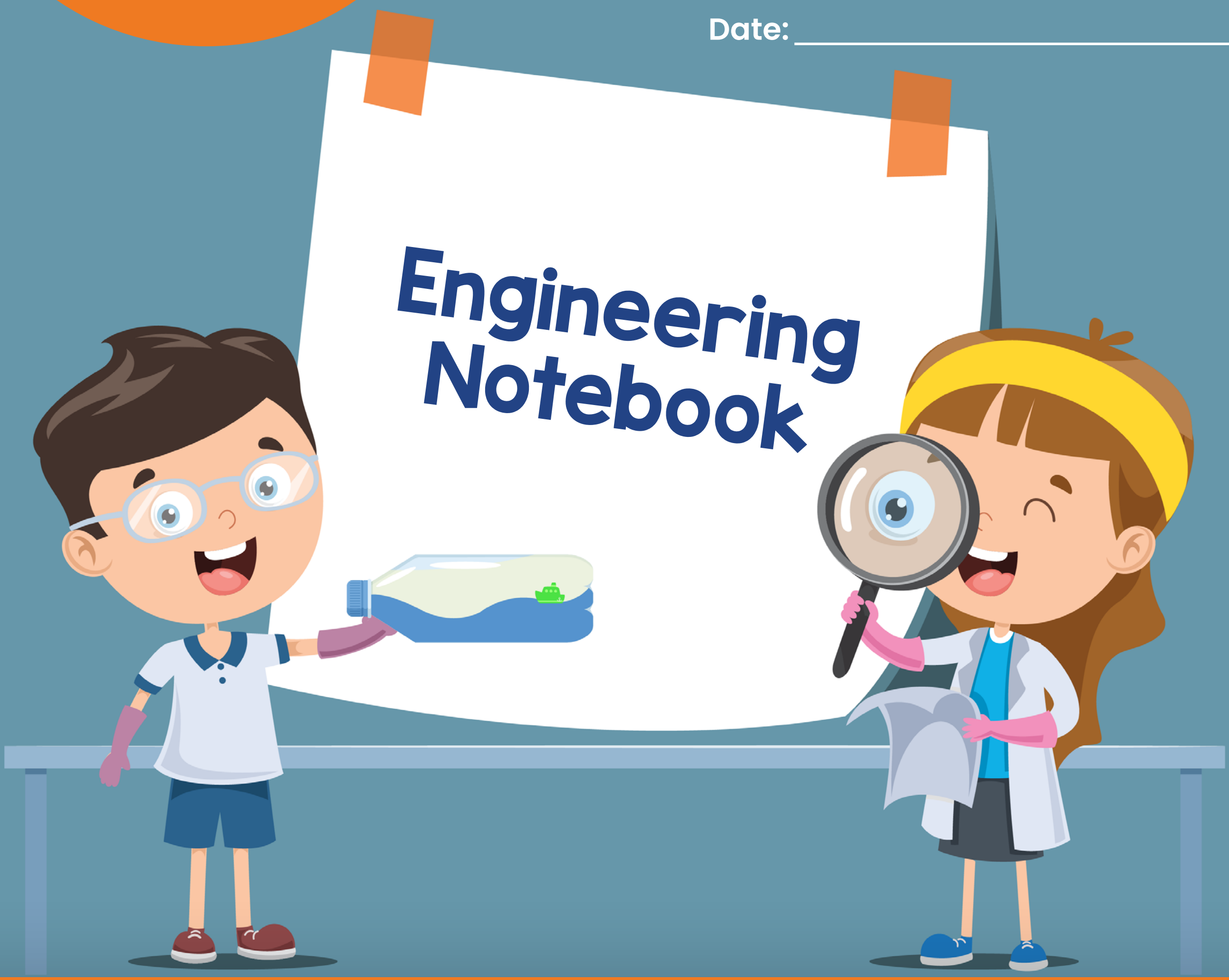
Making Waves

Grades K-2

Student Activity Workbook

Name: ______________________________

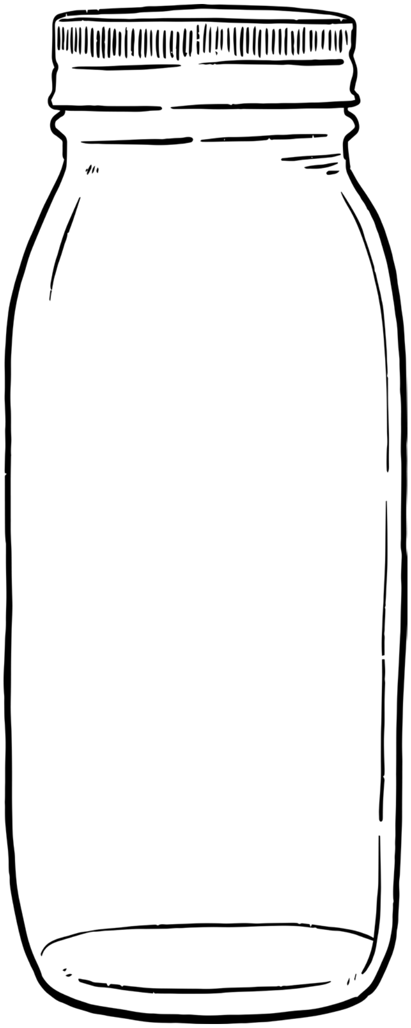
Date: ______________________________



Seaworthy STEM™ in a Box Series

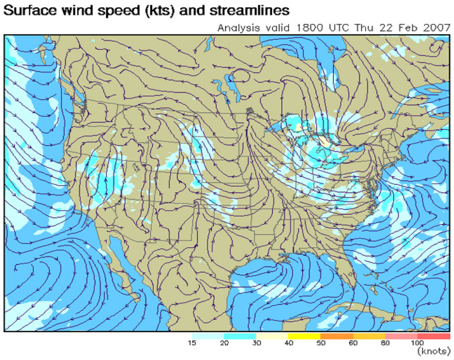
Making Waves

1 Draw and color a model of your wave bottle at rest.

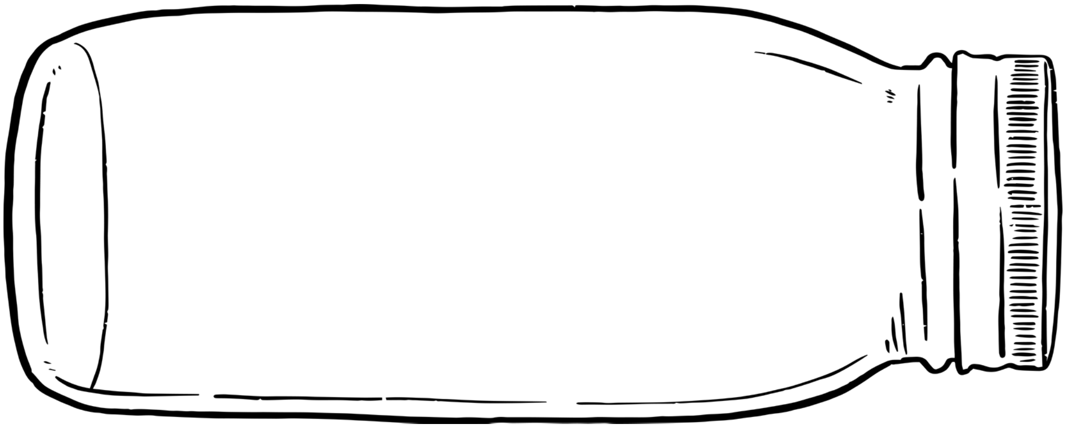


Fun Fact!

The wind is the driving force of weather at sea, as wind generates local wind waves, long ocean swells, and its flow around the subtropical ridge helps maintain warm water currents such as the Gulf Stream. Weather ships were established by various nations during World War II for forecasting purposes, and were maintained through 1985 to help with transoceanic plane navigation.



2 Draw and color the waves moving inside the bottle. Then draw arrows to show which way the waves are moving.



3 Which of the following fan speeds will cause the strongest waves?" (Circle one)

Low **Medium** **High**

4 Why did the highest setting on the fan create the strongest waves?

Fun Fact!
Today, the Navy relies on weather forecasting with the help of technology and meteorologists. A series of Meteorology and Oceanography Centers—Naval Meteorology & Oceanography Command—provide weather-related information to the fleet.

#SeaworthySTEM

Making Waves Engineering Notebook

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Oh Barnacles!

Grades K-2

Teacher Guide

Seaworthy STEM™ in a Box Series

Oh Barnacles!

Teacher Guide for K-2

Seaworthy STEM™ in a Box Educator Kit description:

Seaworthy STEM™ in a Box activities are a Navy initiative to provide enhanced Naval-relevant, standards aligned, hands-on activities to K-12 teachers and students. Components of this program include, curated sets of classroom activities that aim to build deep conceptual understanding in Naval-relevant content areas. The kits also includes comprehensive lesson plans, material lists, scientific background information, STEM related literacy books, and student activity sheets. The Seaworthy STEM™ in a Box program is designed to support teachers as they select content, acquire materials, and implement more hands-on STEM activities in their classrooms. Increasing student access to hands-on STEM activities, also increases awareness of STEM career paths, engage students in STEM, and support development of student's abilities in STEM content.

The Seaworthy STEM™ in a Box kits were designed to guide students through the scientific inquiry-based theory and the engineering design process. The content and Naval-relevant activities are aligned with the Next Generation Science Standards. The topics and content covered within the lessons are connected and scaffolded based on distinct grade bands (K-2nd, 3rd-5th, 6th-8th, and 9th-12th).

NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

Table of Contents

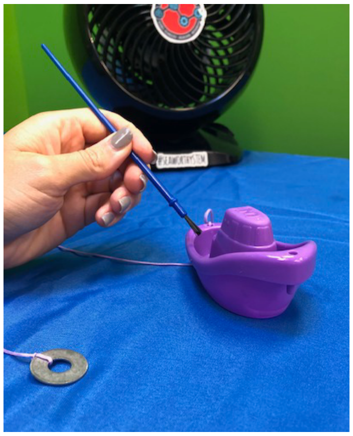
Lesson Title: Oh Barnacles!

Time:
1 Class period (45-60 minutes)

Student Objectives:

Students will learn the effects of marine life on water crafts, which is a key consideration in the designing and building of water vessels. Students will learn how the Navy protects and maintains ships for safe operating conditions. Students will use problem solving skills to find a solution to protect their own boat from marine life such as barnacles.

Lesson Overview:



Students will learn about crustaceans, in particular barnacles. Barnacles have a huge impact on the viability of a water vessel. Engineers in the field of ship design, have to problem-solve this impact on boats. The best solution is to seal and coat water vessels to prevent barnacles, algae, and other crustaceans from latching on the boat's surface. Students will work in teams and receive two toy boats. The Pom-Poms will act as barnacles in this activity. Students will first observe how barnacles attached to a boat's surface will cause drag. Then students will coat the second boat using petroleum jelly and observe how barnacles are no longer able to attach to the boat. The petroleum will act as an anti-fouling coat used by naval engineers to protect ships from marine life. This lesson was designed for students to receive the hands-on realistic approach that naval engineers use to solve this economical problem.

Next Gen Science Standards (NGSS):

- K-ESS3-1
- 1-LS1-1
- 2-LS4-1
- K-2-ETS1-1
- K-2-ETS1-3

Notes

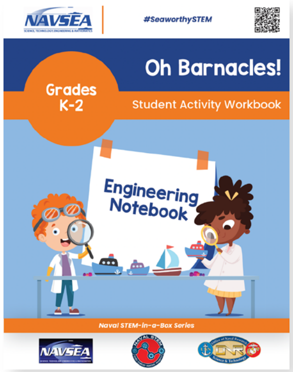
Washers of less mass will cause the boat to move more slowly, and make it easier to measure the difference in drag. Also, the overall impact of the barnacles will be more easily observed.

Materials and Equipment List (Per Team):

- Water
- Foil pan
- 2 Toy boats
- 2 pieces of string, 12' inch each
- Petroleum jelly
- 3 Paint brushes
- 8 Pom-Poms
- 8 glue dots
- 2 washers (same weight)
- Stopwatch (or any timing device)

Student Activity Sheets/Handouts:

Student Activity Workbook

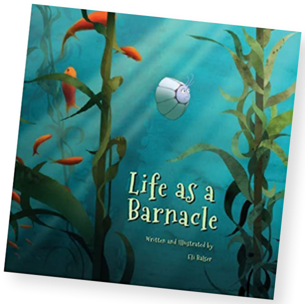


Technology Tools:

Stopwatch (or any timing device) to measure and collect travel time of the boats, for comparing.

Suggested STEM Related Literacy Book:

Life as a Barnacle by Eli Balser



Procedure:

1. The teacher will give a brief introduction about drag, boats, and information about barnacles. *(Read description below in Scientific Information.)*

2. The teacher will introduce the activity and guide students through listed materials.

3. The teacher will divide the class into small groups, 3-4 students per group.

4. Each group will receive the following materials;

   - 2 toy boats- with string and washer attached
   - 1 foil pan filled halfway with water
   - 3-4 paint brushes
   - 8 Pom-Poms
   - 8 glue dots

5. Have teams place one boat in the water. Allow the washer to hang off the side of the foil pan. Have the students practice letting go of the boat and gravity should pull the washer to the ground, moving the boat! Teams can now practice releasing both boats at the same time.

6. Guide students by modeling how to place the "barnacles" (pom-poms) on only one boat by using the glue dots. Have the students place 4 barnacles on one boat.

7. Have students place both boats in the pan again, and experiment releasing the boats at the same time. Students will observe the drag created on the barnacle boat.

8. The teacher will direct students to use paper towels to dry off the non-barnacle boat. Students will now use the paint brushes to place a thick coat of "anti-fouling" (petroleum jelly) on the boat.

9. The teacher will then tell students to place the remaining barnacles on the now anti-fouling coated boat.

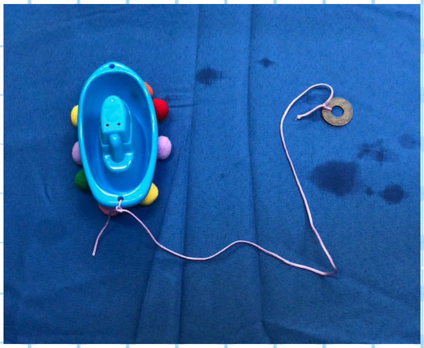
The teacher can guide students through the following questions:

"Do you observe how your boat moves in the water?"

"How can you make your boat go faster? Slower?"

"Which boat is slower (Why?)"

"Do you think the barnacles cause drag to the boat?"



(Helpful tip: The pom-poms may fall off at this point or in the water.)

10 Have teams experiment by placing both boats in the water again. Students will observe the difference in the newly coated boat.

11 To conclude activity, the teacher can guide students in cleaning up and completing the engineering workbook.

The teacher can ask these guided questions:

"Does your boat still work in the water?"

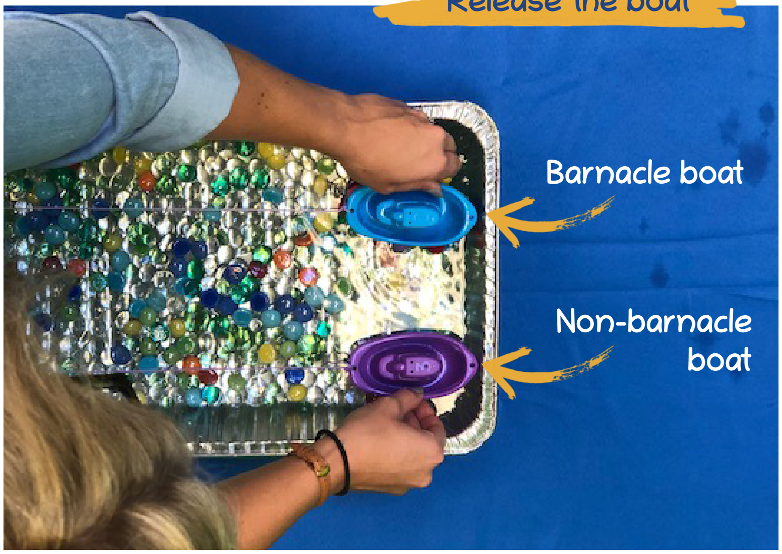
"Did any barnacles stick to your second boat? (Why or why not?)"

"Do the barnacles stay latched on? Can you push them off?"

"Does the coated boat have any drag?"

"Oh barnacles! Would you look at that drag?"

"Release the boat"



Vocabulary Terms:

- Anti-fouling coat: A coating applied to the outer layer of the hull to limit biological growth (i.e. barnacles) on a ship or a boat.
- Crustacean- An aquatic organism in the same group as crabs, lobsters, and shrimp.
- Drag- A force that opposes the forward progress of an object as it moves forward through a fluid.
- Food Chain- A diagram showing how a living thing gets its food.
- Marine Ecosystem- An aquatic environment containing a high level of dissolved salt.

Misconceptions/ Science information:

Barnacles are part of the crustacean family and play a key role in the marine ecosystem. Barnacles can play both a positive and negative impact within the marine ecosystem. Barnacles are filtering organisms and play a major role in the food chain of their ecosystem.

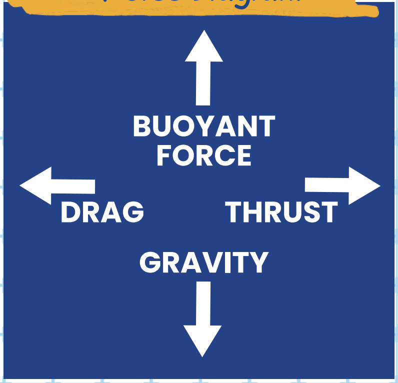
Unfortunately, Barnacles do also play a negative impact on human made vessels such as boats. Barnacle larva will attach themselves to objects in the ocean such as boats, whales, and rocks. They have a glue-like substance to attach themselves head-first to a host. This “glue” is extremely strong and even if the barnacle dies, the crustacean will stay attached. When multiple barnacles attached to a boat they can negatively impact the drag and weight of the boat. This impact will cause negative economic cost to fuel emissions and the life of a boat. To solve this problem, the Navy will coat boats with an anti-fouling paint that will help decrease any type of crustacean and algae trying to “stick”.

A boat uses thrust to move forward. When something lessens the forward motion of a boat as it moves through the water, its called drag.

Drag in Action!

A girl is walking down the street with an open umbrella. When the wind blows, the moving air enters the umbrella and forces the girl to step backwards.

Force Diagram



STEM Related Career:

- Marine Biologist
- Ship Design Engineer
- Mechanical Design Engineer

Reference Photos:

Full size reference photos are on the following pages.

NAVSEA

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

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#SeaworthySTEM

Oh Barnacles Teacher Guide

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Oh Barnacles!

Grades K-2

Student Activity Workbook

Name: ______________________________

Date: ______________________________

Seaworthy STEM™ in a Box Series

Oh Barnacles!

1 Draw your observation of the toy boats moving in the water. Then draw an arrow in the direction that the boats are moving.

Fact: Barnacles are a type of arthropod!

2 After sticking the barnacles onto a boat, record and compare the time each boat took to travel the same distance. Then circle which boat was faster.

Record the time of the boat without the barnacles:

____

Record the time of the boat with barnacles:

____

3 After painting the anti-fouling coat, observe and draw the last observation of your boats in the water. Count and write down how many barnacles fell off your boat.

Fact: Barnacles are part of the crustacean family and thus are related to crabs!

4 Looking at your data, how did the boat's speed change and why?

#SeaworthySTEM

Oh Barnacles! Engineering Notebook

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Sailor Knots

Grades K-2

Teacher Guide

Seaworthy STEM™ in a Box Series

Sailor Knots

Teacher Guide for K-2

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NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

Table of Contents

Lesson Title: Sailor Knots

Time:
1 Class period (30-45 minutes)

Student Objectives:

Students will learn about different rope knots that are used on boats. Students will learn the importance of different type of rope knots for sailors and other naval careers at sea. Students will work together or independently to develop fine motor skills with hands-on learning.

Lesson Overview:

Students will receive a brief introduction on the importance of tying knots. Students will receive two different color shoe laces. Students will learn 3 different types of rope knots used on boats. (Please be advised, depending on age-level the rope knots are listed below from beginner to advanced.) Students can work in pairs and use the guided step-by-step visual aid in the student engineering notebook.

- Beginner - Half Hitch
- Beginner/Intermediate - Double Half Hitch
- Intermediate/Advanced - Square Knot

Next Gen Science Standards (NGSS):

K-2-ETS1-1
K-2-ETS1-2
K-2-ETS1-3

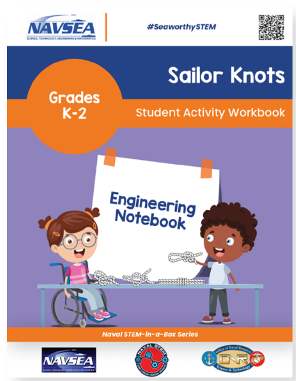
Materials and Equipment List (Per Team):

- Shoe laces, (2 colors)
- Clip board or cardboard
- Zip ties (optional)
- 2” C clamp
- 12 inch ruler

Helpful hint:
These are a great option in the classroom!

Student Activity Sheets/Handouts:

Sailor Knots Student Activity Workbook

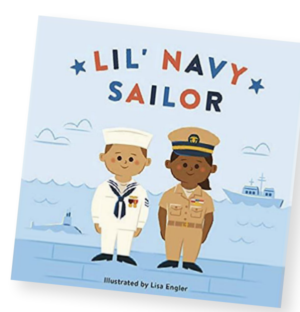


Helpful hint:

Look around your surroundings to come up with your own clever solution. In the provided student activity worksheet, we used a C-clamp on a work surface to create a quick and easy “handle” for our knot tying. Share your setup with #SeaworthySTEM”

Suggested STEM Related Literacy Book:

Lil’ Navy Sailor by Anne Miranda



Pre-Activity Setup:

If needed , cut out two holes 4 inches apart in the middle of the cardboard. Using a zip tie, loop it around the two holes creating a handle. This is for students to be able to tie the knot onto something, The teacher can use door handles inside the classroom as well.

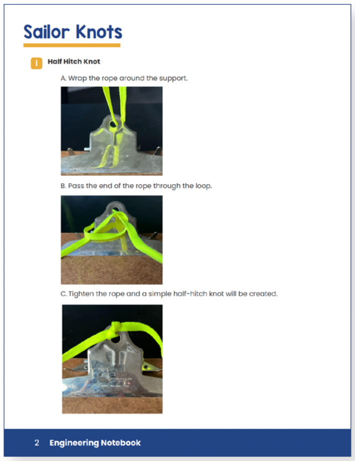
Procedure:

1. The teacher will go over the importance of knots used in everyday practical situations. The teacher will guide students in whole group discussion using the introduction questions on the side panel.

2. The teacher will have students work in pairs or individually, depending on grade level ability. The teacher will hand out the listed materials: 2 shoe laces that are different colors and some type of handle to tie the knots on.

3. Students will start with the first knot using the guided step-by-step directions and guided help from the teacher.

    - Have students use the ruler to experiment with different lengths of rope material.
    - Have students create knots and test the strength of knots made of different materials (i.e. fishing line)."
    - Guided directions from the Student Activity Workbook:



Sailor Knots

1 Half Hitch Knot

A. Wrap the rope around the support.

B. Pass the end of the rope through the loop.

C. Tighten the rope and a simple half-hitch knot will be created.

2 Engineering Notebook

The teacher can guide students through the following questions:

"What is a knot?"

"Why do we use knots?"

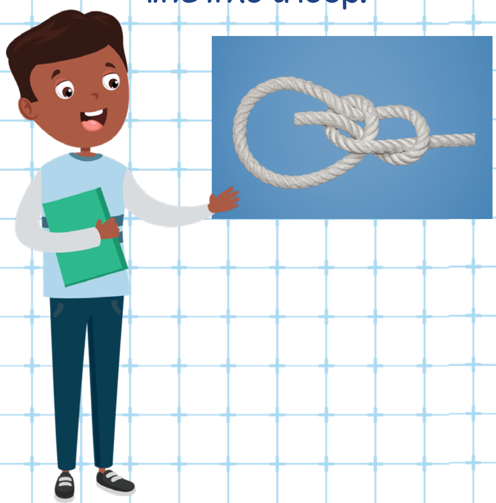
"What causes a knot to stay in place?"

"Why would a sailor or other related careers need to know how to tie different knots on a boat?"

"What holds a knot in place"
*This would be an appropriate time to discuss how friction helps knots stay in place.

"If you had a longer rope do you think you could tie a stronger knot? Why? Why not?"

Fun Fact!
The bowline is the king of sailing knots. It has been in use by sailors continuously for at least 500 years. Simply put, the bowline is way of turning the end of your line into a loop.



4 Students will check work with the teacher and will repeat step #3 with the next level knot.
(Please be advised due to fine motor skill ability/ age level, students may only be able to do 1 type or all the knots. Teacher will use discretion.)

5 When completed, the teacher will conclude the lesson by asking the following guided questions.

- “What knots were you able to complete?”
- “Did you get frustrated or have a difficult time?”
- “What helped you overcome those feelings?”
- “What knot was your favorite to try? (Least favorite?)”

Vocabulary Terms:

- Friction: a force that acts between two objects that are in contact with one another

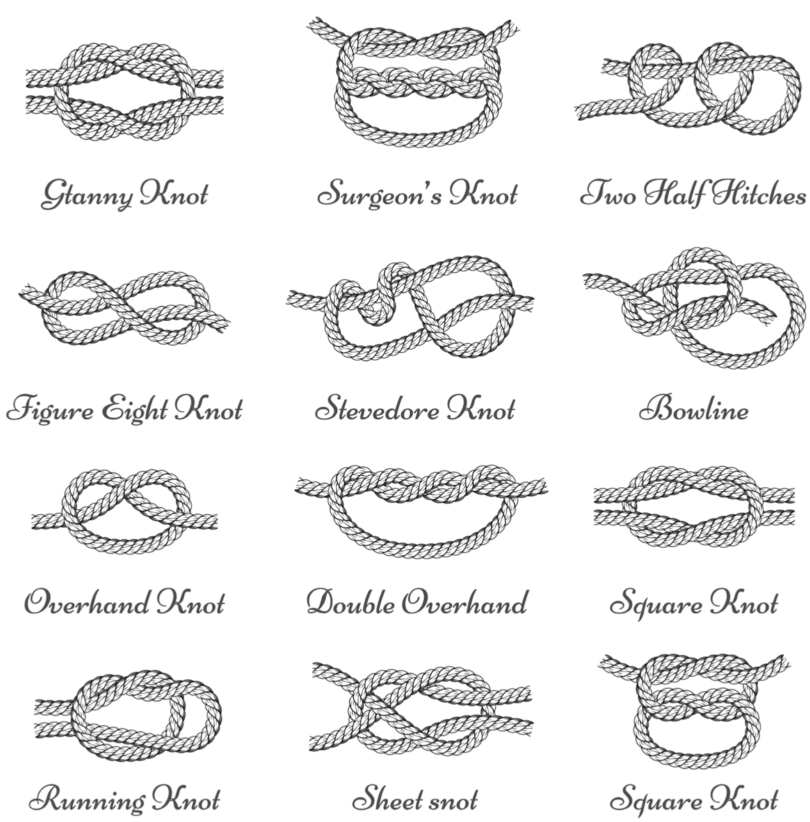
Misconceptions/ Science information:

Different types of knots have been used to help maintain a boat and sail(s) when in use. The following knots are mainly used in sailing. Sailors should learn different types of knots to be able to lift, moored, and hitch the boat and/or sail. Sailors have used these common knots for many years and each knot has a particular use on the boat. Each knot maybe used for a different function. Any type of knot is held together by the friction at the center of the knot. The strongest knots tend to be the most complicated because the more turns within the knot will create more friction.

STEM Related Career:

- Sailor, Crew-member
- Deck Officer
- Ship Captain

Reference Photos:



Fun Fact!

The monkey's fist is a bit of a bonus knot and even though it sounds silly can be an important tool to use at sea! The monkey's fist is used as a weight at the end of the line so it can be thrown from bow to stern or vessel to dock.

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#SeaworthySTEM

Sailor Knots Teacher Guide

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

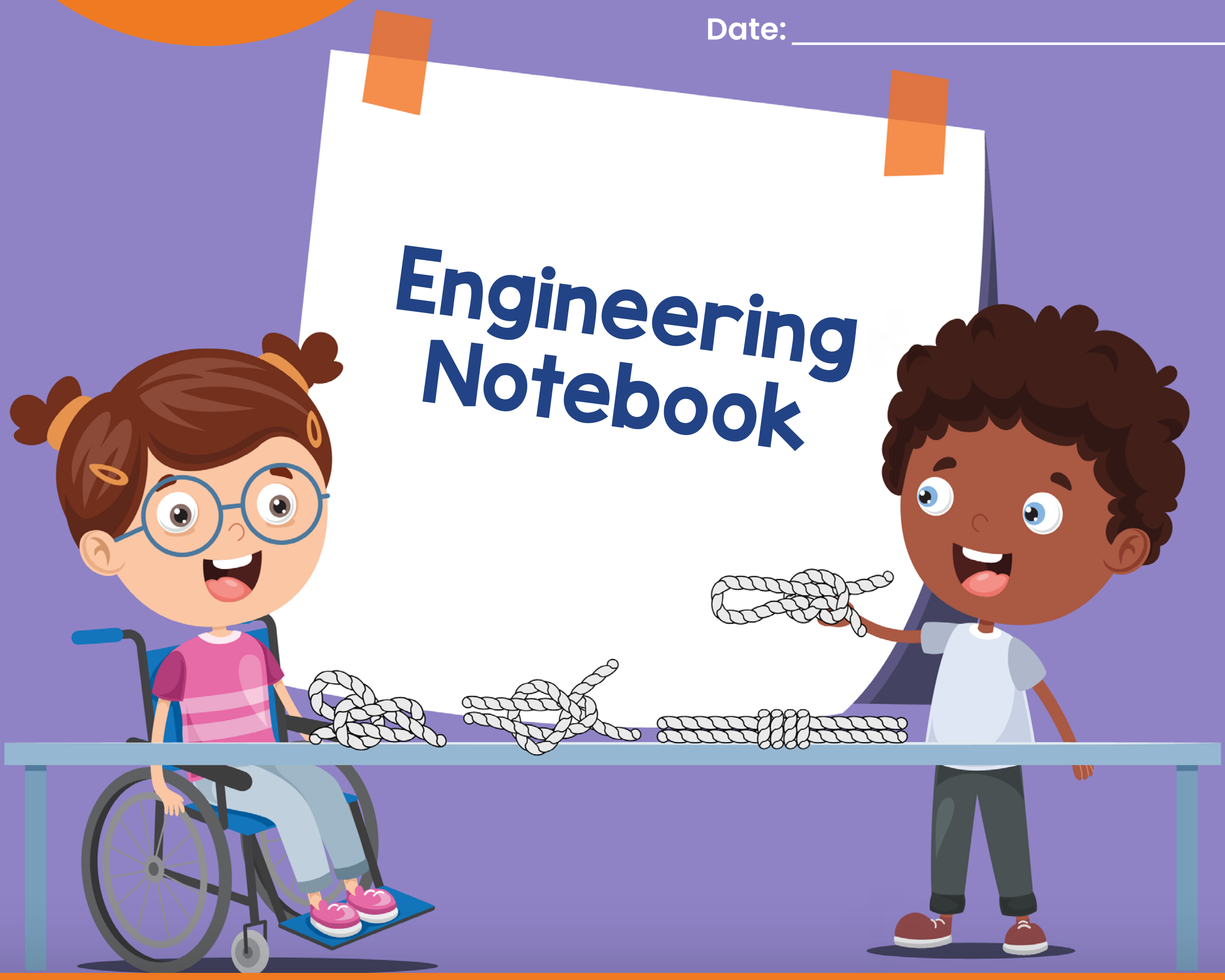
Sailor Knots

Grades K-2

Student Activity Workbook

Name: ______________________________

Date: ______________________________

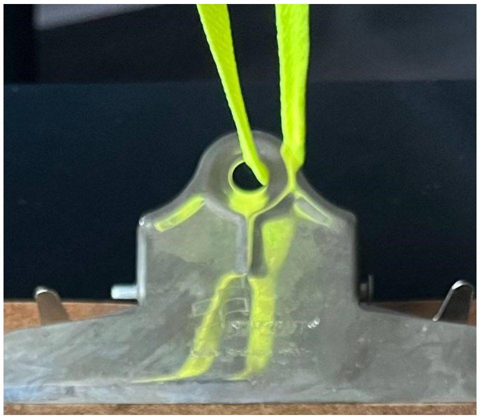


Seaworthy STEM™ in a Box Series

Sailor Knots

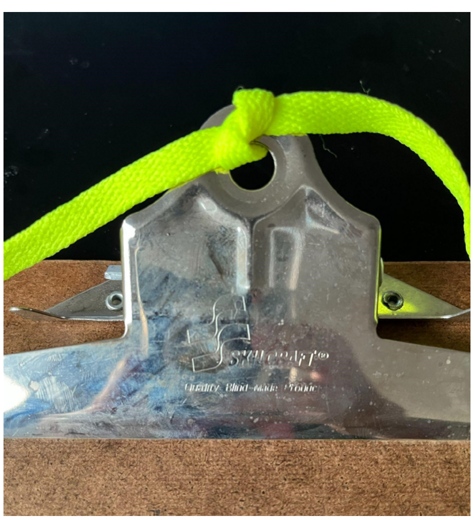
I Half Hitch Knot

A. Wrap the rope around the support.



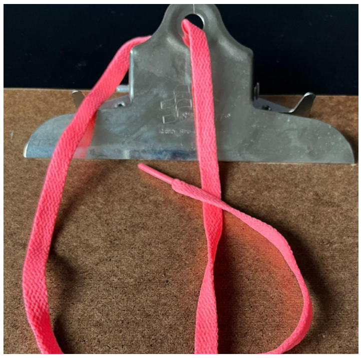
B. Pass the end of the rope through the loop.

C. Tighten the rope and a simple half-hitch knot will be created.



2 Double Half Hitch Knot

A. Wrap the rope around the support.



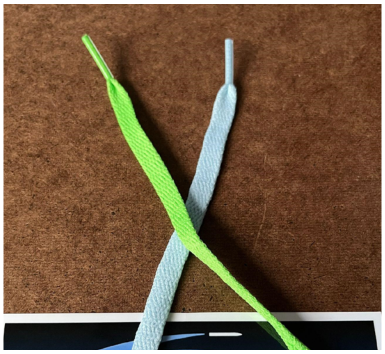
B. Pass the end of the rope through the loop.

C. Wrap the end around the standing straight part of the rope.

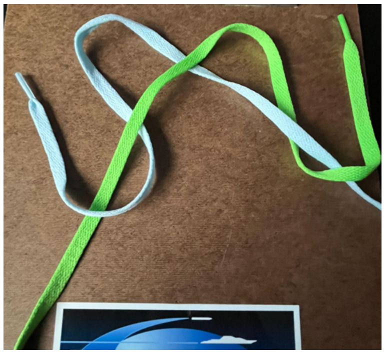
D. Tighten the rope to complete a two half-hitch knot also known as a double half hitch knot.

3 Square Knot

A. Grab both color ropes. Hold an end of a rope in each hand.

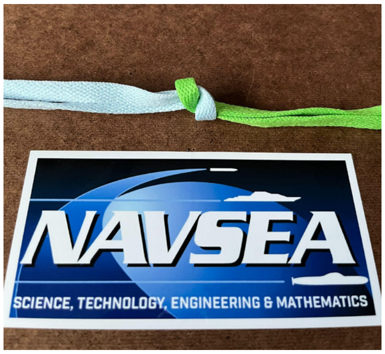


B. Pass the right end over and under the rope in your left hand.



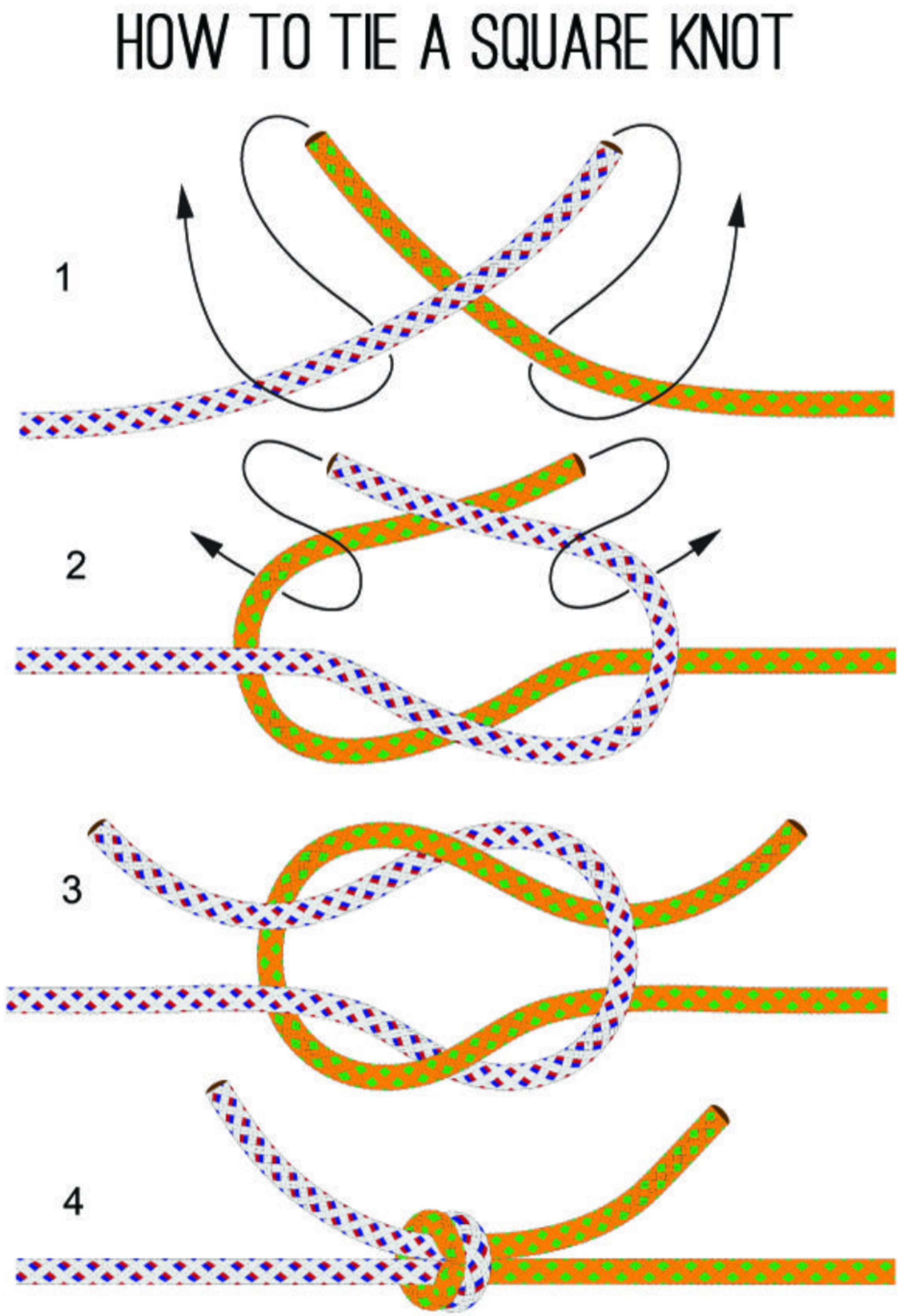
C. Pass the rope end in your left hand over and under the rope in your right hand.

D. Tighten the knot by pulling on both ends at the same time.



As seen in this handy diagram!

Square Knot Diagram



. *Diagram from: Survivallife.com*

4 What holds a knot in place?

5 If you had a longer rope do you think you could tie a stronger knot? Why? Why not?

Fun Fact!

Shoes create friction between you and the ground which helps you run faster.

Want a challenge?
Try these advanced knots!

Monkey's fist knot

The monkey's fist is a bit of a bonus knot and even though it sounds silly can be an important tool to use at sea! The monkey's fist is used as a weight at the end of the line so it can be thrown from bow to stern or vessel to dock.

Bowline knot

The bowline is the king of sailing knots. It has been in use by sailors continuously for at least 500 years. Simply put, the bowline is way of turning the end of your line into a loop.

#SeaworthySTEM

Sailor Knots Engineering Notebook

Seaworthy STEM™ in a Box Series

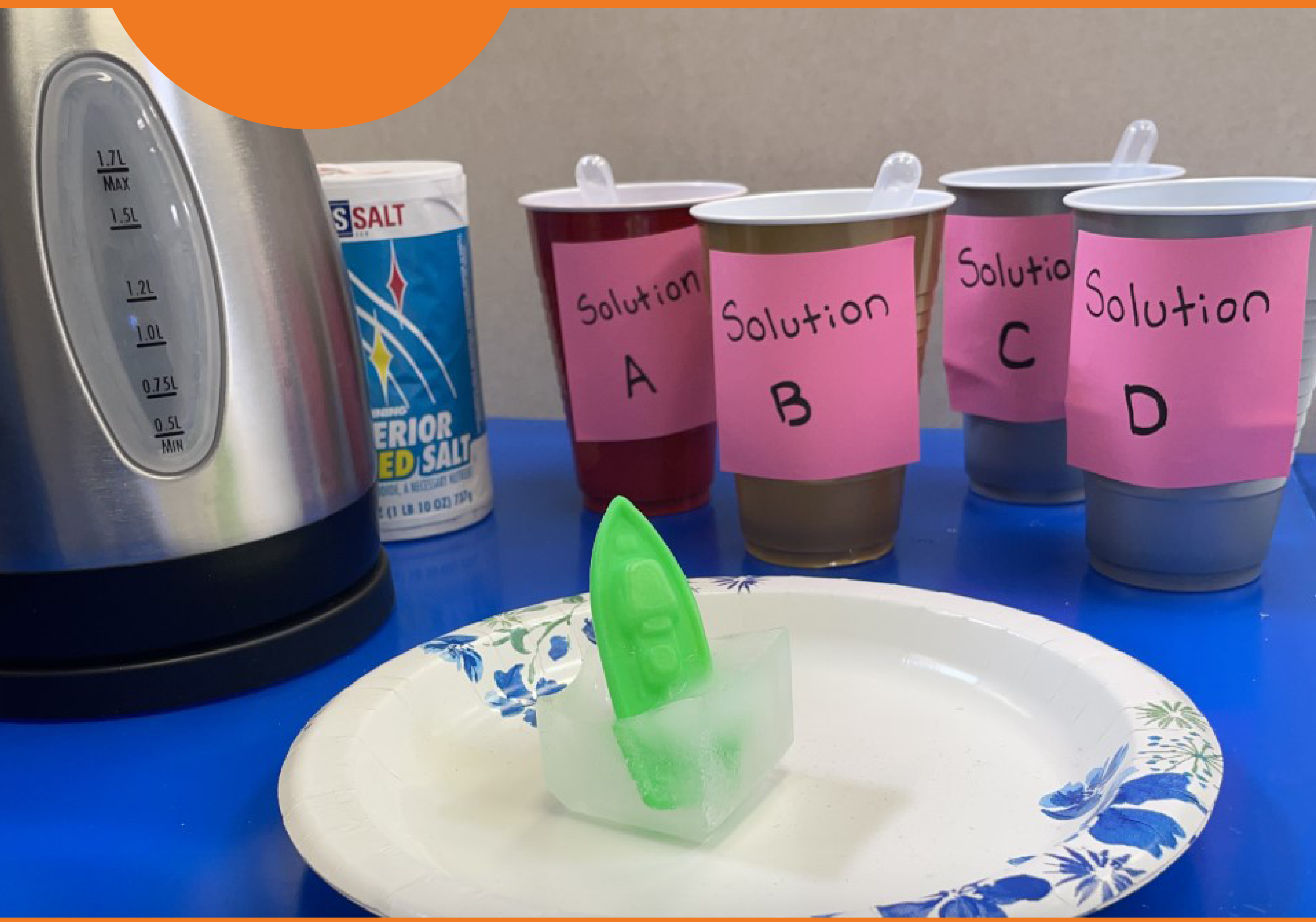
NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

#SeaworthySTEM

Save A Boat!

Grades K-2

Teacher Guide



Seaworthy STEM™ in a Box Series

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Save A Boat!

Teacher Guide for K-2

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The Seaworthy STEM™ in a Box kits were designed to guide students through the scientific inquiry-based theory and the engineering design process. The content and Naval-relevant activities are aligned with the Next Generation Science Standards. The topics and content covered within the lessons are connected and scaffolded based on distinct grade bands (K-2nd, 3rd-5th, 6th-8th, and 9th-12th).

NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

Table of Contents

Lesson Title: Save A Boat!

Time:
45-60 minutes

Student Objectives:

Students will learn how a solid can change into liquid form by melting. Students will discover different melting points. Students will be challenged to use different solutions to observe which solution will melt the ice the fastest to save the boat. This activity touches on a real-life problem that engineers help solve in their role with the United States Navy.

Lesson Overview:

Students will be given a toy boat stuck in a block of ice. Students will have to save the toy boat out of the block of ice without using their hands. Students will be given a pipette and will use different water temperatures solutions to try and free the boat from the block of ice. Students will use their observations and experimentation to discover how the block of ice melts when using 4 different solutions. Students will discover what solution is best to use to recover the boat. Students will learn that salt lowers the freezing point of water. This activity was created to teach students about the melting point of ice and how salt can be a freezing point depressor for water. This activity was also created to show a visualization of matter changing from solid to liquid form.

Next Gen Science Standards (NGSS):

2-PS1-4.
2-PS1-2.
K-2-ETS1-1.
K-2-ETS1-2.
K-2-ETS1-3.

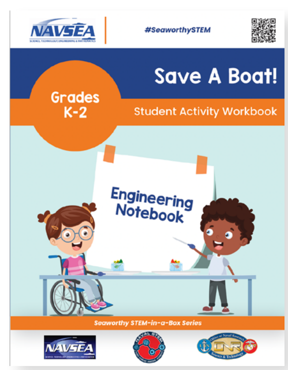
Notes

Materials and Equipment List:

- Heated water
- Room temperature water
- Ice cube tray
- Pipettes
- Cups
- Salt
- Mini toy boat
- Bowls
- Timing Device

Student Activity Sheets/Handouts:

Save A Boat Student Activity Workbook



Technology Tools:

Timing Device

Suggested STEM Related Literacy Book:

Fairy Science (Solid, Liquid, Gassy)
by Eli Balser

Pre-Activity Setup:

1. **24 hours in advance:** Place a toy boat into each ice cube slot. Fill up each ice cube slot with water. Place the tray in the freezer and let the ice cubes set completely for activity. Place a plate on top of the boats to ensure that they all become frozen in a similar way.
2. **Day of lesson:** Heat some water to 100 degrees F. The remaining water should be at room temperature, ~68 degrees F.
3. Each team will receive 4 cups for solution mixtures. Label each cup - Solution A, Solution B, Solution C and Solution D.
4. For solution A, pour the heated water into the cup.
5. For solution B, pour the room temperature water into the cup.
6. For solution C, pour the remaining heated water into the cup and add 2 tablespoons of salt. (Don't forget to stir!)
7. For solution D, pout the remaining room temperature water into the cup and add 2 tablespoons of salt. (Don't forget to stir!)
8. Place a pipette in each solution.

Procedure:

1. The teacher will go over the stages of change, (Solid-Liquid-Gas). The teacher can use the guided questions in the side panel to open a whole class discussion.
2. The teacher will go over the directions for the activity with students. The teacher will put students into teams and give each group the following materials:

Fun Fact!

When a ship is stuck at sea, the navy will use Icebreakers to help clear the path. Icebreakers clear paths by pushing straight into frozen-over water or pack ice.

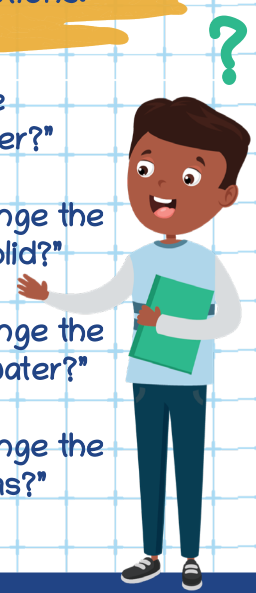
The teacher can ask these guided questions:

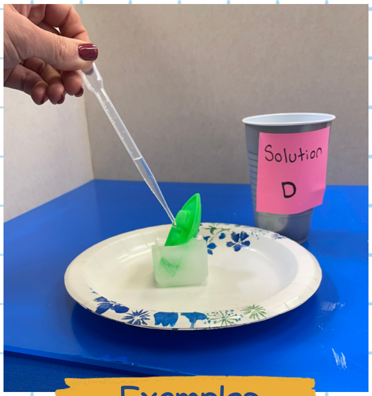
"What are three phases of water?"

"How can I change the water into a solid?"

"How can I change the ice cube into water?"

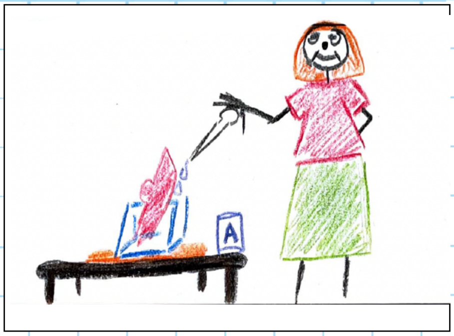
"How can I change the water into a gas?"

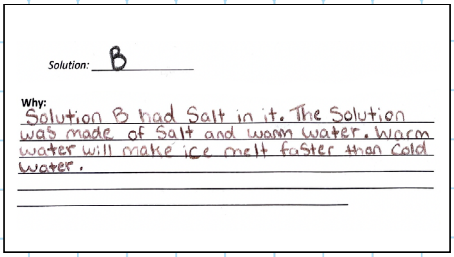




Examples

Check out these great examples of a student's observation!





- 4 solutions
- 4 pipettes
- 4 bowls
- 4 ice cubes w/ toy boat inside of the ice cube

3 The teacher will then give the following directions for:

1. Place 1 ice cube into a bowl.
2. Each student or team will be in charge of 1 ice cube and 1 solution.
3. The teacher will have each of their groups start a timer.
4. The student will use the pipette to place a few drops from the solution onto the ice cube.
5. The student will keep using the same solution till the designated time is over. If the group is able to free their boat prior to the teacher stopping the experiment, the group should stop their timer and record their time in their student workbook.
6. All four students or teams should be working independently and observing their own ice cube melting using the designated solution.
7. After the experiment time is over, have the 4 students or teams observe the 4 ice cubes and collaborate on which ice cube is most melted and which solution was the best to save the boat. Have students share their solutions and the amount of time it took to free their boat. If the ice didn't melt enough to free the boat, the class should show the boat in the ice cube to the class, so the students can compare the effectiveness of each solution.

8. Students will work together to complete the guided worksheet.

4 The teacher can guide students to clean up and can finish the lesson with the following guided conclusion questions below.

- “Did you save the boat?”
- “Which solution was best to speed up the process of melting?”
- “What do you think the solutions are made of?”
- “How did you work as a team?”

5 The teacher can use the suggested guided STEM literacy book as an extension or to conclude the lesson.

Fun Fact!

Brrrrr.... It's cold up here! Did you know that the Navy has a research facility even in the Arctic! The International Cooperative Engagement Program for Polar Research (ICE-PPR) is a program located in the Arctic. The program is a collaborative partnership with other nations. It's purpose is to create strong cooperative relationships that preserve safe, stable and secure Polar regions for all countries involved.

Vocabulary Terms:

- Solid: An object with a fixed shape and volume
- Liquid: An object with a fixed volume, but without a fixed shape and can take the shape of its container
- Gas: An object without either a fixed shape or fixed volume which can take the shape of its container.
- Freezing Point: The temperature at which liquid water can turn into a solid
- Melting Point: The temperature at which frozen water turns from a solid into a liquid
- Evaporation Point: The temperature at which liquid water turns into a gas
- Dissolve: When a solid combines with a liquid to form a solution
- Solution: A mixture of two substances with the same distribution of particles throughout.

Misconceptions/ Science information:

Recently, there is more interest in the study of the Arctic within the Navy. However, the Navy must be careful in navigating in icy waters. Ship design engineers have created specialty boats that are well equipped to navigate within icy waters. These boats are called icebreakers and the design of the boat allows movability in ice-covered waters and also provides safe waterways for other boats. When water reaches its freezing point at 32 degrees Fahrenheit, the particles in water will settle into a stable arrangement forming ice. When particles are heated above 32 degrees Fahrenheit the ice will reach melting point and start to melt. The loosely bound particles will transition from a solid to a liquid. When students add the salt solution to the ice cube, the salt will first dissolve the surface of the ice cube and lower the freezing point of the ice cube. The ice cube in contact with salt water will melt, creating more liquid, which will dissolve the salt more and that will continue the melting process.

STEM Related Career:

- Biologist
- Marine Engineer
- Research Scientist

Reference Photo:

Check out this Icebreaker ship!

The Seaworthy STEM™ in a Box curricula was developed through collaborative efforts of a team of individuals at the Naval Surface Warfare Center Carderock Division and Albert Einstein Distinguished Educator Fellows via an inter-agency agreement with the U.S. Department of Energy for the Albert Einstein Distinguished Educator Fellowship (AEF) Program. We are grateful to the following Content Specialists who contributed their knowledge and expertise by researching and writing on selected topics: Suzanne Otto, Stephanie Klixbull, and Thomas Jenkins. We'd also like to acknowledge the contributions of AEF participant Ms. Deborah Reynolds, the inaugural AEF Educator at Carderock that helped inspire the design of Seaworthy STEM™ in a Box content. With the help of Albert Einstein Fellow, Melissa Thompson, and Carderock Outreach Specialist, Ashlee Floyd, special additions to the curriculum such as career portfolios, workforce trading cards, and in-house short story publications are included that reflect the diversity of NAVSEA Sites.

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#SeaworthySTEM

Save A Boat Teacher Guide

Seaworthy STEM™ in a Box Series

NAVSEA SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

#SeaworthySTEM

Save A Boat!

Grades K-2

Student Activity Workbook

Name: ______________________________

Date: ______________________________

Seaworthy STEM™ in a Box Series

NAVSEA SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

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Save A Boat!

Use the solution and pipette to help save the boat from the arctic ice!
Answer the following questions below to guide you through the ice.

1 What solution are you using to save the boat?

Solution: ____________

2 Inside the drawing box, draw what happens to the ice cube as you use the solution to save your boat.

3 Were you able to free your boat in the time provided by your teacher? If so, how long did it take?

4 Record the times:

Room Temperature/Tap Water Time:	Room Temperature/Salt Water Time:

Warm Temperature/Tap Water Time:	Warm Temperature/Salt Water Time:

5 Please circle (above) the solution that melted the ice in the least amount of time.

6 At the end of the activity, which solution was best? Why was this solution best to use?

Solution: ____________

Why?

Fun Fact!

When a ship is stuck at sea, the navy will use Icebreakers to help clear the path. Icebreakers clear paths by pushing straight into frozen-over water or pack ice.

Check out this Icebreaker ship!

Notes

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Save A Boat Engineering Notebook

Seaworthy STEM™ in a Box Series

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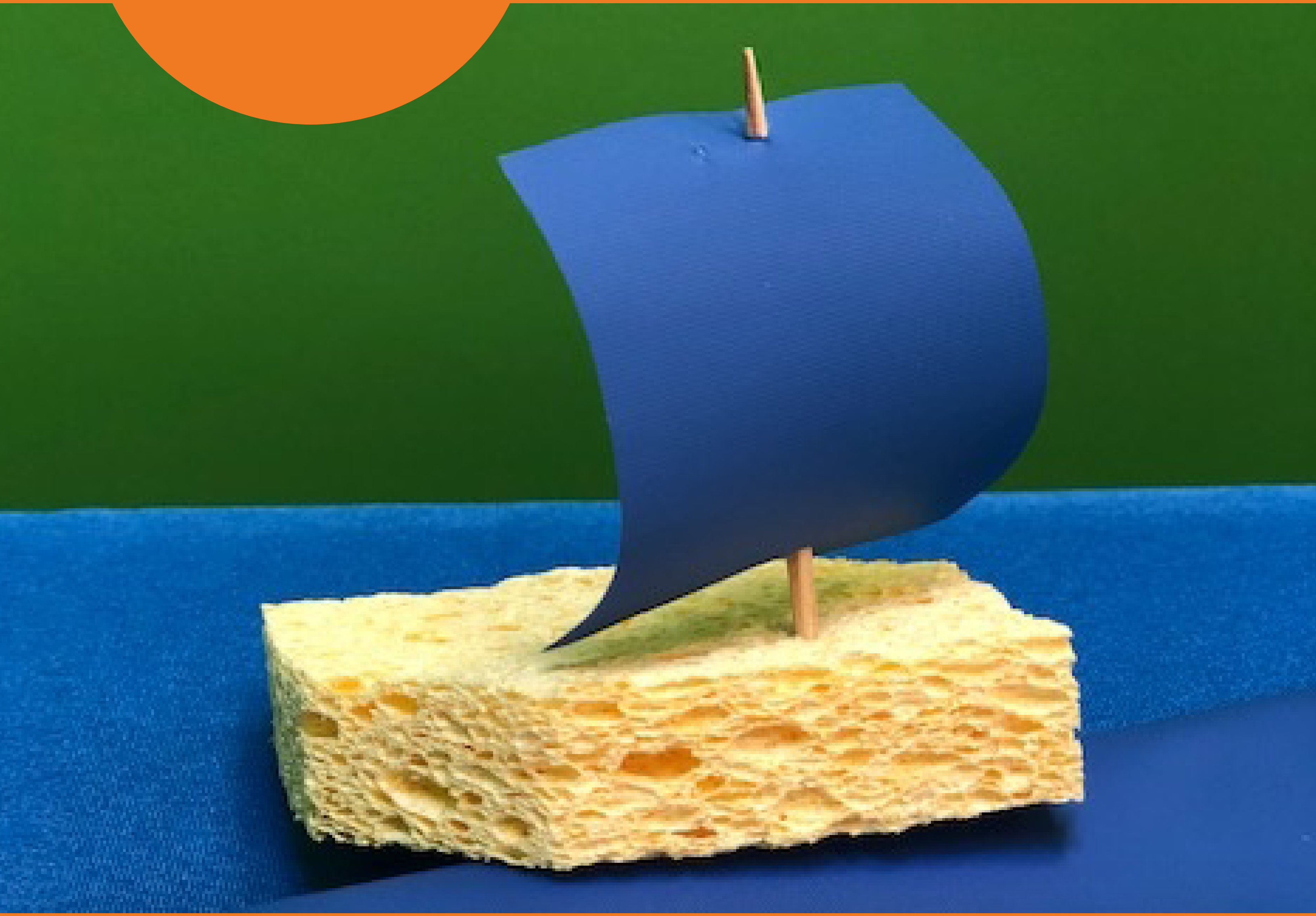
#SeaworthySTEM

Sponge Boat!

Grades
K-2

Teacher Guide



Seaworthy STEM™ in a Box Series

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Sponge Boat!

Teacher Guide for K-2

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NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

Table of Contents

Lesson Title: Sponge Boat

Time:
1 Class period (45 minutes)

Student Objectives:

Students will use the engineering process to design and build their own sailboat. Students will be able to experiment by placing the sailboat in water and observe how the boat moves with the use of wind created by a fan. Students will re-design to improve the model of their sponge boat.

Lesson Overview:

Students can explore different shapes for their boat and the sail. They can modify where to place their sail and the size/shape of the boat and sail. Students will be able to build their boat and then test it out in the water. The fan will be place by the water to create wind for the sail boat. The main goal of the activity is for students to observe how their boat moves in the water and to modifying the boat after experimenting. Students should direct the majority of allocated time to re-designing to continuously improve their boat model.

Next Gen Science Standards (NGSS):

K-PS2-1.
K-PS2-2.
2-PS1-2.

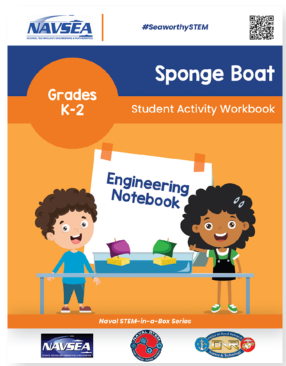
Notes

Materials and Equipment List:

- Sponges
- Scissors
- Markers
- Swizzle sticks or toothpicks
- Table cover, (Plastic)
- Water
- Fan
- Fish tank or water container
- Hole-puncher
- Timing Device

Student Activity Sheets/Handouts:

Sponge Boat Student Activity Workbook

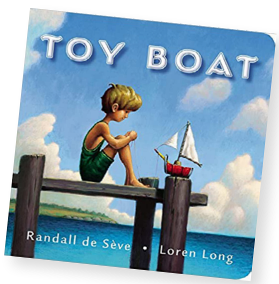


Technology Tools:

Timing Device

Suggested STEM Related Literacy Book:

Toy Boat
by Randall De Seve



Fun Fact!
The measurement that ships use for navigation is the nautical mile. One nautical mile per hour is called a "knot".

Pre-Activity Setup:

1. Take Table cloth and cut into 1 ft X 1 ft squares for each student.
2. Pour water into the foil pan. The pan should be half full. Then place the fan by the end of the foil pan.

Procedure:

1. The teacher will give a brief introduction into sailboats. The teacher can use the guided questions in the side panel to open a whole class discussion.
2. The teacher will explain the main goal of the activity. The teacher will model how to design the sail sponge boat.
3. The teacher will give each student the following materials that are listed: 1 sponge, 1 swizzle stick or toothpick, 1 square of table cloth, 1 pair of scissors, and markers.

a. Draw the shape of your boat on the sponge.

b. Use scissors to cut sponge and create the shape.

c. Draw the shape of your sail on the table cloth.

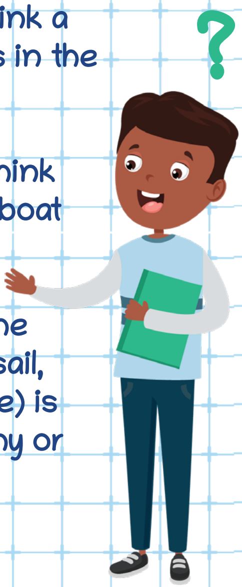
d. Decorate the sail using markers.

The teacher can ask these guided questions:

"How do you think a sail boat moves in the water?"

"What do you think the sail on the boat does?"

"Do you think the design of the sail, (the shape/size) is important? (Why or why not?)"



e. Use scissors to cut out sail.

f. For step G, the teacher will need to make a hole at the top of sail and bottom of sail.

g. Use the guided holes in the sail to place the swizzle stick through the sail.

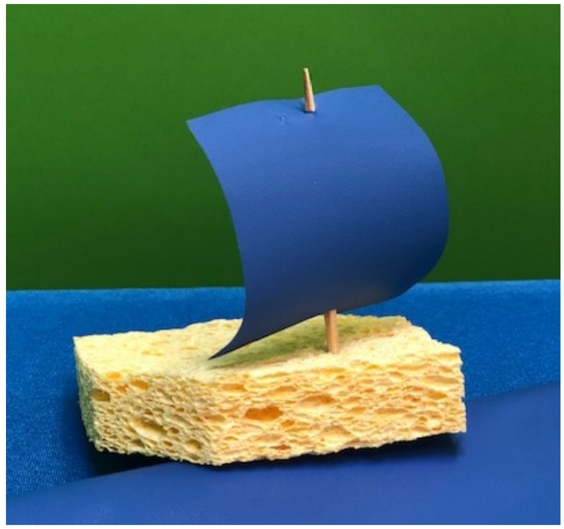
h. Stick the swizzle stick into the sponge, standing up. (Teacher guided help)

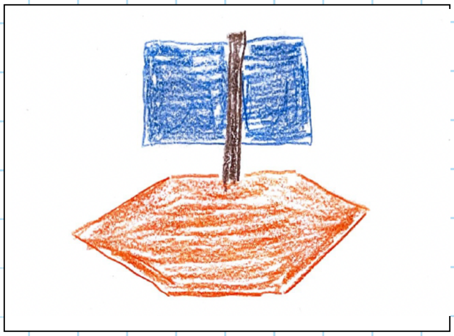
i. Place boat in the water.

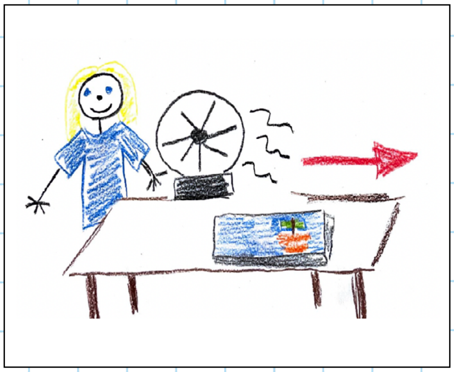
4 Students will observe how their sponge boat moves in the water. The student(s) will record the time of each version of their sailboat to see which design moves the fastest.

5 Students can re-design the sail, create a new sail, have multiple sails, and modify the placement of sail.

Check out these great examples of a student's observation!







6 The teacher can guide students in cleaning up and use the following guided conclusion questions to finish the lesson.

- "Did your boat move in the water?"
- "Did you observe if you boat change in direction or speed when modified?"
- "Do you think engineers change and modify their boat models?"

- “If given another sponge, how would you change your sponge boat?”
- Which designs were the fastest? What do you notice about the fastest boats?
- If you were given another sponge- how would you cut it? If you were given another sail- how would you cut it?” The students can draw their future designs to demonstrate growth.

7 The teacher can conclude the lesson using the following guided STEM literacy reading resource.

Fun Fact!

Even though the Navy started experimenting with steam-powered ships as early as the War of 1812, ships of sail remained the backbone of the fleet until the Civil War. The Navy still has one sailing ship in commission, the USS Constitution. Check out the USS Constitution on page 10!

Vocabulary Terms:

- Energy: the ability to do work. Wind in a sail is a form of energy
- Force: A push or pull on an object

Misconceptions/ Science information:

Wind is a form of energy. Sailboats use the forces of the wind on the sail. The wind blows against the sail and will get lift like the wing of an airplane. The shape of the boat combined with the sail will push the boat forward. In most cases, the more wind the sail is able to capture, the faster the sail boat will move. For a sail boat to move, the sail needs to be angled against the wind. The sail boat will be pushed perpendicular to the wind direction. For students to achieve a working sail, the sail should not be like a flat sheet of cloth but rather curved, like a wing of a bird. This allows the sail to “capture” the wind. This activity was created to have students use the engineering design process and in particular to use the re-design step. Students should be able to design and experiment with different types of sails to achieve the best solution to capture the wind from the fan.

STEM Related Career:

- Materials Engineer
- Meteorologist
- Wine Turbine Technician

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#SeaworthySTEM

Sponge Boat Teacher Guide

Seaworthy STEM™ in a Box Series

NAVSEA SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

#SeaworthySTEM

Sponge Boat

Grades K-2

Student Activity Workbook

Name: ______________________________

Date: ______________________________

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Sponge Boat

1 Use crayons to draw and color your sponge-boat model.

2 Build your sailboat then use the timer to see how fast it moves across the pan. How many seconds did it take?

____

3 Draw and time your second boat.

4 Record how much time it took for your second boat to move across the pan.

____

5 What do you notice about the fastest boats?

Fun Fact!
The measurement that ships use for navigation is the nautical mile. One nautical mile per hour is called a "knot".

6 If you were to make a 3rd boat, what changes would you make? How would those changes make your boat go faster?

Fun Fact!
Even though the Navy started experimenting with steam-powered ships as early as the War of 1812, ships of sail remained the backbone of the fleet until the Civil War. The Navy still has one sailing ship in commission, USS Constitution.

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Sponge Boat Engineering Notebook

Seaworthy STEM™ in a Box Series

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Seaworthy STEM™ in a Box

Lessons for Grades 3-5

Teacher and Student Lesson Books for:

- Biofuel Jell-O
- Brace Against the Wind
- Break the Ice
- Glacier Gak
- Glowing Jellyfish
- Morse Telephone

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SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

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Biofuel Jell-O

Grades 3-5

Teacher Guide

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Biofuel Jell-O

Teacher Guide for 3-5

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The Seaworthy STEM™ in a Box kits were designed to guide students through the scientific inquiry-based theory and the engineering design process. The content and Naval-relevant activities are aligned with the Next Generation Science Standards. The topics and content covered within the lessons are connected and scaffolded based on distinct grade bands (K-2nd, 3rd-5th, 6th-8th, and 9th-12th).

NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

Table of Contents

Lesson Title: Biofuel Jello

Time:
1 Class period (45-60 minutes)
(This may take 2 separate class periods due to refrigeration involved.)

Student Objectives:

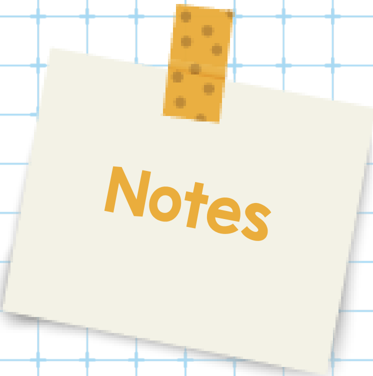
Students will learn about algae and how it is part of the marine food ecosystem. Students will gain knowledge about naval research and development into new biofuel and sustainable energy sources such as algae. Students will create their own “biofuel” using the same ingredients incorporated in Jell-O.

Lesson Overview:

Students will learn about sustainable and biofuel energy sources such as algae. Students will work together to create their own biofuel source. Students will learn how biofuels can be used as an energy source and how the Navy is currently exploring sustainable production of different types of biofuels.

Next Gen Science Standards:

3-LS4-4
3-LS4-3
4-PS3-4
4-ESS3-1
5-PS1-4
5-PS3-1

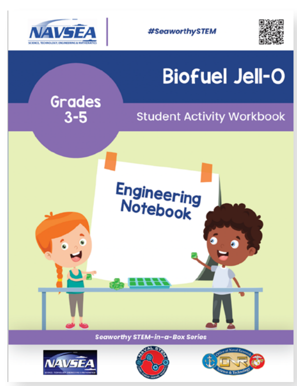


Materials and Equipment List:

- 2 packs of instant Jell-O
- Tonic Water
- Ice cube trays
- Black light
- Fridge
- Kettle
- Bowl
- Mixing spoons
- Measuring cups
- Tap Water
- Black Light

Student Activity Sheets/Handouts:

Biofuel Jell-O Student Activity Workbook

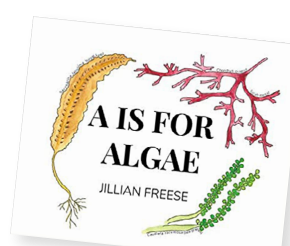


Technology Tools:

- Black light
- Learn about the Navy's Great Green Fleet initiative: https://allhands.navy.mil/Features/GGF/

Suggested STEM Related Literacy Book:

A is for Algae by Jillian Freese



Procedure:

1. Students will receive a brief introduction into sustainable and biofuel energy sources. The teacher will also introduce the research on energy sources such as algae. The teacher can direct a classroom discussion with the following introduction questions.

2. The teacher will split students into teams and hand out materials. Based on grade level, teacher may use discretion to have students work in teams or as whole class.

3. The teacher will then demonstrate how students will create the "biofuel Jell-O" using the kitchen ingredients listed in materials.

4. Give students 10-15 minutes to create the instant Jell-O in teams. This mixture will follow the recipe on the Jell-O box with one exception, please use the tonic water instead of regular tap water.

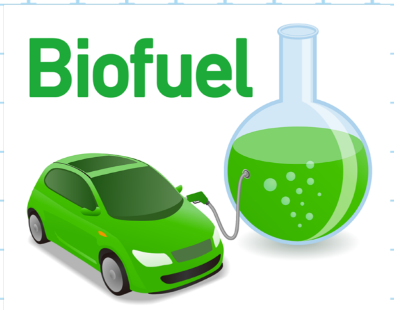
The teacher can guide students through the following questions:

"What is algae?"

"Why do animals eat algae?"

"If algae is a source of energy for animals, could we use that energy for other sources?"

Helpful tip:
Follow the directions on the instant Jell-O package directions. Replace the 2 cups of water with the listed 2 cups of tonic water. The tonic water is crucial to produce the "glowing" trait of the biofuel algae.



5. After making the Jell-O, pour into the ice cube tray and have set in the fridge.

Time for students to do their lesson worksheet!

Helpful tip:

This break would be a great time to read the STEM related literacy book and have students work on the Biofuel lesson worksheet in the engineering notebook.

6. Now that the "Biofuel Jello" has been created, it is suggested that the instructor encourages the students to make predictions and creates 3 additional different mixtures to compare to compare and to contrast. Examples include:
   - Tap water with the suggested amount of Jello powder
   - Measure more Jello powder and less tap water than the original recipe
   - Measure less Jello powder with more tap water than the original recipe

   Have the students note their new recipe and record a prediction in their student activity workbook.

7. When the Jell-O is set, give each student a cube of the biofuel Jell-O from the tray.

8. Use the blacklight and turn off the lights to see if it glows. The student will then pass out the second student engineered recipe to gather observations which they can compare and contrast with the Biofuel Jello. The students may then eat both of the samples.

9. Discuss the "Scientific Background" information with the class and guide a discussion focusing on sustainable energy. The teacher can use the whole group discussion questions in the side panel.

The teacher can use these group discussion questions:

"Why is algae a great source for fuel?"

"Does algae have energy?"

"Where does the algae get energy from?"

Vocabulary Terms:

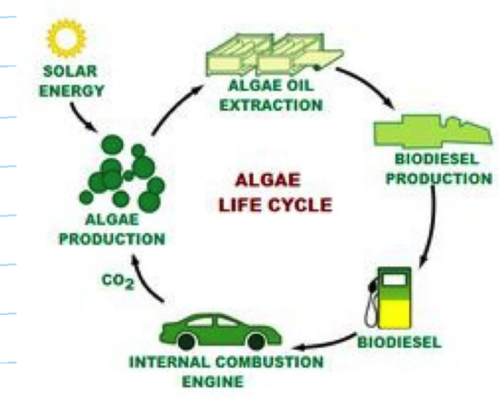
- Algae: a simple, nonflowering, and typically aquatic plant of a large group that includes the seaweeds and many single-celled forms. Algae contain chlorophyll but lack true stems, roots, leaves, and vascular tissue.
- Bioluminescence: the biochemical emission of light by living organisms such as fireflies and deep-sea fishes.
- Colloid: a mixture is two or more substances mixed together but not chemically combined (they can be separated)
- Gas: matter without a fixed shape or volume, but can fill its container.
- Liquid: an object with a fixed volume, but without a fixed shape and can take the shape of its container.
- Mixture: a mixture is when two or more substances are combined, but each substance keeps its physical properties
- Observations: Observation is the process of using one's senses to gather information about the world
- Solid: an object with both a fixed shape and a fixed volume
- Solution: a mixture of two or more substances that stays evenly mixed.

Scientific Background:

Algae is a group of aquatic nucleus-bearing organisms that lack roots, stems, leaves, and other functions that are typical of most plants. Algae is a critical food source in the marine life ecosystem. Animals such as snails, fish, and reptiles graze on algae. Algae is not only a good source of protein for these animals but also has a key role in producing oxygen to maintain a healthy marine ecosystem. In recent developments, research in sustainable energy has discovered that algae can be used as an alternative to liquid fossil fuels. Algae is not only a source of energy for marine life but can also be a source of energy for human transportation. Algae can be turned into biofuel through the extraction of fatty acid contained in lipids. To extract this fatty

Fun Fact!

This diagram is a basic cycle of how algae is developed and then how it is turned into a biofuel source for human transportation such as a car.



Source: https://cla.auburn.edu/ces/energy/algae-as-energy-a-look-to-the-future/

acid it requires removing all the water from the algae. This results in a dry powder or "slurry" substance. For instance the Jell-O packet mix is in a powder green and looks similar to the dehydrated algae. Algae has the potential to yield at least 30 times more energy than land-based crops such as other alternative energy sources like corn and sugarcane. The Navy is exploring the use of algae as a biofuel source. The use of eco-friendly fuels such as algae are generally much better for the environment as compared to fossil fuels like diesel and gasoline.

STEM Related Career:

- Energy Analyst
- Energy Transition Technical Specialist
- Energy Systems Engineer

Reference Photo:

Fun Fact!

This reference photo is an example of the excess growth of algae blooms due to stagnant water combined with the rise of warm temperatures.

NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

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#SeaworthySTEM

Biofuel Jell-O Teacher Guide

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Biofuel Jell-O

Grades 3-5

Student Activity Workbook

Name: ______________________________

Date: ______________________________

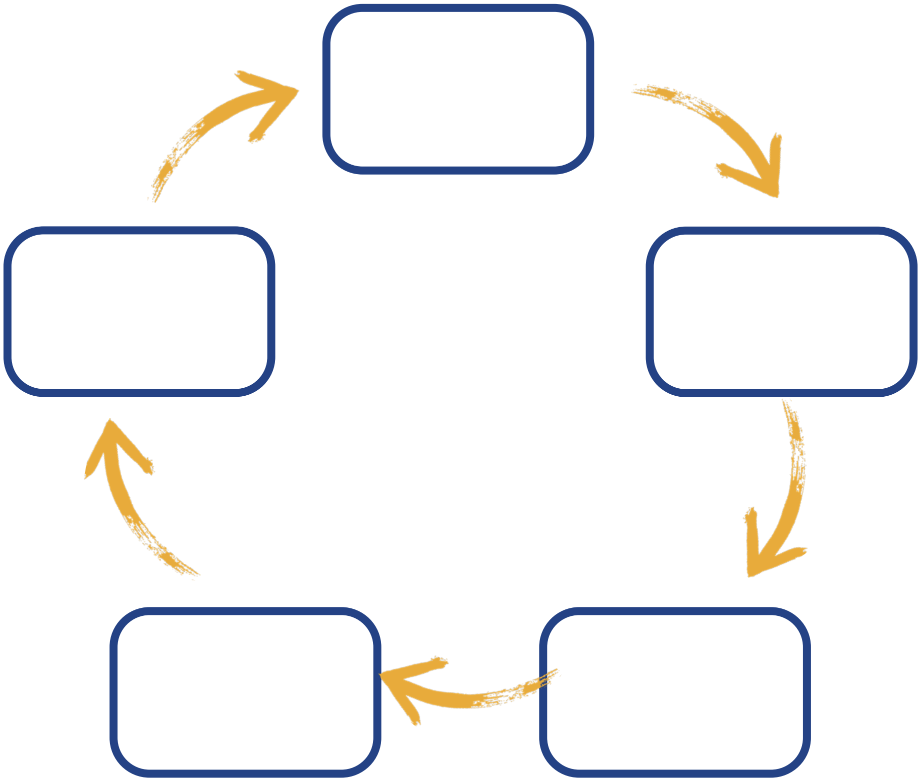
Seaworthy STEM™ in a Box Series

Biofuel Jell-O

1

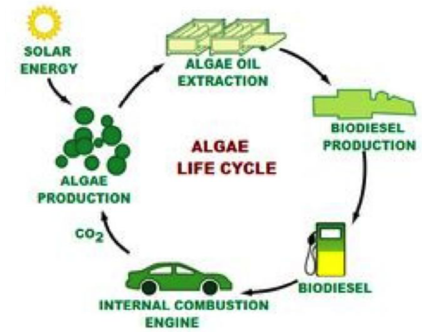
Solution Type	Prediction (What will it look like tomorrow?)	Observations	Does it react with blacklight?
Biofuel Jello			
Jello and Tap Water (normal recipe)			
More Jello Powder and Less Water			
Less Jello Powder and More Water			

2 In the blank circular diagram below, use colors to draw and label the steps to explain the process of how to make biofuel Jell-O. Remember to label each part of the process.



Helpful Tip!

Use the biofuel algae diagram to help you brainstorm some ideas!



Fun Fact!

This diagram is a basic cycle of how algae is developed and then how it is turned into a biofuel source for human transportation such as a car.

3 Think about what you have learned today about sustainable energy. Now think about what you used today to create biofuel Jell-O. In the two boxes below, describe the **similarities and differences** between biofuel Jell-O and biofuel algae.

Similarities:

Differences:

4 In the text box below, write a short paragraph describing why sustainable energy is important for our planet? What kind of careers do you think work with the development of sustainable energy?

#SeaworthySTEM

Biofuel Jell-O Engineering Notebook

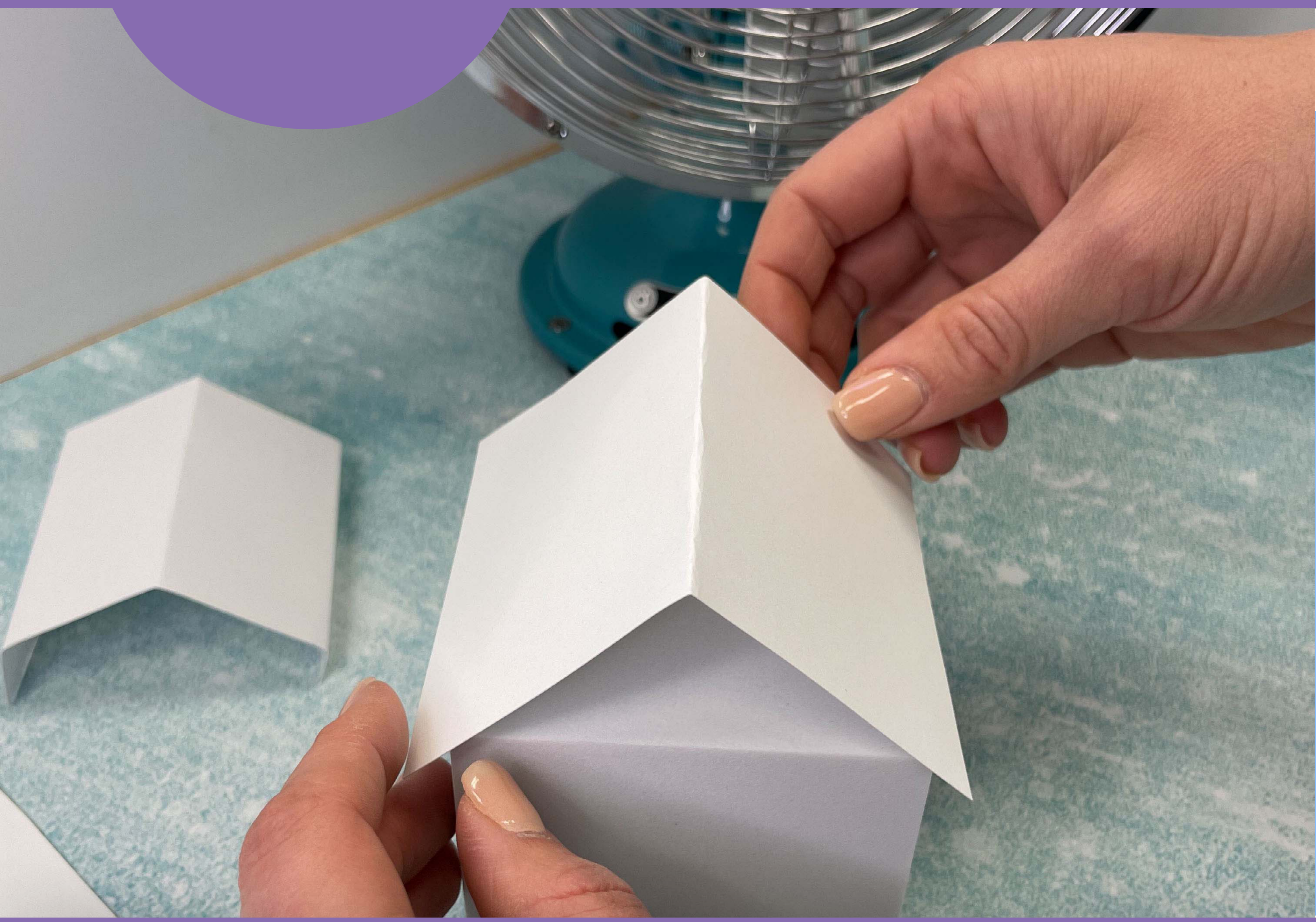
Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Brace Against the Wind

Grades 3-5

Teacher Guide



Seaworthy STEM™ in a Box Series

Brace Against the Wind

Teacher Guide for 3-5

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NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

Table of Contents

Lesson Title: Brace Against the Wind

Time:
1 Class period (45-60 minutes)

Student Objectives:

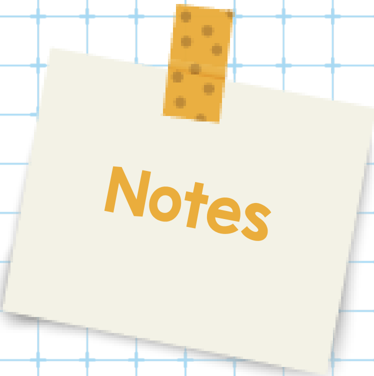
Students will gain knowledge about severe weather and the negative impacts it can have to our cities. Students will work together to design and build paper houses to withhold severe winds. Students will utilize the iterative design process to secure a roof to a paper house that will not blow away.

Lesson Overview:

This lesson is designed to teach students that severe weather; such as hurricanes, can have a negative impact on civilization. Students will learn about environmental engineers and their research to develop structures that can withstand severe weather conditions. Designing safe weather shelters are crucial to protect people and vehicles such as boats. Students will learn about different shapes and types of roof designs. Students will use the re-design method to find the best roof solution to withstand high winds. The students will likely conclude that a hip roof is best solution to use.

Next Gen Science Standards:

4-ESS3-2
3-ESS3-1

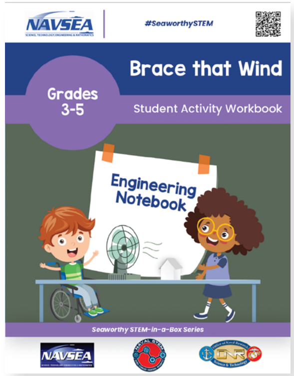


Materials and Equipment List:

- White card stock
- Cardboard desk divider (Testing area)
- Fan (Testing area)
- Scissors
- Markers
- Toy boat
- Stopwatch

Student Activity Sheets/Handouts:

Brace That Wind Student Activity Workbook



Technology Tools:

Stopwatch

Suggested STEM Related Literacy Book:

Feel the Wind by Arthur Dorros

Pre-Procedure:

1. Place the fan on a table. Use Desk divider to create a controlled testing area for paper houses.

Procedure:

1. Students will be given a brief introduction about severe weather, especially hurricanes and the negative impacts to man-made structures.

2. Students will be given the following task and goal to achieve a secured safety shelter.

    A. **The Task:** To create a safe shelter for the toy boat by securing the best roof to withhold extreme weather conditions.
    B. **The Goal:** The roof must stay on the shelter for a minimum of 30 seconds.

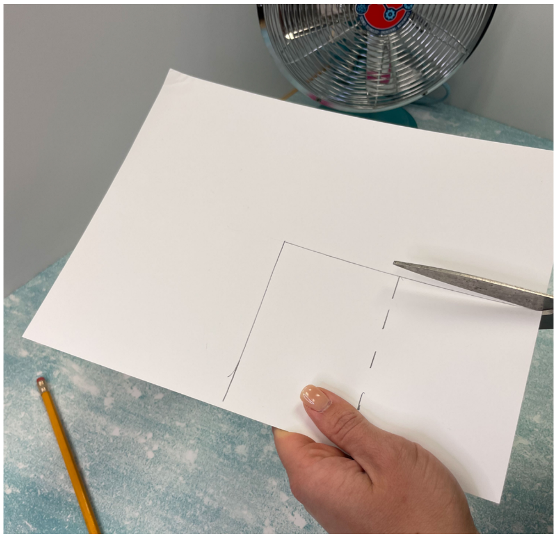
3. Use the following rules for each team during the challenge.

    C. **The Rules:**
    - No tape. (Tape may be used to build and keep the body of the structure maintained but no tape may be placed on the roof.)
    - You may fold or cut paper in anyway.
    - The front of the roof must be placed in the same direction of the front of the house.

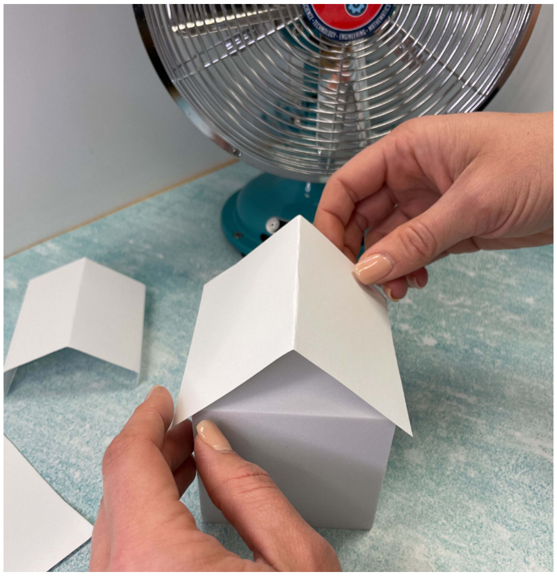
4. The teacher will give students the materials listed and split the class into teams.

Remember to place the boat inside the safety shelter when testing.

5 Give students 15-20 minutes to plan, design, and experiment on making a model shelter that will withstand the hurricane fans. Students can use the structural roof guide in the engineering notebook for help.



6 The teacher will facilitate the testing area and help students test their design. Students will use the stopwatch to time the structure withholding the high winds.



7 Students will be given time to re-design their model house if a failed attempt in experimenting. (Remember, if the roof falls off before the 30 second goal than the team must go back and redesign a new roof.)

Helpful tip:
You can use tape to secure the body of the house to the table. No tape on the roof.

8 The teacher will walk around the room to ensure that all of the groups are using the redesign process in their attempt to find a solution to the problem.

9 After experimenting, the teacher can lead students into writing their observations and conclusions on the activity sheet.

10 The teacher can have a whole group discussion with the class focused on the prompts in the margin.

11 The teacher can finish this activity with the suggested STEM literacy book.

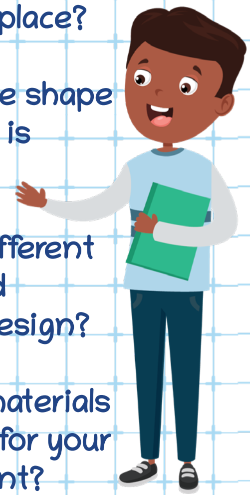
The teacher can have a group discussion with the following questions:

Why or why not did your shelter stay in place?

Do you think the shape of your design is important?

Do you think different materials would improve your design?

What type of materials would you use for your next experiment?



Vocabulary Terms:

- Aerodynamics: The study of the motion of air, particularly when affected by a solid object like an airplane
- Drag: The aerodynamic force that acts opposite to the direction of motion
- Gable Roof: A roof with two sloping sides and a gable at each end
- Hip Roof: A roof with the ends inclined, as well as the sides
- Lift: The aerodynamic force that moves an object upwards

Scientific Background:

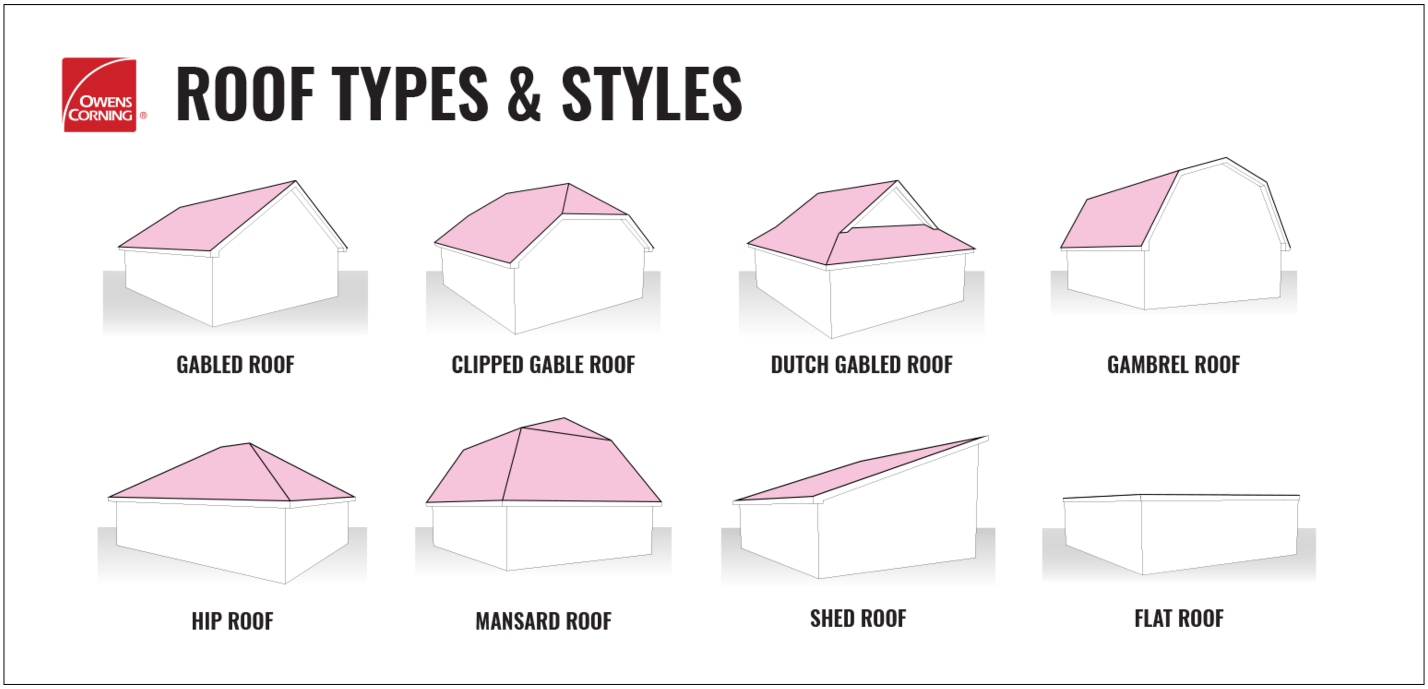
Engineers study climate, air pollution, and weather to address problems which might occur over the course of a building's life. It is crucial for architects and engineers to create and maintain buildings that are strong enough to withstand severe weather. Designing buildings can be similar to designing airplanes when it comes to aerodynamics. For this activity, students will determine the best type of roof for their shelter. The best result is to use a hip roof. Hip roofs are widely considered to be amongst the strongest types of structures.

A hurricane is a type of storm that forms over warm ocean water. It is also called a tropical cyclone. The warm water provides the energy that fuels the storm. A hurricane starts with a small area of low pressure, which means there is less air in that area than in the surrounding air. This low-pressure area causes the surrounding air to rush in, which creates wind. As the wind continues to blow, it causes more air to rise and more wind to form. This cycle continues and the storm grows bigger. When a hurricane reaches sustained winds of 74 miles per hour (119 kilometers per hour) or more, it is classified as a hurricane. Hurricanes are very powerful and can cause a lot of damage. They can produce strong winds, heavy rain, and storm surges (a rise in sea level caused by the storm) that can cause flooding.

STEM Related Career:

- Meteorologist
- Environmental Scientist
- Civil Engineer

Reference Photos:



https://www.ohioexteriors.com/8-common-roof-types

Fun Fact!

When a ship tips due to wind or waves, there is a righting motion caused by several engineered elements that brings the vessel upright once more. This includes the structural weight including placing heavier equipment and cargo below deck to create a low center of gravity. However, there comes a point in which a ship cannot correct itself and will capsize. This is the tipping point or angle of vanishing stability. Knowing at what angle a ship can safely roll and when it is in danger are crucial for naval architects and pilots alike as they work to keep the lives of those on board safe.

Fun Fact!

Even though we are designing paper houses in this experiment, builders wouldn't want to use paper to build an actually shelter! When building a safety shelter, engineers and architects use mental to build the structure's roof. A metal roof can weather hurricane-force winds up to 160 mph, making it the most wind-resistant solution. Metal roofing systems are expensive but they last longer and are more durable than any other types of roofing.

Notes

NAVSEA

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

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Brace Against the Wind Teacher Guide

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

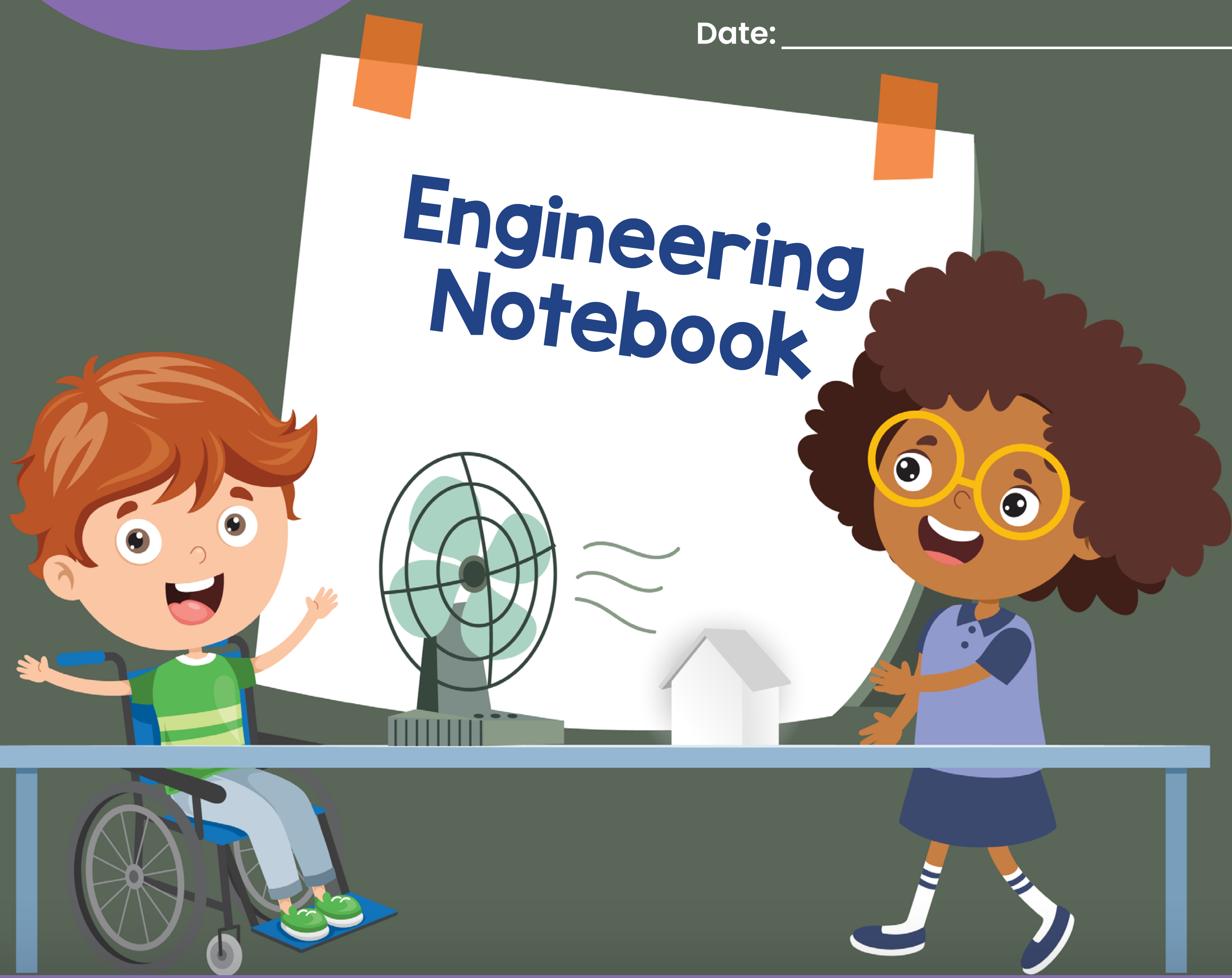
Brace Against the Wind

Grades 3-5

Student Activity Workbook

Name: ______________________________

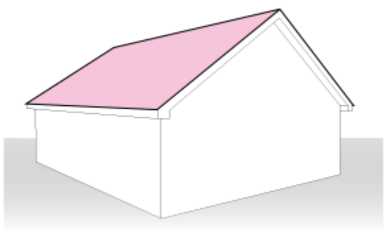
Date: ______________________________



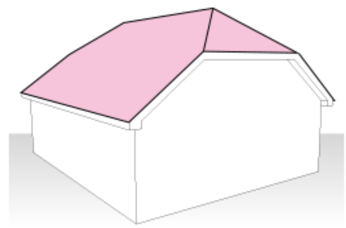
Seaworthy STEM™ in a Box Series

Brace Against the Wind

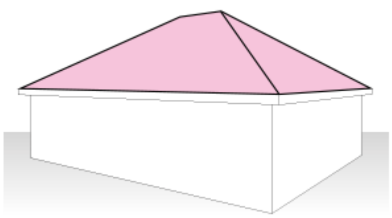
Roof Types and Styles:



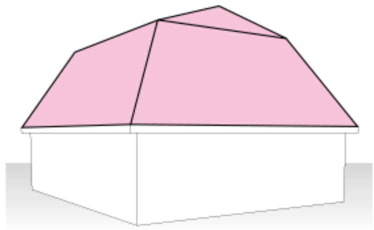
GABLED ROOF



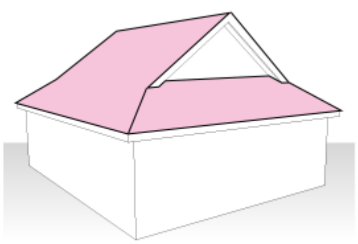
CLIPPED GABLE ROOF



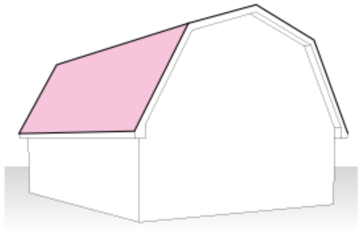
HIP ROOF



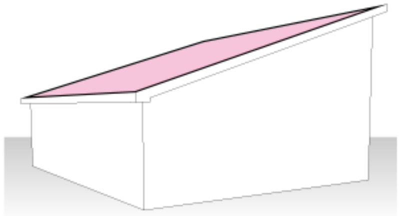
MANSARD ROOF



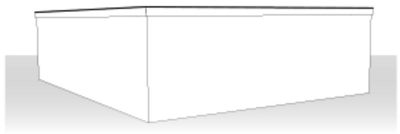
DUTCH GABLED ROOF



GAMBREL ROOF



SHED ROOF



FLAT ROOF

Did You Know?

Engineers study climate, air pollution, and weather to address problems which might occur in a building's life. It is crucial for engineers to create and maintain a safe infrastructure with the ability to withstand severe weather conditions. Designing buildings can be similar to designing airplanes when it comes to aerodynamics.

I Your team was tasked to find the best solution to protect the boat from extreme weather conditions. Look at the pictures on page 2 of the workbook. What type of roof do you predict will work best when tested in windy conditions? Describe why by completing a short paragraph then drawing a design of what your team will build for testing.

Describe:

Draw out your solution:

2 **Redesign.**

Please write in the space below of how you changed your design and why. Please draw your newly redesigned roof in the box at the bottom of the page.

Describe:

Draw out your solution:

3 The Navy has hundreds of boats within its fleet! When the weather forecast predicts possible hurricanes or other natural disasters, where do you think the Navy moves its fleet to protect the boat and crew members?

4 Environmental scientists and engineers are constantly creating new solutions and ways to protect our buildings and citizens from natural disasters. Below is a model of a town by a coastline. The weather forecast predicts high winds, rise of water levels, and possible flooding. What would you do to protect the town? Draw out your solution and use the text box to describe how you would protect the town.

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#SeaworthySTEM

Brace Against the Wind Engineering Notebook

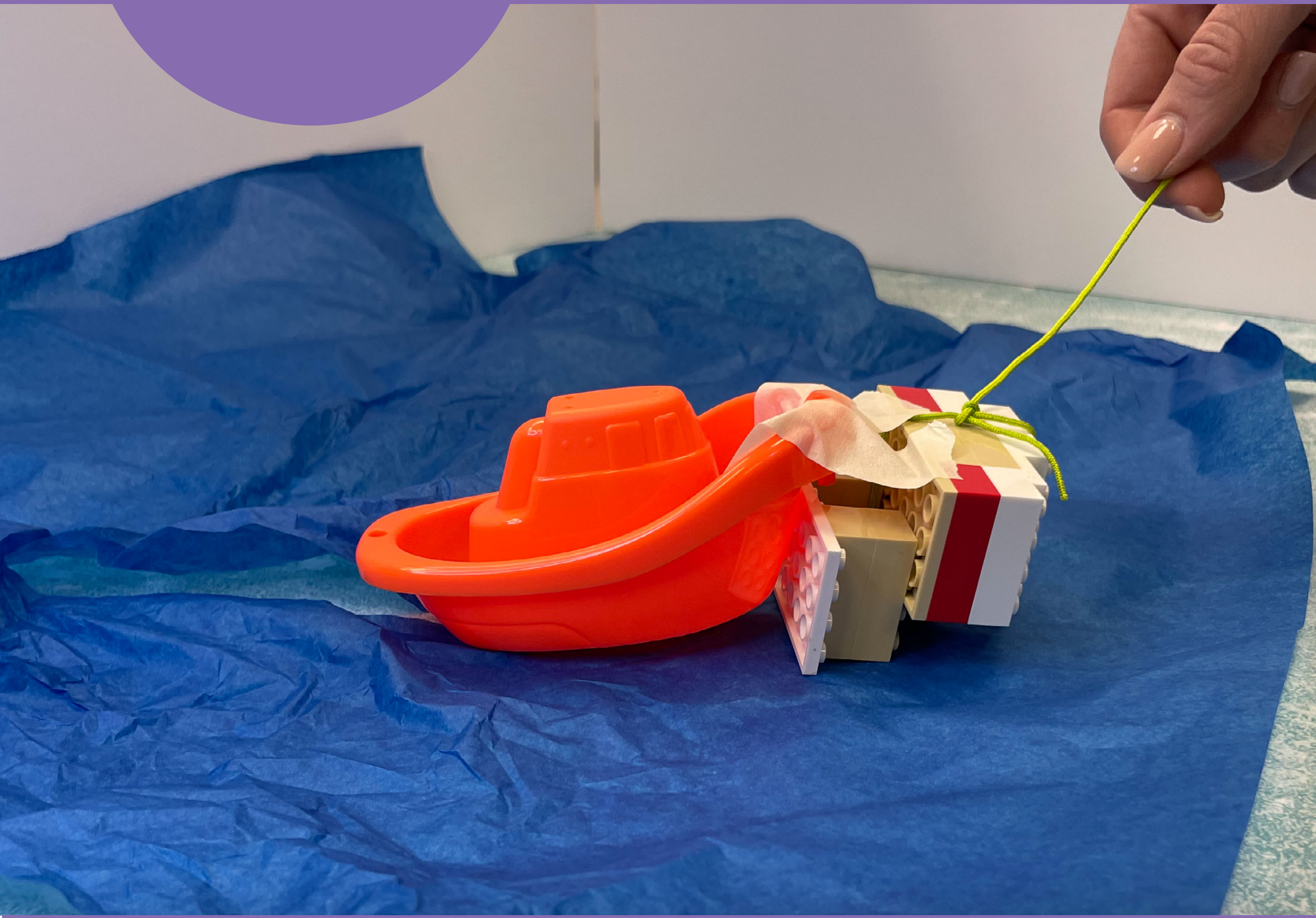
Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Break the Ice

Grades 3-5

Teacher Guide



Seaworthy STEM™ in a Box Series

Break the Ice

Teacher Guide for 3-5

Seaworthy STEM™ in a Box Educator Kit description:

Seaworthy STEM™ in a Box activities are a Navy initiative to provide enhanced Naval-relevant, standards aligned, hands-on activities to K-12 teachers and students. Components of this program include, curated sets of classroom activities that aim to build deep conceptual understanding in Naval-relevant content areas. The kits also includes comprehensive lesson plans, material lists, scientific background information, STEM related literacy books, and student activity sheets. The Seaworthy STEM™ in a Box program is designed to support teachers as they select content, acquire materials, and implement more hands-on STEM activities in their classrooms. Increasing student access to hands-on STEM activities, also increases awareness of STEM career paths, engage students in STEM, and support development of student's abilities in STEM content.

The Seaworthy STEM™ in a Box kits were designed to guide students through the scientific inquiry-based theory and the engineering design process. The content and Naval-relevant activities are aligned with the Next Generation Science Standards. The topics and content covered within the lessons are connected and scaffolded based on distinct grade bands (K-2nd, 3rd-5th, 6th-8th, and 9th-12th).

NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

Table of Contents

Lesson Title: Break the Ice

Time:
1 Class period (45-60 minutes)

Student Objectives:

Students will gain knowledge about ship design and about specialty boats such as Icebreaker ships. Students will plan and design their own Icebreaker ship. Students will work in teams and experiment their ship design by “breaking” the ice platform. Students will collaboratively design their ship so that it is able to break the “ice” while adding the least amount of mass to their ship.

Lesson Overview:

Students will learn about Icebreaker ships and how they are used to break the ice for voyages in freezing waters. Students will learn that the main purpose of icebreaker ships is to clear a pathway through the ice to help prevent other ships from getting stuck. Students will work in teams and use the engineering design process to create their own icebreaker ship. Students will be given the task to “break” the ice on their voyage. Students will have completed the task if the “ice” platform has broken due to the ship breaking the ice formation.

Next Gen Science Standards:

3-PS2-1
3-PS2-2
4-PS3-1
4-PS3-3

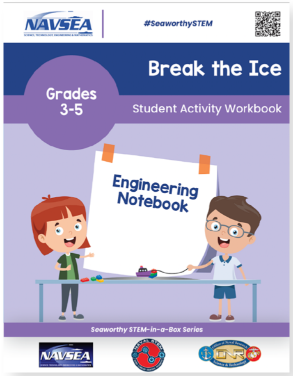
Notes

Materials and Equipment List (Per Team):

- ☑ 1 Toy Boat
- ☑ Lego tape or regular tape
- ☑ Legos or other forms of blocks
- ☑ 1 sheet of blue or white tissue paper
- ☑ Scissors
- ☑ String
- ☑ Digital Scale
- ☑ Ruler

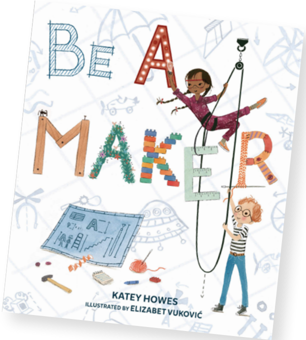
Student Activity Sheets/Handouts:

Break the Ice Student Activity Workbook



Suggested STEM Related Literacy Book:

Be a Maker by Katey Howes



Pre-Procedure:

1. Each team should set up two desks that are 2 ft. apart. Take the sheet of tissue paper and tape one end to the end of the desk. Then tape the other side to the end of the second desk. The tissue paper will act as the ice that is formed on top of the ocean.

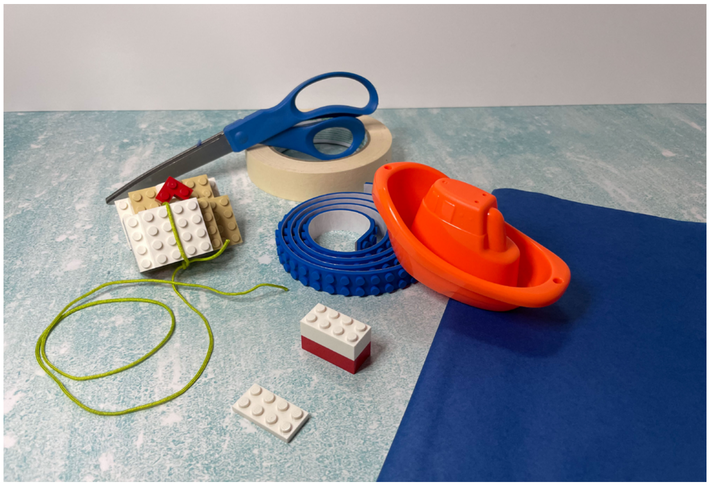
2. Each team will measure and cut 12 inches of string. Then tie the string to the front of the boat. The string will be used to pull the ship across the tissue paper.

Helpful tip:
Before taping down the tissue paper. Make sure to crinkle up the tissue paper to act as water/ice in the ocean.

Procedure:

1. The teacher will give students a brief introduction to the lesson about Icebreaker ships. The teacher will describe the importance of the hull being heavy enough to break the ice (tissue paper).

2. The teacher will split students into teams then give the listed materials to each team.

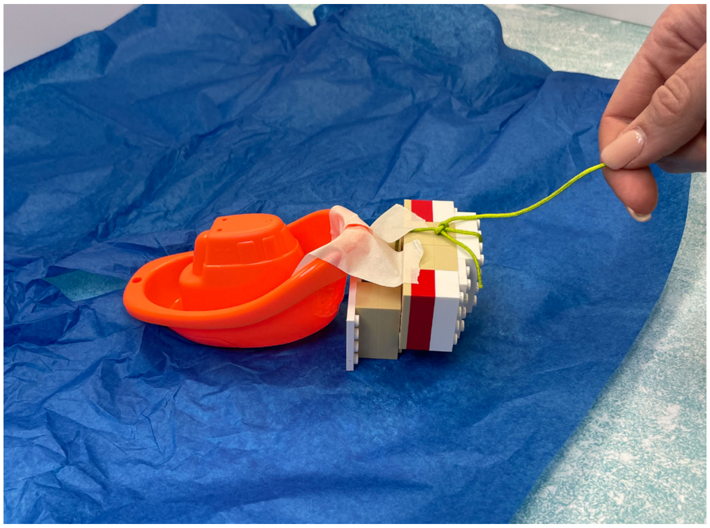


3. The teacher will model the activity and discuss the task and goal for each team. The teacher will demonstrate how to apply the Legos on to the hull of the toy boat.

    A. **The Task:** Each team will create an icebreaker using the blocks to create a heavy hull.
    B. **The Goal:** The hull will be heavy enough to rip the tissue paper.

4. Give students the following guided student directions on page 9 and allow students time to build and test their designed icebreakers.

5. Once design is complete, have students apply their icebreaker ship by using the string to pull the ship across the tissue paper. The goal is for the boat to tear the tissue paper by the weight of the hull, (Legos).



6. If a team does not complete the goal then the team will need to redesign and apply an improved hull.

7. When completed, teams will clean up their station.

Fun Fact!

Did you know that the Navy doesn't operate the icebreakers fleet but the U.S. Coast Guard does! The Coast Guard currently has only two operational icebreakers in its fleet actively working with the Arctic Ocean.

Student Directions:

1. As a team, draw and plan the design for the Icebreaker ship.
2. Place the tape on the front of the ship.
3. Place Legos on the front of the ship. Your design and Icebreaker model should align.
4. Place the boat at the start of the tissue paper.
5. One team member will drag the boat across the tissue paper using the string to pull across.
6. Students should observe if the icebreaker ship is "breaking the ice" by tearing the tissue paper as it crosses over.
7. If the boat does not break the ice. The team will have to redesign the boat and try again.
8. Once the students' boat has broken the ice they should put their Legos on a digital scale to find the mass of their build. They should then record the mass in their student activity workbook.

Fun Fact!
For a ship to be considered an icebreaker, it requires three traits that other ships do not have. To be an icebreaker the ship must have a strengthened hull, an ice-clearing shape, and the ability to push through the sea ice.

Vocabulary Terms:

- Antarctica or Polar Region: A continent around the South Pole, situated mainly within the Antarctic Circle and almost entirely covered by ice sheets.
- Arctic Ocean: A sea that surrounds the North Pole and lies within the Arctic Circle. Much of the sea is covered with pack ice throughout the year.
- Hull: A hull is the watertight body of a ship or boat.
- Propeller: A mechanical device for propelling a boat or aircraft, consisting of a revolving shaft with two or more broad, angled blades attached to it.

Scientific Background:

Icebreakers are designed to break through the thickest ice in the Atlantic Ocean, mostly in the Polar Regions. Icebreaker ships are designed to break through the ice by the strength of the hull. The bow on the hull of the ship is usually round so that it can ride over the ice and make it break due to the weight of the vessel. The rounded bow hull helps the icebreaker ship to go over the thick layers of ice as the friction is much less than trying to cut through the ice. The heavy weight of the hull is crucial to break the ice. The weight of the ship crushes the ice as it glides over it. The smooth design of the hull ensures that the ice gets pushed out of the way. This will allow other ships to be able to pass through the same route as the Icebreaker leads the way.

STEM Related Career:

- Ship Design
- Marine Transportation Specialist
- Navy Seaman

Reference Photos:

Notes

NAVSEA

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

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#SeaworthySTEM

Break the Ice Teacher Guide

Seaworthy STEM™ in a Box Series

NAVSEA SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

#SeaworthySTEM

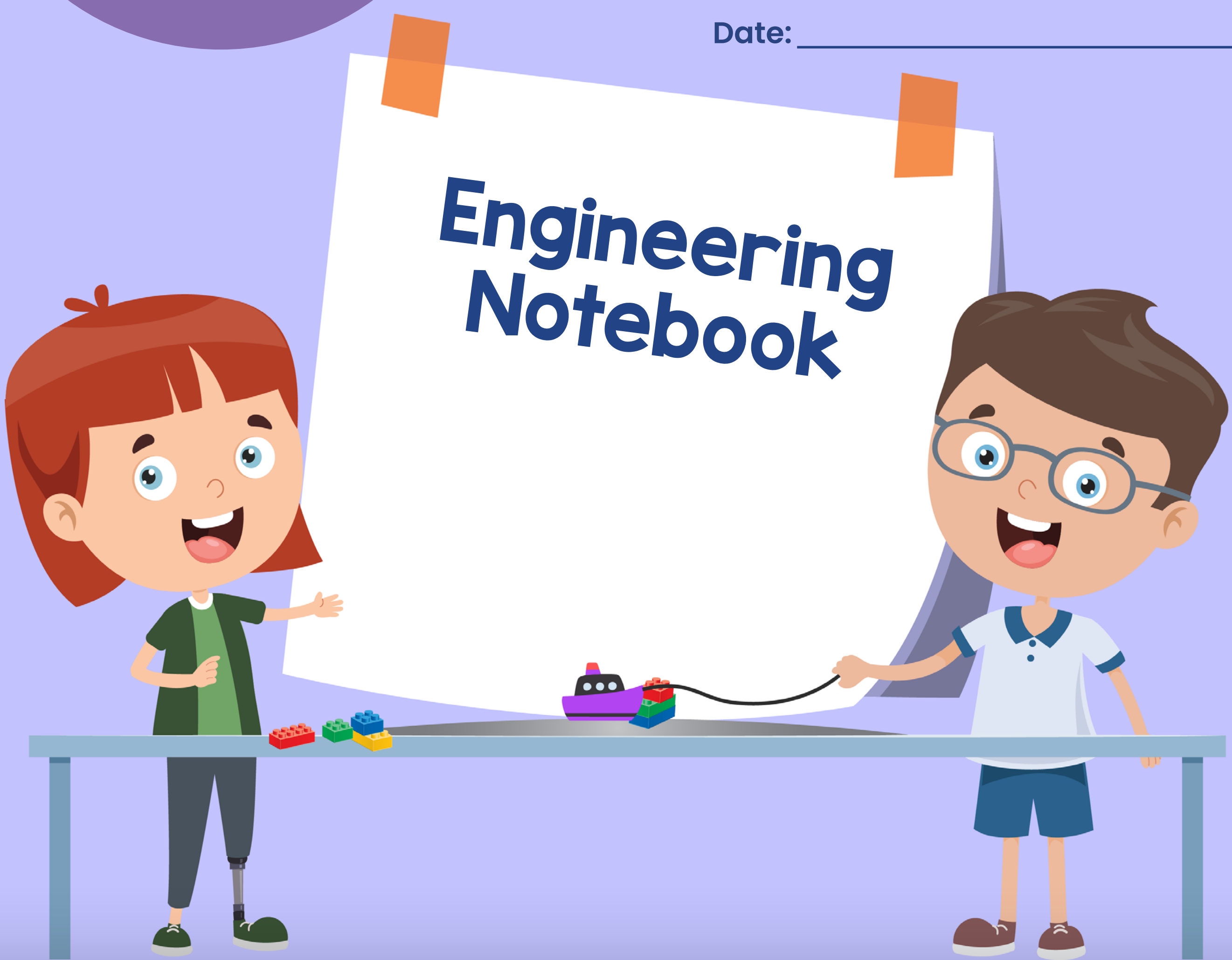
Break the Ice

Grades 3-5

Student Activity Workbook

Name: ______________________________

Date: ______________________________



Seaworthy STEM™ in a Box Series

Break the Ice

1 Fill in the blank:

Icebreaker ships are designed to ________________ the ice to create a safe passageway in the Arctic Ocean. Icebreakers do not break the ice by cutting into it but rather the ship's ________________ pushes down on the ice.

2 Your team was tasked with creating enough weight at the front of the ship to tear the tissue paper. In the box below, draw your design which will show how you will create a heavy bow to break through the "ice." Make sure that you label each of the items in your drawing (including the number of each item). Your team's goal is to position your materials so that you add the least amount of mass to your ship while still being able to break the "ice."

Fun Fact!

Did you know that the Navy doesn't operate the icebreakers fleet but the U.S. Coast Guard does! The Coast Guard currently has only two operational icebreakers in its fleet actively working with the Arctic Ocean.

3 After you are able to break the ice, you should find the mass (in grams) of your entire build. *All of the materials including the boat and the string should be on the scale. Record the mass in your student activity workbook.

4 Your team and you were given different types of materials to build your model icebreaker. Let’s pretend your teacher has now asked you to build a new and improved model icebreaker, what different materials would you use from the classroom to create a new model icebreaker? Why would you use these materials?

Fun Fact!

For a ship to be considered an icebreaker, it requires three traits that other ships do not have. To be an icebreaker the ship must have a strengthened hull, an ice-clearing shape, and the ability to push through the sea ice.

#SeaworthySTEM

Break the Ice Engineering Notebook

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Glacier Gak

Grades 3-5

Teacher Guide

Seaworthy STEM™ in a Box Series

Glacier Gak

Teacher Guide for 3-5

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NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

Table of Contents

Lesson Title: Glacier Gak

Time:
1 Class period (45-60 minutes)

Student Objectives:

Students will gain knowledge about glaciers and the importance of research on the formation of glaciers. Students will make a kitchen recipe of gak and place the gak on a downward slope to recreate the formation of glaciers. Students will gain visual observations of how glaciers move.

Lesson Overview:

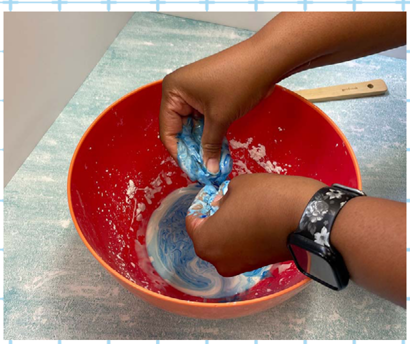
Students will learn about glaciers and use this background information to recreate a glacier using household items. Students will be in teams to make glacier gak from water, color dye, and cornstarch. Students will then layer the two colors, (Blue & white) by stacking them on top creating a pattern. The gak will slowly move down the slope and this recreation will demonstrate how glaciers form. The final product will be layers of white and blue gak spreading out over the foil pan. This represents the hundreds of years of annual precipitation that has layered on top of each other within the formed glacier.

Next Gen Science Standards:

3-ESS2-2
3-LS4-4
3-LS4-1
4-ESS2-1
5-PS1-3
5-PS1-4

Notes

Warning!
This lesson could get messy! For best results, have students use their hands to make the gak!"

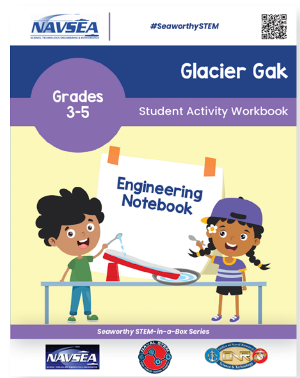


Materials and Equipment List (Per Team):

- Washable paint, (blue)
- Foil pan
- Scissors
- Tape
- 2 bowls
- 2 plastic cups
- ½ cup of Water
- 1 cup of Corn starch
- 2 spoons
- Stopwatch
- Camera

Student Activity Sheets/Handouts:

Glacier Gak Student Activity Workbook

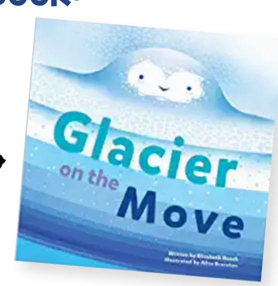


Technology Tools:

- Stopwatch
- Camera (Extension Activity)
  - Have students use cameras to take photos or video of their glacier going down the slope.

Suggested STEM Related Literacy Book:

Glacier on the Move
by Elizabeth Rusch



Procedure:

1. The teacher will start the lesson by going over basic science content about glaciers. (The teacher will introduce the lesson with whole group questions to create classroom dialogue).

2. The teacher will then model how the students should construct their glacier.

3. Students will be given materials and split into small groups.

4. Give students 10-15 minutes to make the kitchen gak. Use the following recipe and divide half of the finished gak into one bowl. Then pour the remaining gak into another bowl. Finally, add the blue paint to only 1 bowl to create a blue gak. Each team should have 1 bowl of blue gak and 1 bowl of white gak.

Gak Recipe per group:
1 cup corn starch mix with ½ cup of water.
Add 1-2 drops of washable blue paint to create desired color.

5. Have students set aside the gak, and create a slope using two plastic cups that are cut and taped together to build a slope. Place the slope at a tilted incline angle. Place the bottom of the slope inside the center of the foil pan. Use tape to secure the bottom and top of the slope.

Teams can use other classroom materials to create an incline slope.

The teacher can guide students through the following questions:

"What is a glacier and where can you find one?"

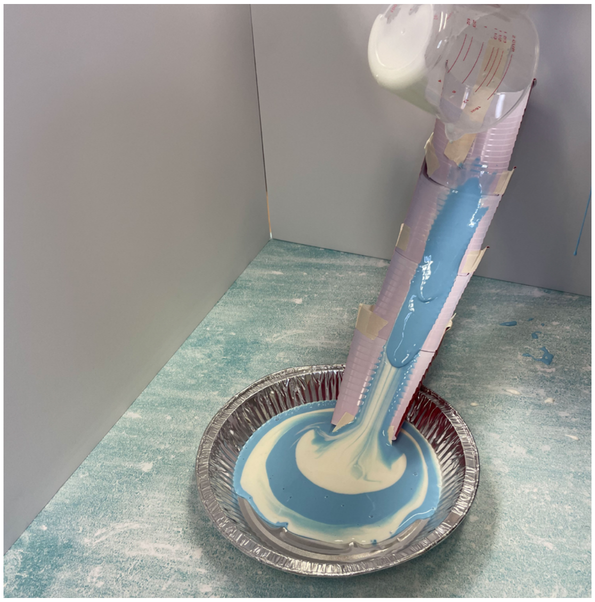
"Do you need an incline plane or slope for a glacier to form? Examples?"

"Why do you think scientists would collect data and observe glaciers?"

Helpful tip:
To add another element to the design process, have students use inquiry learning to collaborate on the tilt of the incline plane.

6 The students should work together to create "layers" of ice crystals by pouring gak colors at the top of the slope. Start with the white gak. Have the students record the time it takes for the majority of the gak to flow down the ramp into the pan. Have them record their time in the student activity workbook.

7 Then the other teammates will pour blue gak directly above where the white gak was poured. Repeat this by pouring every other color to create a pattern of blue and white. Have the students record the time it takes for the majority of their 2nd gak mixture to flow down the ramp into the pan. Have them record their time in the student activity workbook.



Helpful tip: *This is a great time to remind students that "pouring the gak" is similar to a yearly amount of precipitation falling onto the glacier. For example, a big pour would be similar to a year full of heavy rain or snowfall.*

Bonus:

Want to add an element of technology to this activity?! Have students take pictures of their glacier moving down the slope. Students can then make a timelapse with the photos they made.

8. Have students observe how the glacier gak moves down the pipe. Have students collect observation notes on the glacier observation worksheet.

9. When the glacier is done moving down the slope, have students observe the "pooling" that has formed at the bottom of the slope. Students will observe that the gak colors do not blend but rather create rings.

10. Then have students help clean up their station.

11. To conclude this activity, create a whole group discussion using the following concluding questions.
    A. "What did you observe about the movement of the gak?" (Slow or fast?)
    B. "Do you think glaciers move at the same speed or form slower/faster?"

Fun Fact!

Your students will be intrigued by the glacier gak they have created! This gak is a great representative of a polymer. Certain substances act like a liquid until pressure is applied. Then they appear to be a solid. Other great examples of polymers are slime or flubber!

Extension:

Make slime from Borax (A special kind of laundry detergent) and glue then compare its flow rate with the gak. This fun addition will encourage the class to do a comparative mathematical analysis involving different substances as well as providing an opportunity to learn more about polymers.

Slime Recipe:
Slime has two components: a borax and water solution and a glue, water, and food coloring solution. Prepare them separately:

1. Mix 1 teaspoon of borax in 1 cup of water. Stir until the borax is dissolved.
2. In a separate container, mix 1/2 cup (4 oz.) white glue with 1/2 cup water. Add food coloring, if desired.
3. Combine the two mixtures using a bowl and a spoon.

Vocabulary Terms:

- **Atmosphere:** The layer of gas that surrounds Earth.
- **Atom:** The basic building block of matter.
- Climate: The weather found in a certain place over a long period of time.
- **Erosion:** Where land is worn away by different forces. These forces can be water, wind, and ice. It can change the shape and texture of mountains and many other things too.
- **Glacier:** A large area of thick ice that remains frozen from one year to the next. Glaciers also slowly flow over the land.
- **Landforms:** The natural features of the surface of Earth.
- **Molecules:** A molecule is two or more atoms joined (or "bonded") tightly together.
- **Polymer:** Very big molecules made up of many smaller molecules layered together in a repeating pattern.

Scientific Background:

Glaciers are found throughout the world but mostly found around the poles of the Earth. A glacier usually starts to form where snow remains in the same area year-round. A glacier is a large mass formed from ice, rock, snow, and water that has accumulated over time from moving down a slope, for example within a valley or land that has a downward slope towards a body of water. A glacier is a body of dense ice that is constantly moving under its own mass. Glaciers are a great resource for scientists to research and collect data on the Earth's formation from over thousands of years ago. Scientists collect data from drilling into the glacier and collecting samples of the glacier. Scientists then examine the ice crystal formation and minerals within the ice sample. Gathering this data can inform scientists what the Earth's climate was like during the time period a glacier was formed. A glacier's formation can take as long as 100 to 150 years to be fully formed. Glaciers that are located around the poles tend to stay in contact due to the climate staying at a freezing point. Many glaciers in the Antarctic have dated to be millions of years old! The data collected from these glaciers help scientists discover the climate during this primitive era on Earth.

STEM Related Career:

- Glaciologist
- Environmental Scientist
- Geologist

Reference Photos:

Fun Fact!

Did you know that Sailors on the Navy's polar research have found enormous Antarctic glaciers vanishing at an alarming rate? For example, the Sunshine Glacier has shrunk by one seventh in 20 years - an area the size of more than 130 football pitches has melted away. The Navy crew members have recorded the worrying changes when annually visiting the glacier on Coronation Island.

Fun Fact!

Scientists are able to take test samples of a glacier by drilling into the core using a machine called an ice corer. The ice corer is designed very similar to a drill. It has a thread which runs around the outside of the hollow central tube which, when turned, draws the corner into the ground. The sample is forced into the central chamber so that once the ice corer is pulled back up from the ground, the sample can be removed ready for storage and the journey home.

Fun Fact!

Did you know that glaciers are similar to trees? As ice in the glacier lays down in successive layers from previous years, the glacier is similar to the same formation in tree rings. These layers record the weather patterns and circulation as Earth cycles through colder and warmer periods. Just like the inside of a tree, glacier samples look very similar and tell us the history of that glacier's life!

NAVSEA

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

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Glacier Gak Teacher Guide

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

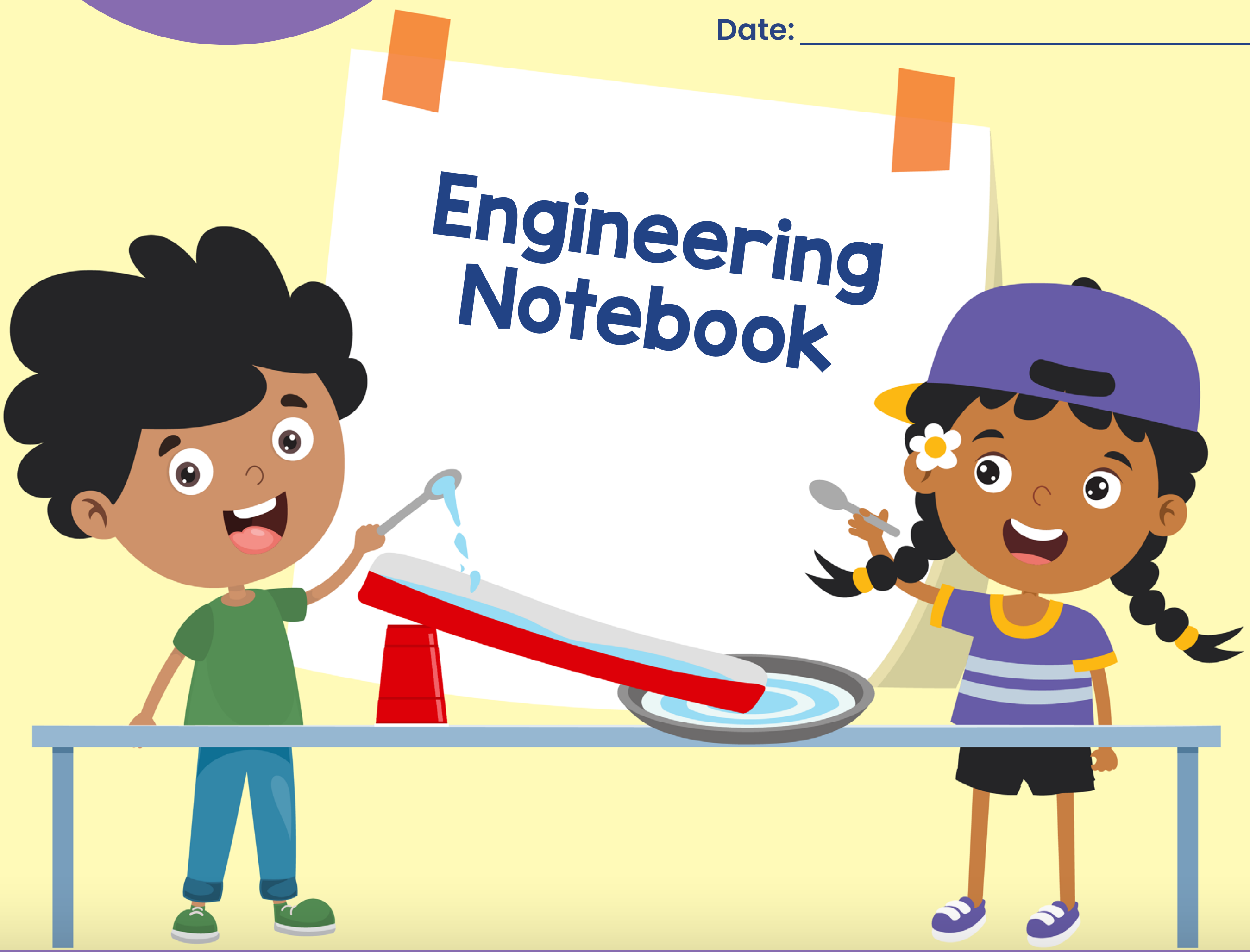
Glacier Gak

Grades 3-5

Student Activity Workbook

Name: ______________________________

Date: ______________________________



Seaworthy STEM™ in a Box Series

Glacier Gak

1 As the glacier gak moves down the slope, use the text box below to describe your observations. Draw and color to describe what you see, hear, smell, and or touch!

3 Record the time of the white gak mixture:

Record the time of the blue gak mixture:

What factors could have made the times different? Will glaciers always move at the same speed in real life? What are some reasons that glaciers may vary in speed from year to year?

3 Once your glacier is done moving down the slope you will notice the glacier has created a pattern at the bottom of the pan. What do you think the pattern can tell you about your glacier?

4 A **glaciologist** is a scientist who studies the movement and physical properties of glaciers. Glaciologists also study the formation of ice. What kind of environment would a glaciologist have to work in? Would you want to become a glaciologist? Why or why not?

Fun Fact!

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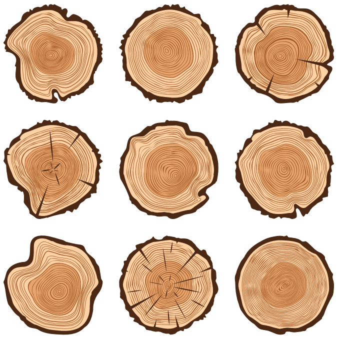

#SeaworthySTEM

Glacier Gak Engineering Notebook

Seaworthy STEM™ in a Box Series

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#SeaworthySTEM

Glowing Jellyfish

Grades 3-5

Teacher Guide

Seaworthy STEM™ in a Box Series

NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

NAVAL STEM

Office of Naval Research
Science & Technology

Glowing Jellyfish

Teacher Guide for 3-5

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NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

Table of Contents

Lesson Title: Glowing Jellyfish

Time:
60 minutes or Multi-day lesson

Student Objectives:

Students will receive background information about Jellyfish and other deep sea creatures that use bioluminescence to survive in their environment. Students will build and create their own glowing jellyfish which will allow them to experiment with the movement of the jellyfish in the bottle. This activity is similar to a Cartesian diver experiment.

Lesson Overview:

Students will learn about deep-sea animal characteristics and traits they have to survive in the extreme oceanic environment. Students will learn that our understanding of deep aquatic environments is very limited due to the physical dangers and technical difficulties of exploring deep areas that have a tremendous amount of water pressure. Students will design and build a glowing jellyfish using a pipette, a chenille stick, and tonic water. Students will be challenged by demonstrating and building a "jellyfish" that is affected by the laws of buoyancy. Finally, students will observe the "diving" movement and bioluminescence of the jellyfish within the sealed bottle using a black light.

Next Gen Science Standards:

3-ESS2-2
3-LS3-2
3-LS4-2
4-LS1-1
5-PS3-1
5-LS1-1

Notes

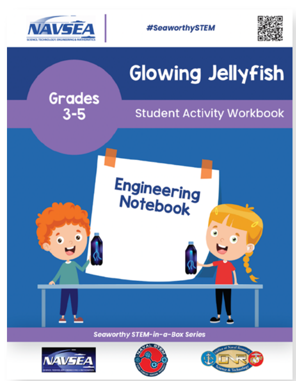
Materials and Equipment List (Per Student):

- Tonic Water
- 1 Pipette
- 1 Chenille Stick
- 1 plastic cup, (for testing area)
- 1 Empty plastic water bottle
- Water
- Black Light

It's very important to purchase water bottles with thick bottle caps! Please test your water bottle before buying a whole class set.

Student Activity Sheets/Handouts:

Glowing Jellyfish Student Activity Workbook

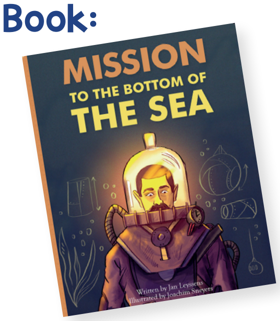


Technology Tools:

Black Light

Suggested STEM Related Literacy Book:

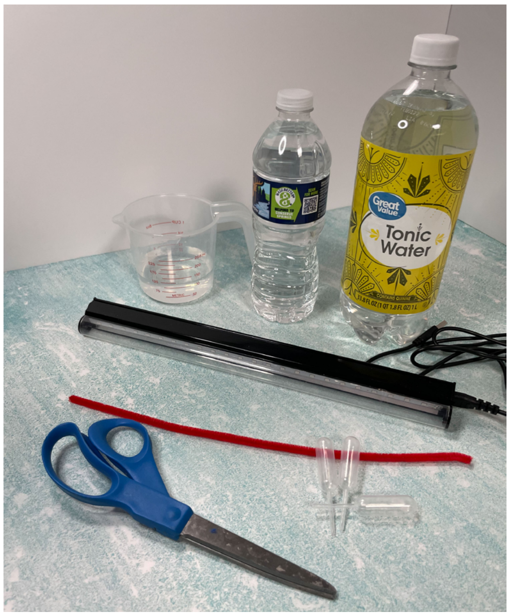
Mission to the Bottom of the Sea
by Jan Leyssens



Procedure:

1. The teacher will introduce the lesson by discussing about deep sea creatures and their animal characteristic traits. The teacher can use the following guided questions on the side panel.

2. Each student or team will receive the following listed materials.



3. The teacher will demonstrate and model how to create the jellyfish. Please follow the guided steps below.

   A. Take the mini pipette and fill the pipette completely with tonic water (this will act as the Jellyfish's head and is similar design as a Cartesian diver.) Explain to students about the air bubble within the pipette and the importance of the air bubble and buoyancy.

   B. Cut the chenille stick into thirds and wrap them around the tip of the pipette to create the tentacles of the jellyfish. (This will also be the weight to allow the jellyfish to sink.)

   C. Place the jellyfish inside the testing area. (A large open lid container filled with water.) Students will observe the jellyfish

The teacher can guide students through the following questions:

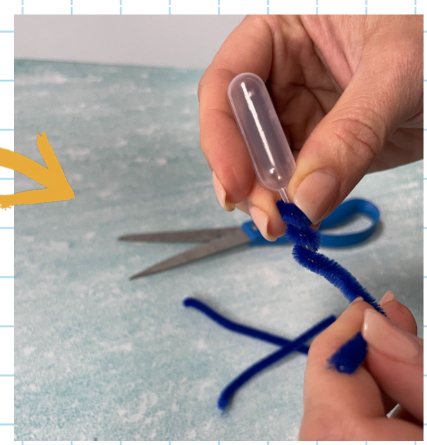
"What is a jellyfish and where do they live?"

"Do some jellyfish live at the bottom of the ocean?"

"Do you know of other deep-sea creatures?"

"How do these creatures survive where there is no sunlight?"

Helpful Tip:
Demonstrate how to fill a pipette completely by filling it up a little bit at a time while squeezing out the air in between "drinks" of tonic water.



sinking. Students will need to achieve the jellyfish barely floating, the top of the pipette barely floating in the testing area.

Important!

To achieve the barely floating phase, students will have to release 1 drop of tonic water from the pipette at a time. Then place jellyfish in water to observe it floating, if not, repeat by releasing 1 drop at a time!

D. Once the jellyfish is floating in the testing area, take the jellyfish out of the water and demonstrate to students they need to get the jellyfish to now barely float in the water bottle.

E. Place the jellyfish in the water bottle and secure the lid. ***Note- the jellyfish should be floating in the water bottle before placing cap. Encourage your students to make the legs vertical if using narrow bottles as they will be less likely to get caught on the sides.***

Helpful Tip:

If a student needs to retrieve the jellyfish out of the water bottle, have the student take the water bottle to a sink. Have the student overfill the waterbottle and the jellyfish should float to the top. This will make it easier for the student to retrieve the jellyfish.

4. Have students practice gripping the water bottle and squeeze the bottle, (holding the squeeze.) Students will observe the jellyfish moving down. Have students practice releasing their squeeze and the jellyfish should go up within the water bottle. ***Note- demonstrate how to squeeze and release the water bottle.***

5. Once practicing is complete, have students place the water bottle by the black light and turn on the light by a dark area. Students will squeeze and release the water bottle to observe the glowing jellyfish moving.


6 When observations are completed, designate students to clean up and the teacher will lead a whole group discussion and/or use the guided engineering student notebook to conclude the activity. The teacher can use the following guided questions to conclude the lesson.

A. “Why do you think your jellyfish was able to go up and down in the water bottle?”

B. “Why do we squeeze the bottle?”

C. “Scientists have barely scratched the bottom of the surface when it comes to observation of the deep ocean, why?”

D. What would scientist and engineers need to improve or build to dive to the depths of the ocean?”

Vocabulary Terms:

- **Bioluminescence:** the biochemical emission of light by living organisms such as fireflies and deep-sea fishes.
- **Buoyancy:** the tendency of a body to float or to rise when submerged in a fluid.
- **Density:** how much space an object or substance takes up (its volume) in relation to the amount of matter in that object or substance (its mass).
- **Mesopelagic Zone:** This barely-lit ocean layer is called the twilight zone. This zone appears deep blue to black in color and extends from 660-3,300 feet below the surface of the ocean making it impossible for photosynthetic organisms to survive.
- **Oceanic Zones:** is typically defined as the area of the ocean lying beyond the continental shelf, but operationally is often referred to as beginning where the water depths drop to below 200 meters (660 feet).

Scientific Background:

Jellyfish are just one type of bioluminescent animals within the oceanic environment. Scientist have discovered over 1,000 different types of species that emit light. Many deep sea creatures like fish, worms, algae, sharks, and sea stars use this process. Bioluminescence is the production and emission of light by a living organism. Animals will use this trait to signal predators and prey, attract potential mates, and other vital activities. Many deep sea creatures are bioluminescent and scientist have learned a lot about these creatures, however there is so much more to learn. Research is limited due to the fact that technology is not yet advanced enough to venture into the deepest zones of the oceans. Engineers and scientists are working together to create underwater vessels that are strong enough to withstand the incredible amount of pressure found at those depths. Deep-sea exploration will help scientists discover more about these sea creatures and will also enhance our understanding of the ocean.

The glowing jellyfish is able to “dive” within the water bottle because of the additional pressure created by the student's hand squeezing the water bottle. The buoyancy caused by the air in the pipette causes it to float in a similar manner to a boat on top of the ocean. When the bottle is squeezed the pressure is equally distributed throughout the bottle in all directions including the jellyfish. When squeezed, water will go up into the straw tip of the pipette causing the jellyfish to sink. When the pressure is released the water will leave the straw tip of the pipette and the jellyfish will float back up to the top of the bottle.

STEM Related Career:

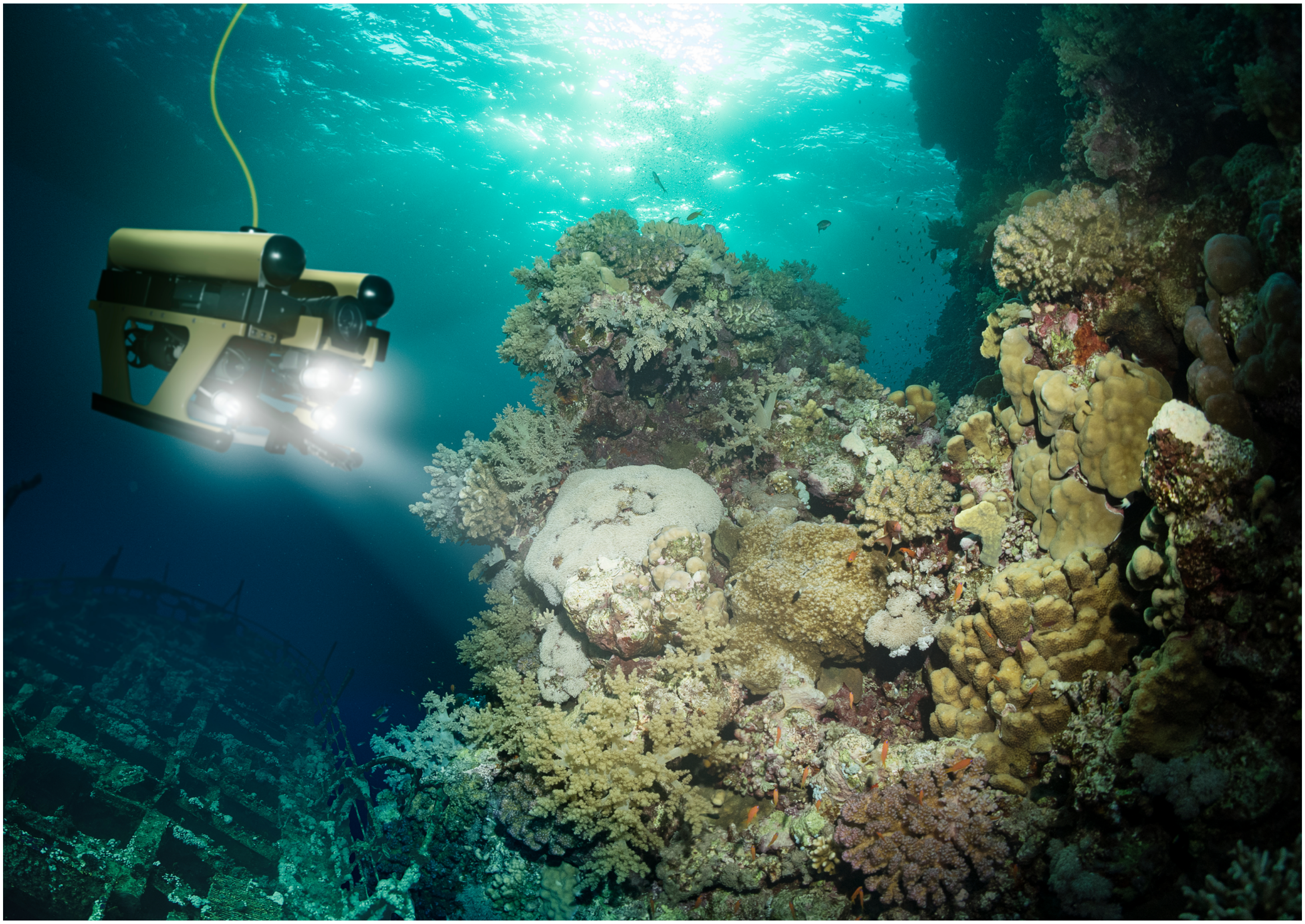
- Oceanographer
- Marine Geologist
- Deep-sea Biologist

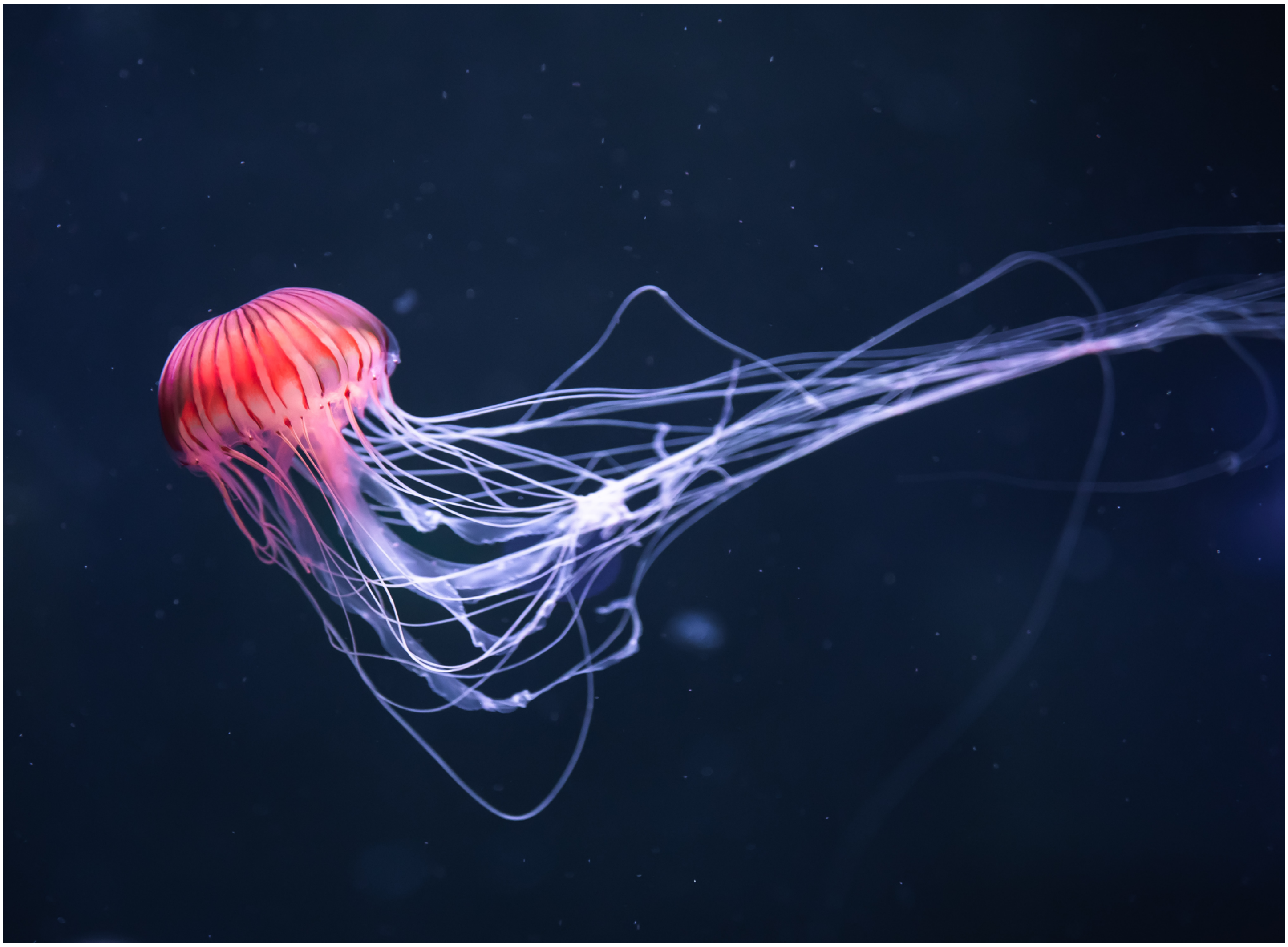
Fun Fact!

The anglerfish typically lives 1,000 meters below the ocean surface. The female Anglerfish are bioluminescent, the light is produce in the "esca". The bulbous appendage that is at the end of its "fishing rod". This light is used to lure its prey.

Fun Fact!

Since the Cold War, the Navy has made deep-sea research as a top priority. The Navy wanted to increase oceanographic knowledge and the ability of diving into the deep-ocean using submarines. With today's technology, Deep Submergence Vehicles, (DSV's) are robotic water crafts that are commonly used today to continue this research and discover.





NAVSEA

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

The Seaworthy STEM™ in a Box curricula was developed through collaborative efforts of a team of individuals at the Naval Surface Warfare Center Carderock Division and Albert Einstein Distinguished Educator Fellows via an inter-agency agreement with the U.S. Department of Energy for the Albert Einstein Distinguished Educator Fellowship (AEF) Program. We are grateful to the following Content Specialists who contributed their knowledge and expertise by researching and writing on selected topics: Suzanne Otto, Stephanie Klixbull, and Thomas Jenkins. We'd also like to acknowledge the contributions of AEF participant Ms. Deborah Reynolds, the inaugural AEF Educator at Carderock that helped inspire the design of Seaworthy STEM™ in a Box content. With the help of Albert Einstein Fellow, Melissa Thompson, and Carderock Outreach Specialist, Ashlee Floyd, special additions to the curriculum such as career portfolios, workforce trading cards, and in-house short story publications are included that reflect the diversity of NAVSEA Sites.

It is the goal of the SeaWorthy Curriculum to embrace NAVSEA technologies from sites nationwide to empower the youth of our nation to purse STEM-centric career pathways. The views and opinions of the Content Specialists expressed herein do not necessarily state or reflect those of the AEF Program, the U.S. Department of Energy, or the U.S. Government. Reference herein to any specific commercial product, process, or service by trade name, trademark, service mark, manufacturer, or otherwise does not constitute or imply endorsement, recommendation, or favoring by the AEF Program, the U.S. Department of Energy, or the U.S. Government.

#SeaworthySTEM

Glowing Jellyfish Teacher Guide

Seaworthy STEM™ in a Box Series

NAVSEA SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

#SeaworthySTEM

Glowing Jellyfish

Grades 3-5

Student Activity Workbook

Name: ______________________________

Date: ______________________________

Seaworthy STEM™ in a Box Series

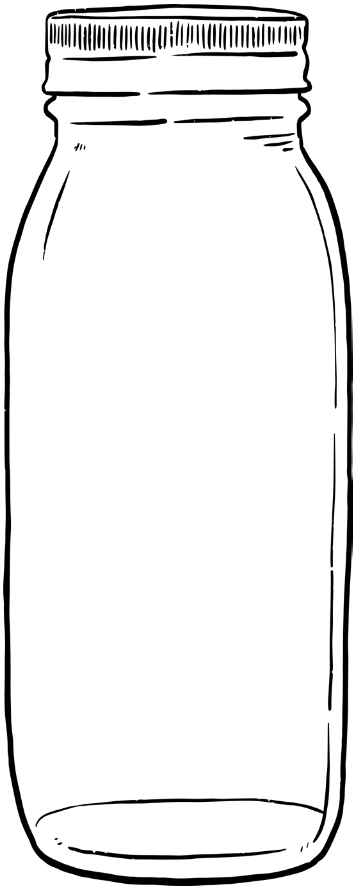
NAVSEA SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

NAVAL STEM SCIENCE · TECHNOLOGY · ENGINEERING · MATHEMATICS

Office of Naval Research ONR Science & Technology

Glowing Jellyfish

1 In the drawing box, use your observations and draw the glowing jellyfish moving within the bottle. Use arrows to represent the movement of the glowing jellyfish in the bottle.



Fun Fact!

The anglerfish typically lives 1,000 meters below the ocean surface. The female Anglerfish are bioluminescent, the light is produced in the "esca".

The bulbous appendage that is at the end of its "fishing rod". This light is used to lure its prey.

2 The jellyfish you have designed should successfully move up and down within the bottle.

1. Describe in the text box, why the jellyfish can move up and down?

2. Did anything else help make the jellyfish move up and down?

3 Fill in the blank:

The acting force of your hand squeezing the bottle causes the jellyfish to move ____________ . Squeezing the bottle is creating _________________ . When you release your hand, the jellyfish moves ____________ . When you release the bottle, you are no longer causing _______________ .

4 Many deep sea creatures like some jellyfish have the ability to use **bioluminescence**. This trait is crucial for animals to live in extreme conditions. Why do you think it is important for an animal to be able to produce its own light?

#SeaworthySTEM

Glowing Jellyfish Engineering Notebook

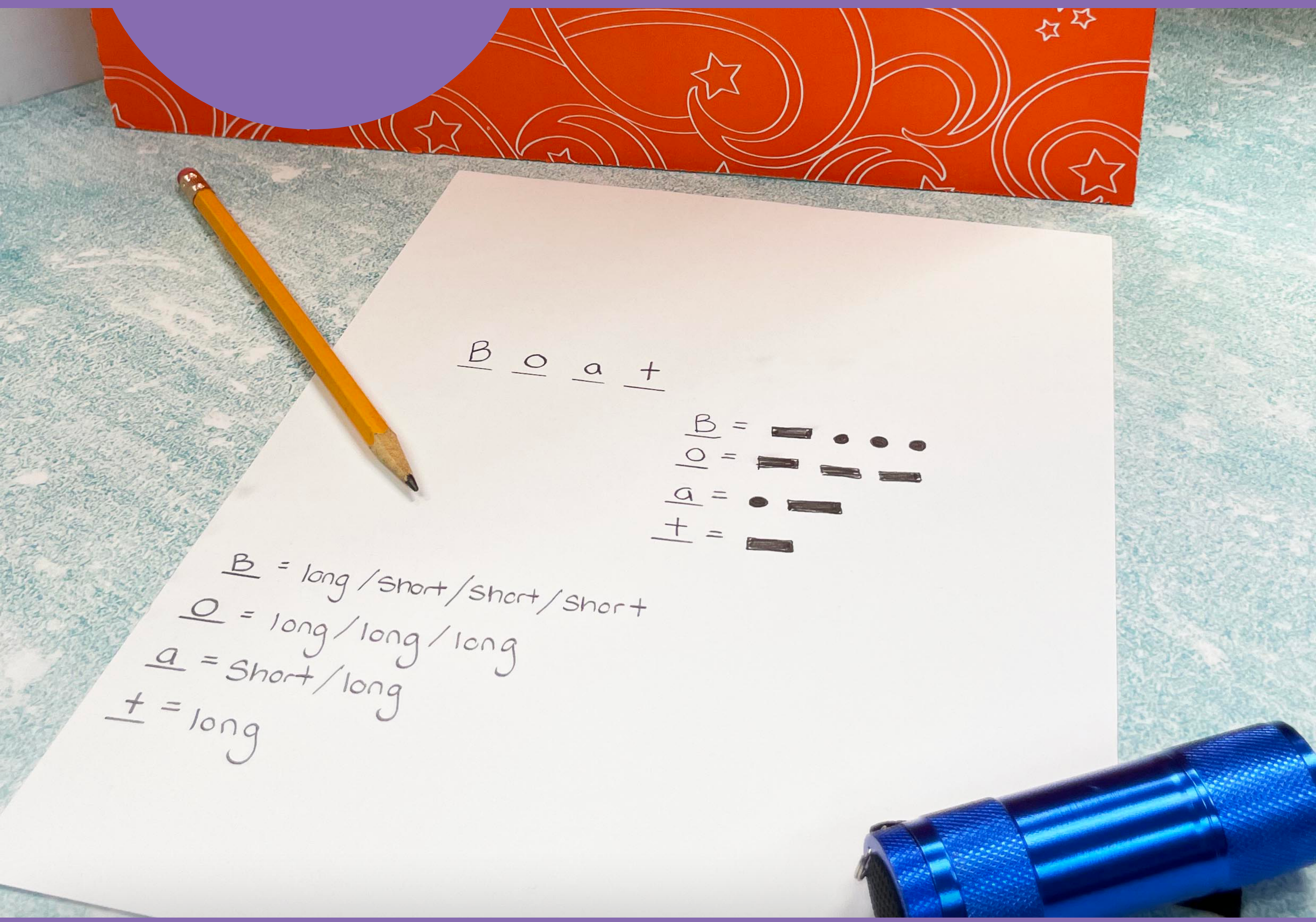
Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Morse Telephone

Grades 3-5

Teacher Guide



Morse Telephone

Teacher Guide for 3-5

Seaworthy STEM™ in a Box Educator Kit description:

Seaworthy STEM™ in a Box activities are a Navy initiative to provide enhanced Naval-relevant, standards aligned, hands-on activities to K-12 teachers and students. Components of this program include, curated sets of classroom activities that aim to build deep conceptual understanding in Naval-relevant content areas. The kits also includes comprehensive lesson plans, material lists, scientific background information, STEM related literacy books, and student activity sheets. The Seaworthy STEM™ in a Box program is designed to support teachers as they select content, acquire materials, and implement more hands-on STEM activities in their classrooms. Increasing student access to hands-on STEM activities, also increases awareness of STEM career paths, engage students in STEM, and support development of student's abilities in STEM content.

The Seaworthy STEM™ in a Box kits were designed to guide students through the scientific inquiry-based theory and the engineering design process. The content and Naval-relevant activities are aligned with the Next Generation Science Standards. The topics and content covered within the lessons are connected and scaffolded based on distinct grade bands (K-2nd, 3rd-5th, 6th-8th, and 9th-12th).

NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

Table of Contents

Lesson Title: Morse Telephone

Time:
1 Class period (45-60 minutes)

Student Objectives:

Students will learn how Morse code is a type of coding used for a line of communication. Students will work in teams to communicate in Morse code. Students will have to work together to receive the correct message.

Lesson Overview:

Students will learn how light and sound travels in waves. Students will also learn about Morse code which was one of the first forms of naval communication. Students will be placed in teams to play the traditional game of telephone with a twist. Each student will have a job to complete the line of communication in the telephone activity. Students will have to use Morse code to communicate from partner to partner. The goal is to repeat the exact same code/message from the original messenger.

Next Gen Science Standards:

4-PS4-3
4-PS4-2
3-PS2-3

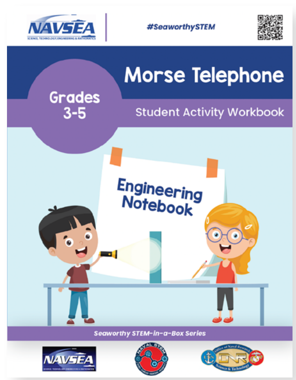
Notes

Materials and Equipment List (Per Team):

- Pencil
- Paper
- Flashlight
- Morse Code worksheet
- Desk dividers or a way to cover Code creators' work
- Calculator

Student Activity Sheets/Handouts:

Morse Code Student Activity Workbook

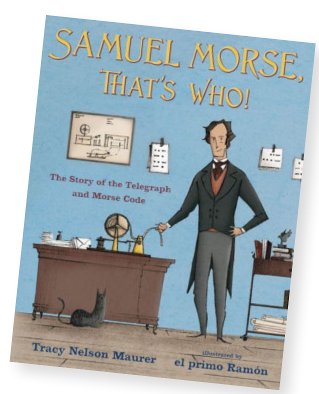


Technology Tools:

A calculator

Suggested STEM Related Literacy Book:

Samuel Morse, That's Who!
by Tracy Nelson Maurer



Procedure:

1. Students will receive a brief introduction to sound and light waves. Students will also gain knowledge about Morse code. The teacher will explain how Morse code has been a way for ships to communicate while at sea.

2. The teacher will split up the class into teams of four and give a job title to each student.

3. Each member of the team will receive an individual job and a Morse code worksheet that is in the student Engineering Notebook. The following jobs are listed below in order:

   A. **Code creator** – In charge of creating the secret word and transferring it into written Morse code.
   B. **Coder of light** – In charge of decoding the Morse code and transferring it to light code.
   C. **Coder of sound** - In charge of decoding the light code and transferring it to sound code.
   D. **Code writer** - In charge of decoding the sound code and transferring it to the original Morse code.

4. The teacher will explain and model the activity. The teacher will go over the directions on page 9, under 'Student Direction' tab.

5. When the activity is completed, the teacher can guide students into a whole group discussion with the following conclusion guided questions.
   1. "Did your group relay the secret word correctly?"
   2. "What was challenging about this activity?"
   3. "What kind of job would be in charge of line of communication on a boat?"
   4. "What kind of duties would this job be in charge of?"

The teacher can guide students through the following questions:

"How do you think ships are able to communicate over seas?"

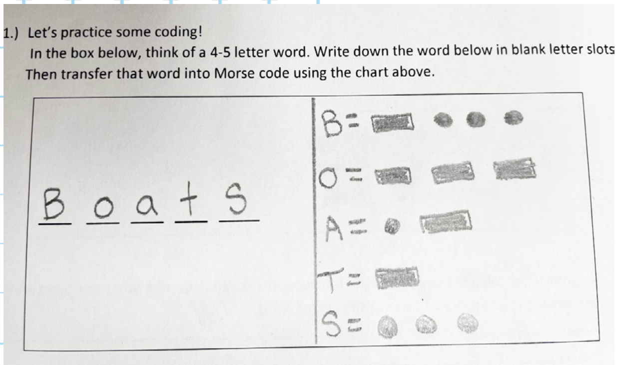
"What is coding?"

"Is speaking the only way we communicate to each other?"

Helpful tip: Prior to students starting, go over rules of the game and go over how students will represent the difference between short and long dashes of code to represent Morse code. On page 8, is an example of how students will use the Morse code chart in their student engineering notebook.

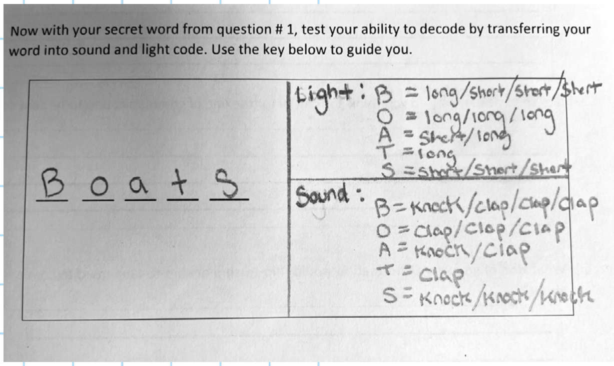
Morse Code Chart:

A	• —	T	—
B	— • • •	U	• • —
C	— • — •	V	• • • —
D	— • •	W	• — —
E	•	X	— • • —
F	• • — •	Y	— • — —
G	— — •	Z	— — • •
H	• • • •		
I	• •	1	• — — — —
J	• — — —	2	• • — — —
K	— • —	3	• • • — —
L	• — • •	4	• • • • —
M	— —	5	• • • • •
N	— •	6	— • • • •
O	— — —	7	— — • • •
P	• — — •	8	— — — • •
R	• — •	9	— — — — •
S	• • •	0	— — — — —


1.) Let's practice some coding!
In the box below, think of a 4-5 letter word. Write down the word below in blank letter slots
Then transfer that word into Morse code using the chart above.

B o a t S

B= — • • •
O= — — —
A= • —
T= —
S= • • •


Now with your secret word from question # 1, test your ability to decode by transferring your word into sound and light code. Use the key below to guide you.

B o a t S

Light: B = long/Short/Short/Short
O = long/long/long
A = Short/long
T = long
S = Short/Short/Short

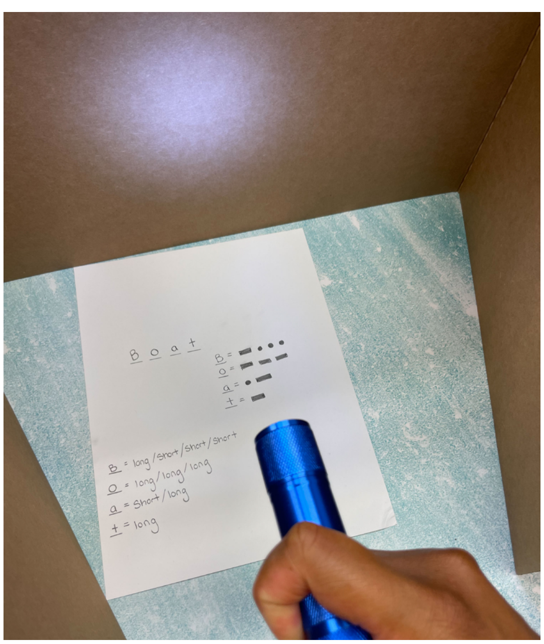
Sound: B = Knock/clap/clap/clap
O = clap/clap/clap
A = Knock/clap
T = clap
S = Knock/Knock/Knock

Check out these great examples of a student's observation!

Student Directions:

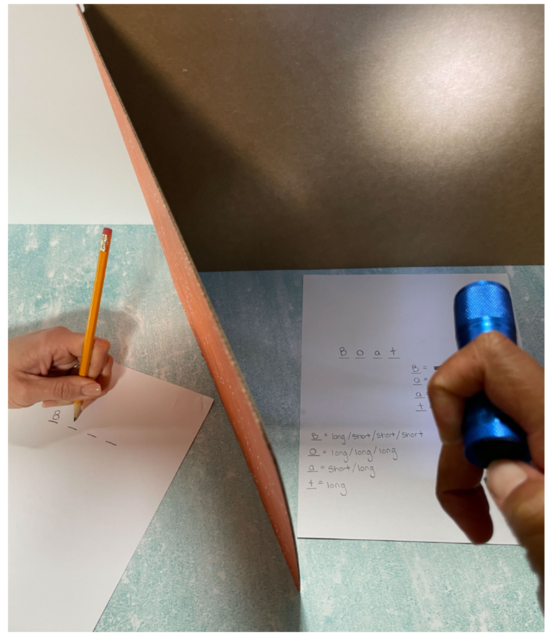
1. The Code creator will start first by creating 1 word (4-5 letters long) to communicate with the rest of the team. The Code creator will write down each letter and then translate it into Morse code on a piece of paper, then the code creator will give the Morse coded word to the coder of light.

2. Then the Coder of light will use the flashlight to transfer the written word into Morse code by using flashes of light directed towards the Coder of sound.



3 Then the Coder of sound will interpret the flashes of light into sound. The Coder of sound will use Morse code by knocking and clapping the given code. The Coder of sound will direct it towards the Code writer.

4 Finally, the Code writer will interpret the sounds into the original form, a written word/message.



5 Students will then gather together and will analyze how the original message is similar and/or different from the overall finished message.

6 **To extend the activity:** Students should change jobs and then students should repeat steps 1-5. Have students create more complex messages to create more of a challenge.

Helpful Tips!

Tell students to allow time between each coder to decode the message. Use the engineering notebook worksheet to sketch out ideas.

Students may visually repeat the code if a team member needs to see or hear it again.

Use this key for lights and sounds!

Morse Symbol	Coder of Light	Coder of Sound
●	Short Flash (1 second)	Knock
▬	Long Flash (2-3 seconds)	Clap

Computer Science Extension: Intro to Binary

Binary code allows us to give instructions to computers. Binary is a code just like Morse code but uses only 1's & 0's. Binary is based in math and increases in powers of 2. Ex: 1, 2, 4, 8, 16, 32, 64...Just like in regular math, the numbers further to the left have a greater value. See examples below:

If you were to type 11, the computer would understand it as one number 2 and one number 1, so it would read it as 2+1= 3

2	1
1	1

If you were to type 101, the computer would understand it as one number 4, zero number 2's and one number 1, so it would read it as 0+4+0+1= 5

4	2	1
1	0	1

If you were to type in the number 11101, the computer would understand it as one number 16, one number 8, one number 4, zero number 2's, and one number 1, so it would read it as 16+8+4+0+1= 29

16	8	4	2	1
1	1	1	0	1

Vocabulary Terms:

- Strike: Amateur Radio
- Binary Code: A coding system using the binary digits 0 and 1 to represent a letter, digit, or other character in a computer or other electronic device.
- Frequency: The rate at which something occurs or is repeated over a particular period of time.
- Telegraph: A system for transmitting messages from a distance along a wire, especially one creating signals by making and breaking an electrical connection.
- Wavelength: The distance between successive crests of a wave, especially points in a sound wave or electromagnetic wave.

Fun Fact!

Radio telegraphy using Morse code was used in the early part of the twentieth century for marine communication. In the 1970's a system was put into place where ship-to-ship or ship-to-shore communication was put into action instead of the use of a 24/7 radio operator. Marine communication between ships or with the shore was carried with the help of onboard systems through shore stations and even satellites.

Scientific Background:

Morse code is a method used in telecommunication to encode signals called dashes and dots. Morse code is named after Samuel Morse who was one of the inventors of the telegraph. A telegraph is an instrument that allows the transmission of information by coded signal over distance. The telegraph was a messaging system used from the 1840's until the late 20th century. To transmit messages across telegraphs, Morse code was created and used through telegraph wires. Morse code was developed so that operators could translate the indentations marked on paper tape into messages. Although telegraph wires were not available overseas, Morse code was still used as a line of communication between ships. The point of contact on a ship would use Morse code and different flashes of light to communicate to another ship that was in their horizon. Morse code became extremely important for the Navy during World War II and it helped improve the speed of communication between ships.

Binary code is a way of representing information using only two symbols: 0 and 1. Computers use binary code to perform all kinds of operations, from basic math to complex calculations. By manipulating binary digits using logic gates and circuits, computers can perform calculations, store and retrieve data, and execute programs. While it may seem strange at first, binary code is actually a very efficient way of representing information for computers, because it allows them to use electronic components that can be easily designed to switch on and off (or represent 0 and 1), using a tiny amount of power.

STEM Related Career:

- Software Development Engineer
- Computer Programmer Analyst
- Security Software
- Ships Communication Officer

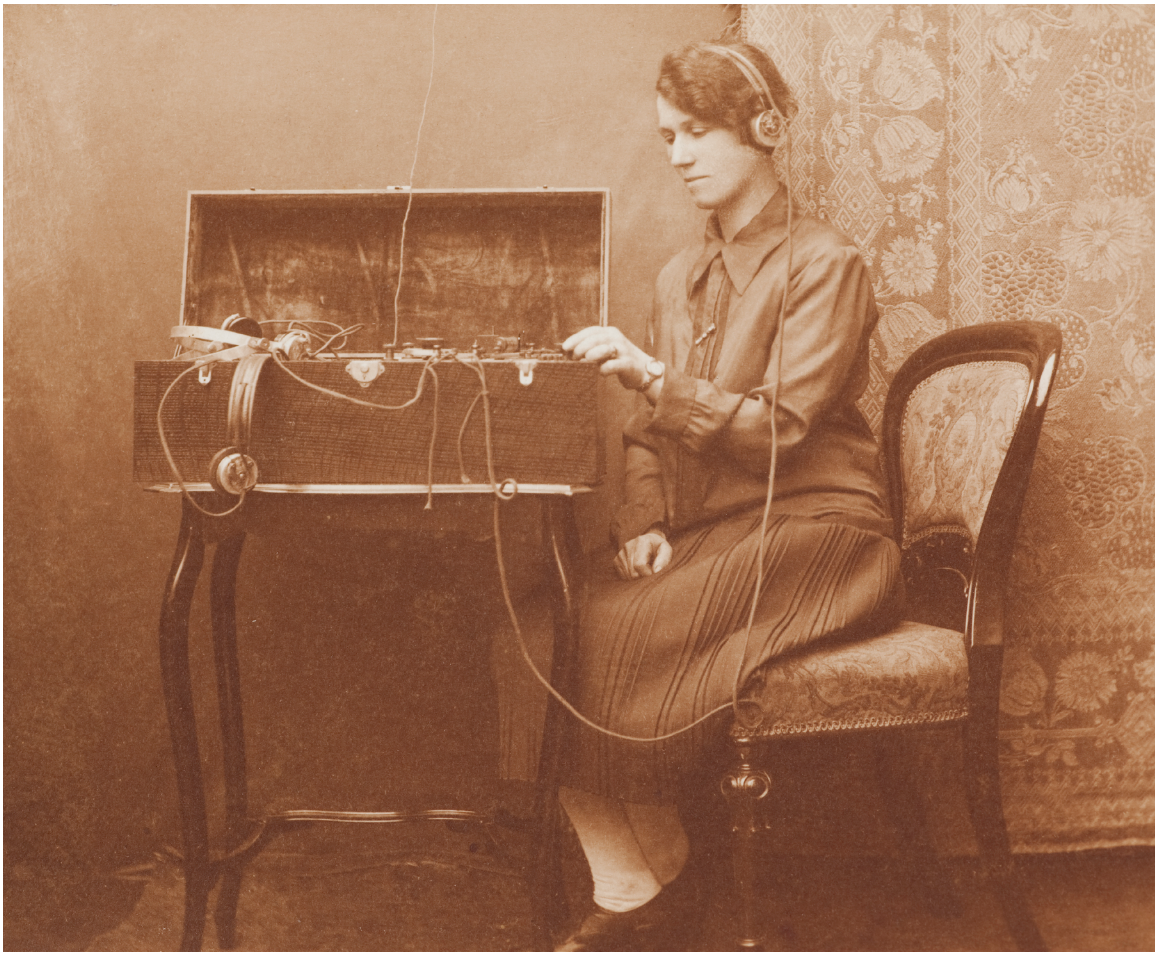
References:

Presently, the Navy still uses code in a line of communication. Below is a chart of a phonetic alphabet chart. The chart is a list of words used to identify letters in a message transmitted by radio or telephone. Spoken words from an approved list are substituted for letters. For example, the word "Navy" would be "November Alfa Victor Yankee" when spelled in the phonetic alphabet. This practice helps to prevent confusion between similar sounding letters, such as "m" and "n", and to clarify communications that may be garbled during transmission.

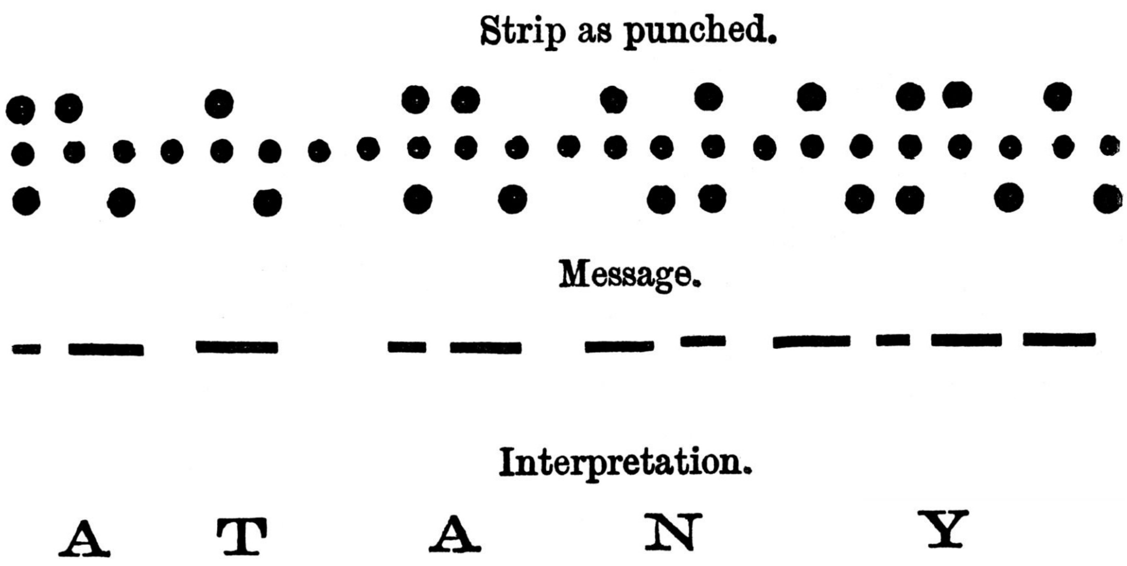
Letter	World War II	1957-Present
A	Afirm (Able)	Alfa
B	Baker	Bravo
C	Charlie	Charlie
D	Dog	Delta
E	Easy	Echo
F	Fox	Foxtrot
G	George	Golf
H	How	Hotel
I	Int (Item)	India
J	Jig	Juliett
K	King	Kilo
L	Love	Lima
M	Mike	Mike
N	Negat (Nan)	November
O	Option (Oboe)	Oscar
P	Prep (Peter)	Papa
Q	Queen	Quebec
R	Roger	Romeo
S	Sugar	Sierra
T	Tare	Tango
U	Uncle	Uniform
V	Victor	Victor
W	William	Whiskey
X	X-ray	X-ray
Y	Yoke	Yankee
Z	Zebra	Zulu

Extension Activity!

Have students play telephone using the phonetic alphabet chart!



"Woman using a Morse code radio communications device housed within an oak box."



"Telegraph example via Morse code"

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#SeaworthySTEM

Morse Telephone Teacher Guide

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

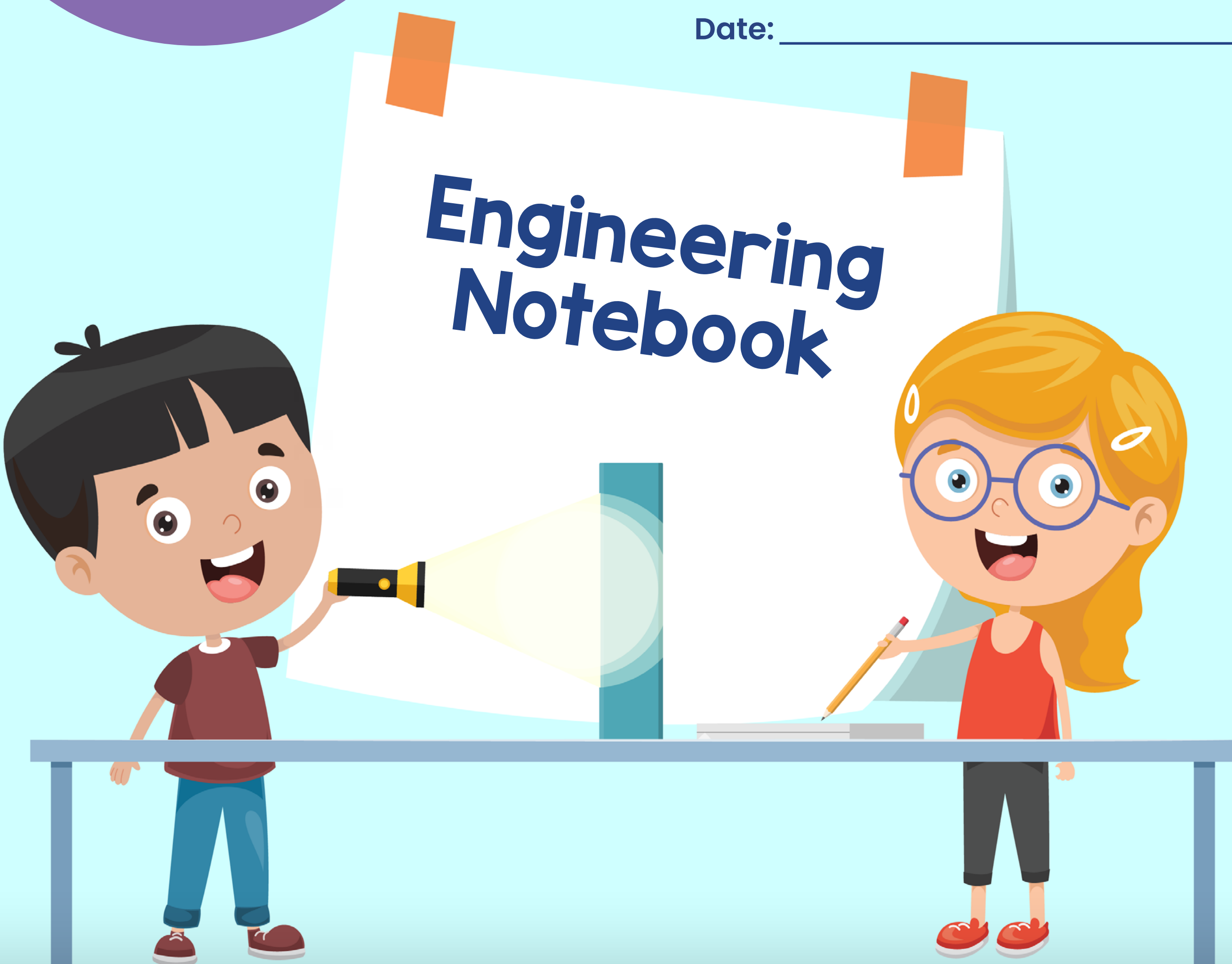
Morse Telephone

Grades 3-5

Student Activity Workbook

Name: ______________________________

Date: ______________________________



Seaworthy STEM™ in a Box Series

Morse Telephone

Use the following Morse code chart below to create secret messages with your team!

A • —
B — • • •
C — • — •
D — • •
E •
F • • — •
G — — •
H • • • •
I • •
J • — — —
K — • —
L • — • •
M — —
N — •
O — — —
P • — — •
R • — •
S • • •
T —
U • • —
V • • • —
W • — —
X — • • —
Y — • — —
Z — — • •

1 • — — — —
2 • • — — —
3 • • • — —
4 • • • • —
5 • • • • •
6 — • • • •
7 — — • • •
8 — — — • •
9 — — — — •
0 — — — — —

1 Let's practice some coding!
In the box below, think of a 4-5 letter word. Write down the word below in the blank letter slots. Then transfer that word into Morse code using the chart.

____ ____ ____ ____ ____

2 Now with your secret word from question # 1, test your ability to decode by transferring your word into sound and light code. Use the key below to guide you.

Morse Symbol	Coder of Light	Coder of Sound
●	Short Flash (1 second)	Knock
▬	Long Flash (2-3 seconds)	Clap

____ ____ ____ ____ ____

3. Time to code!
With your team, have the Code creator make a new 4-5 letter word. When the Code creator is ready, start the game by transmitting the secret word to the next line of communication, the Coder of light. Remember, the Code creator cannot share their secret word with anyone in the group! All coders can use the text box below to help solve the secret word!

___ ___ ___ ___ ___

Fun Fact!

Radio telegraphy using Morse code was used in the early part of the twentieth century for marine communication. In the 1970's a system was put into place where ship-to-ship or ship-to-shore communication was put into action instead of the use of a 24/7 radio operator. Marine communication between ships or with the shore was carried with the help of on board systems through shore stations and even satellites.

4 Did your team solve the code? Use the following text box to describe what strengths and weaknesses your team had when solving the secret word.

5 For ships at sea, why do you think it is crucial for the line of communication to be sent correctly?

6 What kind of important information would ship-to-ship or ship-to-land need to communicate about?

Computer Science Extension:

Binary code allows us to give instructions to computers. Binary is a code just like Morse code but uses only 1's & 0's. Binary is based in math and increases in powers of 2. Ex: 1, 2, 4, 8, 16, 32, 64...Just like in regular math, the numbers further to the left have a greater value.

See examples below:

If you were to type 11 in binary, the computer would understand it as one number 2 and one number 1, so it would read it as 2+1= 3

64	32	16	8	4	2	1
					1	1

If you were to type 101 binary, the computer would understand it as one number 4, zero number 2's and one number 1, so it would read it as 4+0+1= 5

64	32	16	8	4	2	1
				1	0	1

If you were to type in the number 11101 in binary, the computer would understand it as one number 16, one number 8, one number 4, zero number 2's, and one number 1, so it would read it as 16+8+4+0+1= 29

64	32	16	8	4	2	1
		1	1	1	0	1

7 Computer coding challenge!

Pick a number between 1-100 to write in binary code. Write your number in binary below. *Check your math with a calculator. Remember that all of the numbers that have a 1 below them should add up to equal your number when you are done.

64	32	16	8	4	2	1

8 Have a partner play the role of a computer and read your code. You have just communicated using binary code!

Fun Fact!

A singular binary digit, a single 0 or 1, is referred to as a bit. 8 bits are called a byte!

Did You Know?

Presently, the Navy still uses code in a line of communication. Below is a chart of a phonetic alphabet chart. The chart is a list of words used to identify letters in a message transmitted by radio or telephone. Spoken words from an approved list are substituted for letters. For example, the word "Navy" would be "November Alfa Victor Yankee" when spelled in the phonetic alphabet. This practice helps to prevent confusion between similar sounding letters, such as "m" and "n", and to clarify communications that may be garbled during transmission.

Letter	World War II	1957-Present
A	Afirm (Able)	Alfa
B	Baker	Bravo
C	Charlie	Charlie
D	Dog	Delta
E	Easy	Echo
F	Fox	Foxtrot
G	George	Golf
H	How	Hotel
I	Int (Item)	India
J	Jig	Juliett
K	King	Kilo
L	Love	Lima
M	Mike	Mike
N	Negat (Nan)	November
O	Option (Oboe)	Oscar
P	Prep (Peter)	Papa
Q	Queen	Quebec
R	Roger	Romeo
S	Sugar	Sierra
T	Tare	Tango
U	Uncle	Uniform
V	Victor	Victor
W	William	Whiskey
X	X-ray	X-ray
Y	Yoke	Yankee
Z	Zebra	Zulu

Notes

#SeaworthySTEM

Morse Telephone Engineering Notebook

Seaworthy STEM™ in a Box Series

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Seaworthy STEM™ in a Box

Lessons for Grades 6-8

Teacher and Student Lesson Books for:

- Alka-Seltzer Lava Lamps
- Cartesian Divers
- Comparing Mass and Density
- Density Column Exploration
- Film Canister Boat Float
- Golf Ball Float

Seaworthy STEM™ in a Box Series

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NAVAL STEM
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#SeaworthySTEM

Alka-Seltzer Lava Lamp

Grades 6-8

Teacher Guide

Seaworthy STEM™ in a Box Series

Alka-Seltzer Lava Lamp

Teacher Guide for 6-8

Seaworthy STEM™ in a Box Educator Kit description:

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Table of Contents

Lesson Title: Alka-Seltzer Lava Lamp

Time:
1 class period

Student Objectives:

The students will review the states of matter and how they differ from one another. The students will also understand that despite objects changing states the total mass of the initial system remains the same.

Lesson Overview:

The students will explore density as well as the impact of gases being released within a system that contains different liquids. Additionally, students will conduct an investigation that validates the conservation of mass.

Next Gen Science Standards (NGSS):

MS-PS1-2
MS-PS1-5
MS-PS2-2

Notes

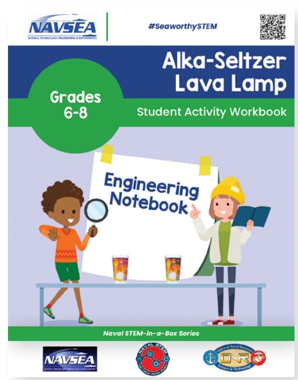
Materials and Equipment List (for each pair of students):

- ☑ Clear plastic cup or jar
- ☑ Approximately 1/3 cup of water with food coloring (teacher may pour from pitcher)
- ☑ Approximately 1/3 cup of vegetable oil
- ☑ 1 or 2 Alka-Seltzer tablets, broken into pieces
- ☑ Writing instruments and activity sheets
- ☑ Optional: Paper plates or aluminum pie pans to catch drips and ease cleanup
- ☑ Beaker
- ☑ Graduated Cylinder
- ☑ Latex glove
- ☑ Pipette
- ☑ Digital Scale

Student Activity Sheets/Handouts:

Guided Observation Worksheet:

Alka-Seltzer Lava Lamps



Technology Tools:

Digital Scale

Sample video: https://funlearningforkids.com/super-cool-lava-lamp-experiment/

Procedure:

1 Students working in pairs will assemble a system consisting of colored water and vegetable oil layers in a clear cup or jar.

To make this system:

1. Pour 1/3 cup of water with food coloring into the cup or jar
2. Add 1/3 cup of vegetable oil to the water
3. Stir and let sit until settled

2 Students will then add pieces of Alka-Seltzer tablets to their system and make observations about what happens.

1. Students are to record/brainstorm their observations, inferences, and questions using the student activity worksheet in the engineering notebook.

3 The teacher will monitor students while they experiment, providing materials, instructions, and answers to student questions as needed for all students to complete their observations. The teacher should also listen carefully for preconceptions in student conversations and ask probing questions that encourage students to think more deeply about their observations. Be careful not to give away all "the answers" at this point in the activity.

Helpful Tip:

Watch the Alka-Seltzer drop! When you drop the Alka-Seltzer pieces, they will sink to the bottom. It sinks straight through the oil without any chemical reactions occurring. When it touches the water, however, a chemical reaction occurs that releases carbon dioxide gas bubbles.

Solubility plays an important role in this activity.

Helpful Tip:

Be sure to handle oil carefully as it is messy if spilled and can be slippery if spilled onto the floor.

4 The teacher will now allow the students to explore changes of state as well as the law of conservation of mass.

1. The students will use a digital scale (set to kg) to find the mass of the cup of fluids, 2 unwrapped Alka-Seltzer tablets, and a latex glove. They will record their measurements in their Student Activity Workbook.

2. The students will add the mass of their 2 Alka-Seltzer tablets to the mass of the cup of fluids and record this mass in their Student Activity Workbook.

3. The students will then put the cup of fluid on the scale and then drop the 2 Alka-Seltzer tablets into the cup. After the Alka-Seltzer dissolves in the fluid the students should record the mass in their Student Activity Workbook. *They should notice that the mass has decreased by 1 or 2 kgs due to the release of carbon dioxide.

4. The students are now challenged with how they can dissolve the 2 Alka-Seltzer tablets in the fluids without losing any mass. *After some time, suggest to the student that they may want to use the glove to capture the CO

5. Have the students record the combined masses of the glove, the 2 Alka-Seltzer tablets as well as the cup of fluids in their Student Activity Workbook.

6. Have the students place the cup on the scale then insert the 2 Alka-Seltzer tablets followed by putting the glove on top of the cup to collect the CO_2.

7. Have the students record the combined masses of the inflated glove and the cup of fluids in their Student Activity Workbook.

5 Clean up the activity. Teacher may want to walk around the room with a large pitcher to collect liquids from each group vs. having students carry them across the room.

Follow-up:

1. After students complete the hands-on activity, the teacher will lead the students in a discussion to elicit their ideas about what they have observed. The teacher should listen carefully to terminology students use in descriptions to see if common misconceptions exist.
2. A brainstorm list should be written on a whiteboard or flip chart. Record all ideas without judgment or correction to encourage all students to contribute their ideas for initial discussions.

> "The chemical reaction in an AlkaSeltzer tablet is between citric acid and sodium bicarbonate (baking soda)"

Teacher Background Information / Notes:

The chemical reaction in an AlkaSeltzer tablet is between citric acid and sodium bicarbonate (baking soda). This acid-carbonate reaction produced carbon dioxide bubbles. The solids in the dry tablet do not react, but once dissolved, the substances are more mobile and can interact.

The oil is less dense than the water, and thus floats on top of the water. As carbon dioxide bubbles form in the water phase, they are surrounded by parcels of water, thus lowering the local density and bringing the gas-water parcel to the top of the system. At the top, the carbon dioxide gas bubbles are released from the water into the air, returning the water to is non-aerated density and allowing it to sink to the bottom again.

Solubility also plays an important role in this activity. Notice that the food coloring is soluble in the water phase, but not in the oil phase. The AlkaSeltzer tablet is not soluble in the oil (and passes through it) but is soluble in the water (which allows the reaction to begin). Also note that oil and water phases are not soluble with each other.

Extension Activity Ideas:

A similar alternative activity that could be used is called "Dancing Raisins" or "Sewer Lice". It involves placing raisins in a container of either clear soda or AlkaSeltzer/

water mixture. Carbon dioxide bubbles will temporarily form on the surface of the raisins, lifting the raisins to the surface. Once at the surface, the bubbles will detach into the air and the raisin will again sink. This activity is commonly used in biology to start a discussion on "living vs. non-living" objects, however, the dynamics of the system are good for density discussions also.

Vocabulary Terms and Mathematical Formulas:

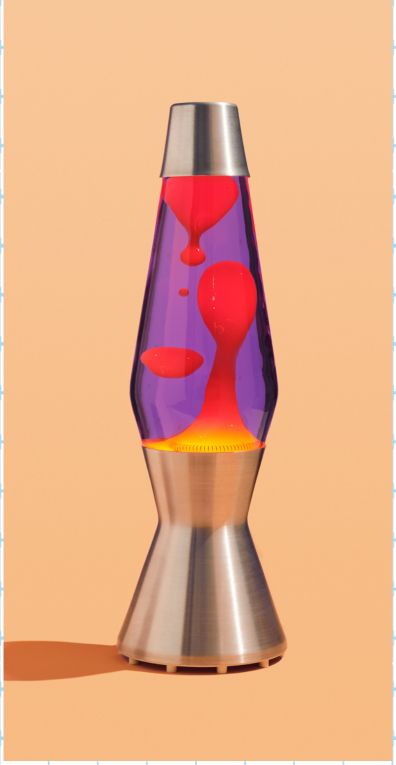
- **Density:** The amount of space an object or substance takes up (its volume) in relation to the amount of matter in that object or substance (its mass) Density = M/V
- **Gas:** A state of matter consisting of particles that have neither a definite volume nor a definite shape
- **Law of Conservation of Mass:** The mass in an isolated system can neither be created nor be destroyed but can be transformed from one form to another
- **Liquid:** A state of matter where particles are free to flow. It has a definite volume, it does not have a definite shape
- **Mass:** The amount of matter in an object
- **Solid:** A state of matter characterized by particles arranged such that their shape and volume are relatively fixed
- **Solubility:** The maximum quantity of a substance that can be dissolved in another.
- **Volume:** The amount of space occupied by an object

STEM Related Careers:

- Chemical Engineer
- Mechanical Engineering

Fun Fact!

The lava lamp was invented in 1948 by an English accountant named Edward Craven Walker. It took Craven Walker 15 years to perfect his design.



Notes

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#SeaworthySTEM

Alka-Seltzer Lava Lamp Teacher Guide

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Alka-Seltzer Lava Lamp

Grades 6-8

Student Activity Workbook

Name: ______________________________

Date: ______________________________

Seaworthy STEM™ in a Box Series

Alka-Seltzer Lava Lamp

1 Part 1:

- Fill your cup about 1/3 full of oil.
- Add 2-3 drops food coloring.
- Add about 1/3 cup of water.
- Stir and then let it sit until settled
- Record your observations – include a sketch and description.

Part 1 Observations

2 Part 2:

- Obtain an Alka-Seltzer tablet.
- Break it into 4-5 pieces.
- Add one piece of the tablet to your cup.
- Watch what happens and record your observations.
- Repeat with other pieces.
- Follow the teacher's instructions for cleanup.

Fun Fact!

The lava lamp was invented in 1948 by an English accountant named Edward Craven Walker. It took Craven Walker 15 years to perfect his design.

Part 2 Observations

3 Use a digital scale (set to kg) to find the mass of:

The cup of fluids ________________________ kg

2 unwrapped Alka-Seltzer tablets ____________ kg

A latex glove ____________________________ kg

4 Find the sum of the cup of fluids and the 2 Alka-Seltzer tablets:

The cup of fluids ________________________ kg

2 unwrapped Alka-Seltzer tablets ____________ kg

Total _________________________________ kg

5 Put the cup of fluid on the scale and then drop the 2 Alka-Seltzer tablets into the cup. After the Alka-Seltzer dissolves in the fluid the students should record the mass below.

Total _________________________________ kg

6 Find the difference of the total mass of Part 4 and the total mass of Part 5.

Part 4 Total Mass ________________________ kg

Part 5 Total Mass - ______________________ kg

Difference ______________________________ kg

7 Challenge: Using what you have at your table, how can you create a system where you can dissolve the 2 Alka-Seltzer tablets in the fluids without losing any mass?

8 Find the sum of the cup of fluids, the 2 Alka-Seltzer tablets, and a latex glove

The cup of fluids ______________________ kg

2 unwrapped Alka-Seltzer tablets _________ kg

A latex glove + ________________________ kg

9 Place the cup on the scale then insert the 2 Alka-Seltzer tablets followed by putting the glove on top of the cup to collect the CO2. After the tablets are dissolved, record the mass below.

Total ______________________________ kg

10 Find the difference of the total mass of Part 4 and the total mass of Part 5

Part 8 Total Mass _________________________ kg

Part 9 Total Mass - _______________________ kg

Difference ______________________________ kg

Notes

#SeaworthySTEM

Alka-Seltzer Lava Lamp Engineering Notebook

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Cartesian Diver Engineering Design

Grades 6-8

Teacher Guide

Seaworthy STEM™ in a Box Series

Cartesian Diver Engineering Design

Teacher Guide for 6-8

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Table of Contents

Lesson Title: Cartesian Diver Engineering Design

Time:
2-3 class periods

Materials and Equipment List

Materials for demonstration

- ☑ Water bottle / soda bottle with lid – full of water
- ☑ Jellyfish" or "octopus" style cartesian diver

Materials for student projects – groups of 2 or 3 students

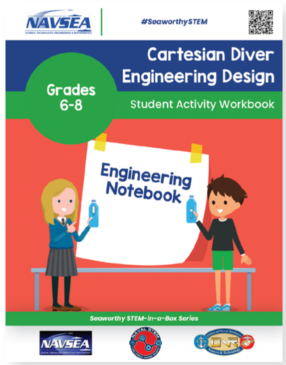
- ☑ Bottle and cap
- ☑ Water
- ☑ Cup or beaker for partially filling diver with water
- ☑ Disposable pipettes or bendy straws (able to trap an air bubble and allow water in/out)
- ☑ Weights such as hex nuts, paper clips, wire, clay, etc.
- ☑ Small objects that can be used as targets for the cartesian divers in games
- ☑ Glue that will allow students to attach targets inside bottles

Notes

It's very important to purchase water bottles with thick bottle caps! Please test your water bottle before buying a whole class set.

Student Activity Sheets/Handouts:

Student Activity Workbook



Technology Tools/Resources:

Students may look up examples of Cartesian divers online for strategies and inspiration. Students may Google “handheld water games” to see classic game designs that used floating and sinking objects in a fluid filled reservoir.

Procedure:

1 **Set up demonstration:** Use the pre-made squid or jellyfish diver to introduce cartesian divers. The diver will need to be partially filled with water so that it barely floats in a cup of water. Add the diver to the bottle of water, seal, and then press on the bottle to ensure the diver sinks when pressure is applied.

2. Show the diver to the students while subtly squeezing and releasing the bottle to keep it in motion. Ask students for observations, inferences, and questions (SEE, THINK, WONDER).

3. Engage students in conversation about what cartesian divers are and how they use pressure to compress an air pocket and move water into and out of the diver's body. Discuss mass and density changes that result.

4. Have students sketch a before-and-after model of a diver with and without pressure applied to show their understanding of how it works.

5. Group students in teams of 2-3 to design a game in a bottle that uses cartesian diver(s) as part of its construction. Students may use the internet to search for information on cartesian divers and how to build different styles. Students should design their game before they begin constructing it. Creativity should be encouraged through themes, game strategies, and element design.

6. Groups should be given 1-2 class periods to prototype, test, and redesign their games.

7. Hold a game showcase so that students can share their creations. If desired, students can partner with younger students as game testers.

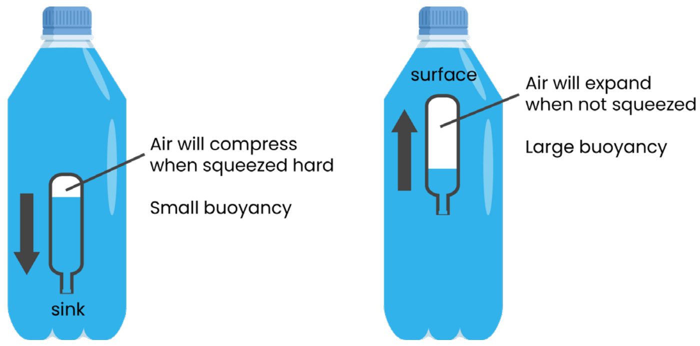
Fun Fact!

The Cartesian Diver, named by the scientist René Descartes who is said to have invented the toy, is an object that ordinarily floats but sinks when it is under pressure.

Teacher Background Information / Notes:

There are many websites and videos that provide instructions for building cartesian divers. Common ones use weighted disposable pipette tops, eyedroppers, or the flexible section of a bendy straw. Straws can also be sealed on one end as another option. There are even examples using ketchup packets on line! The key is to have an object that can trap an air bubble that can then be compressed when pressure is applied.

A cartesian diver rises and sinks based on the pressure applied to the sealed water bottle that it is submerged in. It is partially filled with water, but contains a trapped air bubble that compresses when the bottle is squeezed (increasing the pressure inside). As the air bubble compresses, more water enters the diver's body, making its mass and density increase enough that the diver sinks. When the pressure on the bottle is released, the air bubble expands, water is ejected, and the diver's mass and density drop such that it floats to the top again.



If the bottle is squeezed with just the right pressure, the diver will "hover" in the middle of the water. At this point, its weight matches the upward buoyant force and it exists in a state of neutral buoyancy with the diver's composite density matching the density of the water.

The ability of a diver or submarine to change its density to allow for sinking and rising are critical to their operations. Students may study ballast water systems or diving techniques that allow for adjustable and neutral buoyancy.

Fun Fact!

Navy Fleet Divers (NDs) perform underwater salvage, repair, and maintenance, submarine rescue, and support Special Warfare and Explosive Ordnance Disposal while using a variety of diving equipment.

NAVSEA

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

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#SeaworthySTEM

Cartesian Diver Engineering Design Teacher Guide

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Cartesian Diver Engineering Design

Grades 6-8

Student Activity Workbook

Name: ______________________________

Date: ______________________________

Seaworthy STEM™ in a Box Series

Cartesian Diver Engineering Design

1 Use the following graph paper to sketch and label game design ideas.

Fun Fact!

The Cartesian Diver, named for the scientist René Descartes who is said to have invented the toy, is an object that ordinarily floats but sinks when it is under pressure.

2 Use the following graph paper below to sketch and show how your Cartesian diver is able to dive.

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#SeaworthySTEM

Cartesian Diver Engineering Design Engineering Notebook

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Comparing Mass and Density

Grades 6-8

Teacher Guide

Seaworthy STEM™ in a Box Series

Comparing Mass and Density

Teacher Guide for 6-8

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Table of Contents

Lesson Title:

Comparing Mass and Density

Time:
1 class to gather data
1 class to analyze

Student Objectives:

The students will learn about both mass and volume and their relationship to density. The student will plot data points on a graph and apply a line of best-fit to make predictions focused on the likely density of various fluids.

Lesson Overview:

This lesson serves as a math primer for students that are about to explore the 6-8 Seaworthy STEM-in-a-Box series. The students will explore mathematical relationships between the volume and mass of various liquids. The students will utilize slope calculations as well as statistical analysis to make predictions involving the comparative densities of a given set of samples.

Next Gen Science Standards (NGSS):

MS-PS1-1
MS-ETS1-4

"A cross-disciplinary approach can accommodate diverse learning styles!"

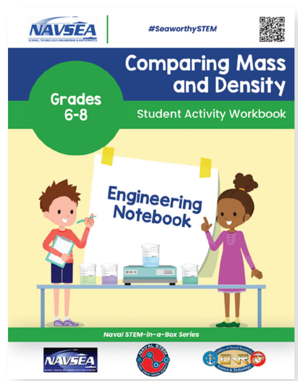
Notes

Materials and Equipment List (for each pair of students):

- 100 ml graduated cylinder
- Electronic balance
- 2 of the following liquids: pancake syrup, corn syrup, vegetable oil, water, salt water, hand sanitizer gel
- Graph paper
- Ruler
- Calculator
- Computer (optional)

Student Activity Sheets/Handouts:

Student Activity Workbook:
Comparing Mass and Volume: Data and Analysis



Technology Tools:

Excel or Google Sheets can be used as a graphing and slope analysis tool.

Procedure:

1. Students work in pairs to measure the mass and volume of 2 different liquids (i.e. fresh water, salt water, vegetable oil, syrup, etc.). Each group should prepare a data table and take at least 5-10 data points for each liquid measured. Students can choose the amounts of liquid that they use and should be encouraged to collect data over a large range. Remind them to record the mass of the empty graduated cylinder. Prior to collecting their measurements, the students may also use the "Tare" button on their scales to account for the mass of the graduated cylinder.

2. Manually prepare a scatter plot with the mass on the x-axis and the volume on the y-axis. Fully label and use 2 different colors and a key to represent data from the different liquids. Once all data is plotted, use a straightedge and draw a best fit line through each data set. Do NOT connect the points dot-to-dot style.

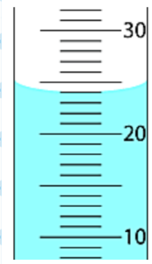
3. Use two points on your best fit line to calculate the slope for each data set.

4. Enter your data points into a Google Sheets or Excel Spreadsheet. Have the spreadsheet calculate a best fit line and provide the calculated slope. Compare your handmade graph to the statistically-produced best fit line. How do they compare?

5. Use data from the graphs to support claims about the relative density of the tested fluids. What conclusions can be drawn about which fluids float and sink? These concepts can be contextualized by having the students also complete the SeaWorthy STEM™ units "Alka Seltzer Lava Lamps" and "Density Column Exploration."

NOTE:

Remind the students to read the meniscus (the lower middle part of the fluid) when finding the volume of a liquid in a graduated cylinder.

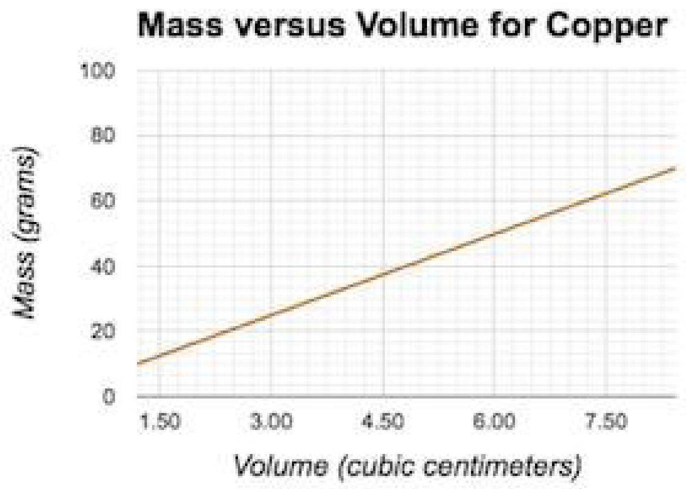


NOTE: Teacher should be sure that students discover the idea that higher density materials will sink in lower density fluids

Teacher Background Information / Notes:

The following website has background information regarding using a graph of mass vs. volume to determine the density of a material. The image below showing an example graph came from this website.

https://study.com/academy/lesson/calculating-density-with-mass-vs-volume-graphs.html



Hints for assisting students in data collection and analyzing their graph:

1. **Volume selections:** It is unnecessary to be picky about which mass-volume pairs each student measures.
    - For example, there is no need to be rigid with measuring in precise 50 ml increments. Similarly, there is no need to take the volume measurements in increasing order; it's OK to take a smaller volume measurement after larger ones are done.
    - When a scatter plot is made, it will plot each point appropriately, whether they are evenly separated or whether they were taken with gaps in the data.

2. **Cylinder Mass:** Be sure that students measure the mass of their empty graduated cylinder so that they can subtract it from their mass measurements to know the mass of the liquid being measured.

    - It is important that students measure their own graduated cylinders since even glassware that looks similar will vary in mass.
    - Alternatively, it is interesting to see the graph produced when a group forgets to subtract out their graduated cylinder mass. Basically, they'll get a graph with the same slope, but it will have a y-intercept point that equals the mass of the empty graduated cylinder. This error presents students with a good opportunity for critically thinking about their data.

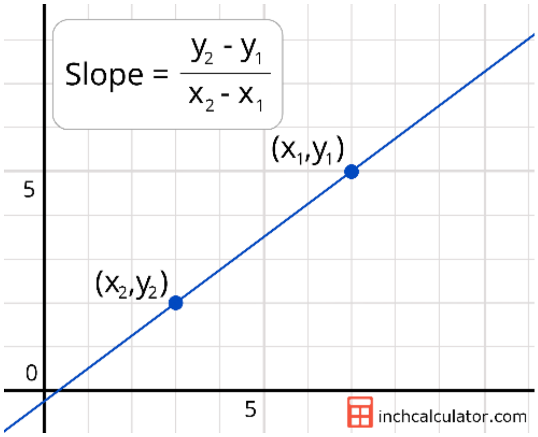
3. **Basics of Statistical Analysis:** This data collection and graphing exercise provides a good opportunity to discuss real world data vs. textbook data. Since this is real world data, it will have some variation (unlike textbook data that is generally idealized). This will show up in the graph as scatter rather than every data point being exactly on a straight-line trend.

    - Discuss that some scatter is expected because of the limitations in any data collection process.
    - Emphasize the use of a best-fit line as the tool that shows the overall average trend while ignoring the experimental errors in individual data points.
    - If you have a correlation coefficient from Excel (R2 value), show it to students and explain that the closer it is to 1.00, the better the correlation between data points and the closer they are to the trend. The trend line represents all of the data point vs. overemphasizing any one point that has errors.

Fun Fact!

Did you know that the Navy has an entire team of environmental scientists who have helped develop a three-tier action plan to minimize any environmental effects from possible oil spills. The Navy's policy is to respond to any possible Navy spills and to undertake direct and immediate action to minimize the spill's effect. Their knowledge of liquids having different densities aids them in this process.

4. **Slope Calculation:** Be sure that students select two points (x1, y1) and (x2, y2) that are directly on their best fit line. If data is relatively scattered, it is possible that none of the measurements will lie on the best-fit line. If this occurs, do not use any of the original measurement, but instead find the coordinates of two new points from the line to use in the slope calculation. As a reminder, the slope formula is presented below (from https://www.inchcalculator.com/slope-calculator/)



Vocabulary Terms and Mathematical Formulas:

- Density: The amount of space an object or substance takes up (its volume) in relation to the amount of matter in that object or substance (its mass) Density = M/V
- Line of best fit: A mathematical concept that correlates points scattered across a graph.
- Liquid: A state of matter where particles are free to flow. It has a definite volume, it does not have a definite shape
- Mass: The amount of matter in an object
- Meniscus: The curved surface of a liquid in a graduated cylinder
- Slope: A value that describes the steepness and direction of a line
- Viscosity: A measure of a fluid's resistance to flow
- Volume: The amount of space occupied by an object

STEM Related Careers:

- Environmental Scientist
- Oceanographer

Fun Fact!

This photo is an example of an oil clean-up. The ship used high speed skimmers on leased OSV assets in support of USCG response efforts during the Deepwater Horizon oil spill in the Gulf of Mexico in 2010.

Notes

NAVSEA

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

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#SeaworthySTEM

Comparing Mass and Density Teacher Guide

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

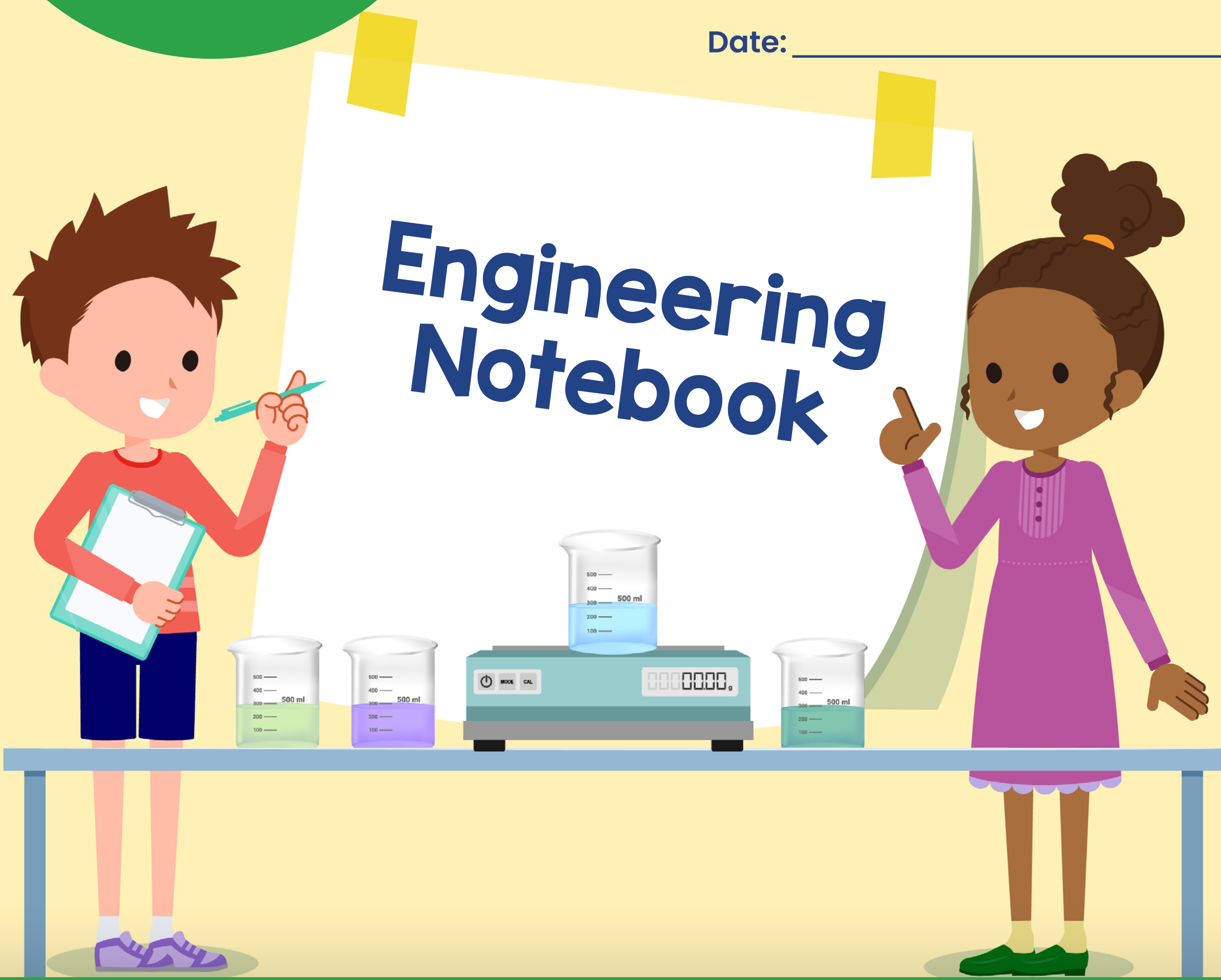
Comparing Mass and Density

Grades 6-8

Student Activity Workbook

Name: ______________________________

Date: ______________________________



Seaworthy STEM™ in a Box Series

Comparing Mass and Density

1 Part 1: Data

In today's lab experience, you will explore how the volume and mass of liquids are related to each other. The measurements that you take will help you build a mathematical model that describes this physical phenomenon.

Procedure:

1. Obtain a balance, graduated cylinder, and beakers of 2 different liquids.
2. You get to choose which volumes you want to measure. Try to cover a wide range of volumes, but the samples sizes you choose are up to you. Take at least 5 – 10 data points per liquid you test.
3. Be sure to record the mass of YOUR graduated cylinder before you begin.
4. When you are done, return your supplies to the counter. Clean up any spilled materials and wash your hands.

Graduated Cylinder Empty Mass: ______________________________ g

Liquid 1: ______________________

Volume (ml)	Mass (g)

Liquid 2: ______________________

Volume (ml)	Mass (g)

2 Part 2: Analysis

Procedure:

1. Use the graph paper on the following pages and two different colored pencils or pens.

2. Set up a set of axes to make a scatter plot with the mass and volume data you gathered. Plot the volume on the x-axis and the mass on the y-axis.

3. Be sure to give your graph a meaningful title and include the units of measure on the axis labels.

4. Look at the ranges of masses and volumes and set up an appropriate scale. Remember to use even increments on your scales. Your scales should look like number lines!

5. Start with your first liquid and use the volume and mass as and (x, y) ordered pair. Plot all the data points for this liquid using one colored pencil.

6. Do you notice any sort of trend? The trend in your data is best represented by a "best fit line" that goes through the middle of your data points. Use a ruler to draw your best fit line. Try to have about as many points above the line as you have below it. *(*Something to think about: Should your line go through the origin (0,0)? What would this mean?)*

7. Use the other colored pencil to plot the data points and best fit line for the 2nd liquid on the same set of axes.

8. Calculate the slope of each of your best fit lines in the space below. Remember to include units of measure!!

Liquid 1 Slope Calculation	Liquid 2 Slope Calculation

STEM Related Career:

- Chemical Engineer
- Mechanical Engineering

Fun Fact!

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Notes

#SeaworthySTEM

Comparing Mass and Density Engineering Notebook

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Density Column Exploration

Grades 6-8

Teacher Guide

Seaworthy STEM™ in a Box Series

Density Column Exploration

Teacher Guide for 6-8

Seaworthy STEM™ in a Box Educator Kit description:

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NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

Table of Contents

Lesson Title:

Density Column Exploration

Time:

- ½ class period for the teacher to share student background information
- 1 class period for student challenge

Student Objectives:

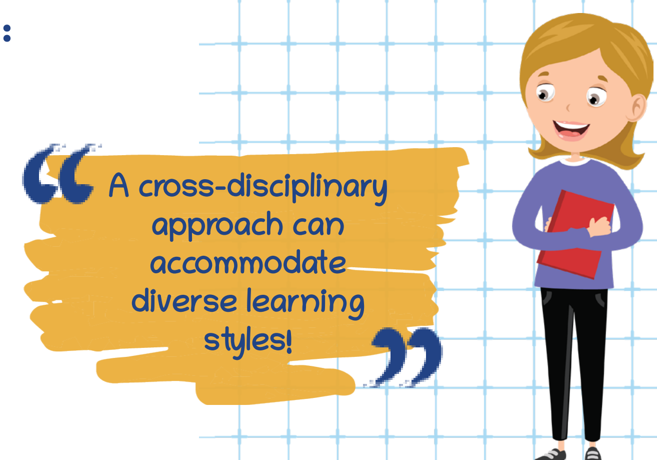
Students will learn that an object's density equals its mass divided by its volume. Students will learn that various objects possess varied densities. Students will apply this knowledge as they create a system where objects are stacked in a predictable manner.

Lesson Overview:

The teacher will begin the lesson by leading a density demonstration using a large column with varied ingredients in front of the students. During this activity, the teacher will share terms associated with the layered column lesson, ensure that the students know how to correctly work the scale, and complete a few density related math problems with the class. The teacher may need to review how to find the volume of both regular and irregular shaped objects. The final challenge will involve the application of all of the aforementioned as the students complete an engineering design challenge.

Next Gen Science Standards (NGSS):

MS-PS1-1
MS-ETS1-1
MS-ETS1-2
MS-ETS1-3
MS-ETS1-4



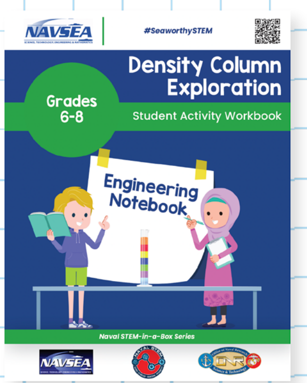
Materials and Equipment List:

For demonstration:

- ☑ 100 ml or 250 ml transparent graduated cylinder
- ☑ Liquids: corn syrup, pancake syrup, fresh water with food dye, salt water with food dye, vegetable oil, hand sanitizer gel
- ☑ Solids: cubes or other samples of various plastics (PVC, nylon, acrylic, polypropylene), wood, metal, glass

For challenge (1 set per pair of students):

- ☑ Small test tube or clear straw
- ☑ 4 cups or beakers for mixing solutions
- ☑ Waste beaker
- ☑ Salt and sugar
- ☑ Water – iced, room temperature, near boiling
- ☑ Stir sticks or spoons
- ☑ Food dye
- ☑ Disposable pipettes
- ☑ Thermometer
- ☑ 3 solid items that will become suspended between different liquid layers (cubes or other samples of various plastics, wood, metal or glass
- ☑ Digital Scale
- ☑ Metric Ruler
- ☑ Calculator



Student Activity Sheets/Handouts:

Guided Observation Worksheet:
Density Column Exploration

Technology Tools:

Digital Scale
Calculator

Procedure:

1 Teacher Demonstration:

Teacher leads demonstration to produce a large-scale density column in front of whole class. Density column consists of several layers of liquids and solids that are added after the liquids are layered.

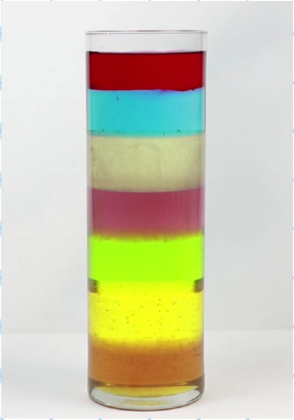
1. There is no need to start with dense materials. Each material will find its way to the proper level in the column based on its density.

2. Add liquids slowly and along the edge with the column tipped to the side. This is especially important for the fresh water and salt water layers which will mix easily.

3. Solids will settle into various liquid interfaces depending on their relative densities.

4. Students may ask what happens when the column is shaken. They may have the idea that all the layers will re-form if it is shaken and allowed to re-settle. This is not the case: all the aqueous (watery) layers will combine into a new solution and not separate. If you choose to do this at the end of the demonstration, be sure to explain that the corn syrup (which is hard to get to fully mix due to its viscosity) may not fully mix into the others, and therefore may re-settle partially.

5. To increase engagement, ask students for predictions as each new material is added and have students make notes about the relative position of each added material.



Helpful Tip:

Use a window as a backdrop to the density column so that it is easier for students to see the layers as they form.

Many common household liquids such as juice and milk have a density very close to that of water, so you might not notice a difference. Oil, however, has a lower density than water, meaning it can float on top of water. (It is buoyant.) You can see this in your density column, the oil bubbles will float on the surface.

2 Teacher Part 2:

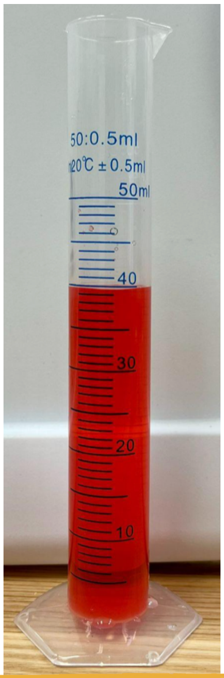
1. Review related terms and math concepts with the students

2. Explain to the students that their predictions can be more accurate if they use math to help them find the density of the various objects in the column. Additionally, share that distilled water has a density of 1 g/ml, so objects that "sink" have a greater density and objects that "float" on top of the water have a density less than 1 g/ml.

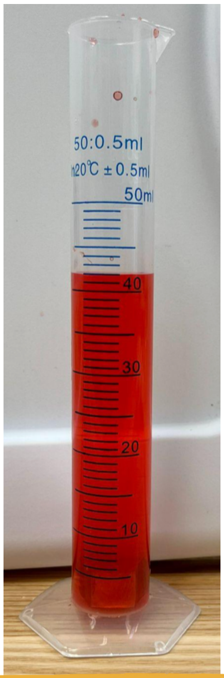
3. Share that an object's density is its mass divided by its volume

   1. Volume of regular shaped objects can be found by using formulas (these can be found in the terms and formulas section of this guide)

   2. Volume of irregular shaped objects can be calculated by the amount of water displaced in a graduated cylinder (see below).



40ml without the cube



40ml with the cube

3 Student Density Activity:

Density column challenge activity – students work in pairs to mix 4 solutions with different densities and then to stack them in layers in either a small test tube or a clear straw.

1. Students have the flexibility to use temperature, sugar concentration, or salt concentration as a way to change solution density.

2. Food coloring should be used to differentiate between the different mixtures.

3. Stacking the solutions may be done:

   a. In a clear straw that is "stabbed" into each cup of liquid. Higher density solutions will remain under lower density solutions as they are added. If a lower density solution is added to the bottom of the straw, mixing will occur.

   b. In a small test tube with disposable pipettes used to add layers. Students must work slowly and drip the solutions down the edges of the test tubes to prevent unwanted mixing. As long as solutions are added in order of decreasing density, layers will form. If A higher density material is added to the top of the test tube, it will sink and produce mixing.

4. It will likely be more difficult to stack solutions by temperature difference. To help, provide ice water and near-boiling water to allow for a wide temperature difference. Also, students must work quickly because, the longer the solutions sit, the more their temperatures will equalize with room temperatures.

Helpful Tip:

Have a classroom discussion about the term, Viscosity! Viscosity is a measure of a fluid's resistance to flow.

4 Navy Design Challenge:

The Navy wants to set sonar buoys at different depths so they can detect intruders within your 40 ml column of liquids. It is your mission to find a combination of fluids and solids that will allow you to place one buoy at 10ml, one buoy at 20 ml, and one at 30ml.

**The teacher will provide the students with several food colored liquids and solid objects, which will represent acoustics buoys (small density blocks work great) of various densities so that the students can have intermingled columns of liquids and solids.*

Teacher Background Information / Notes:

The materials will stack in density order, with the most dense materials at the bottom. Don't forget to mention that there is an air layer at the very top!

Including hand sanitizer gel in the stack will help students disconnect the ideas of viscosity and density. The pancake syrup and corn syrup are both dense and viscous and can lead to students thinking that these properties always go together. Since hand sanitizer gel is viscous, but has a lower density than water, it provides a counterexample to help eliminate this misconception.

An example video can be seen here:
https://www.youtube.com/watch?v=KgZ7JtmOgHI

The materials in the video are different from the ones I've suggested, but you can improvise depending on what you have readily available. Be cautious is you include lamp oil or alcohol as they are flammable and need to be carefully handled in the classroom setting.

Vocabulary Terms and Mathematical Formulas:

- Density: The amount of space an object or substance takes up (its volume) in relation to the amount of matter in that object or substance (its mass) Density = M/V
- Liquid: A state of matter where particles are free to flow. It has a definite volume, it does not have a definite shape
- Mass: The amount of matter in an object
- Mixture: A combination of two or more substances, such that each maintains its chemical identity
- Solid: A state of matter characterized by particles arranged such that their shape and volume are relatively fixed
- Solution: A solution is a homogeneous mixture of two or more substances
- Viscosity: A measure of a fluid's resistance to flow
- Volume: The amount of space occupied by an object
    - Formula for volume of a square or rectangle= LxWxH
    - Formula for volume of a sphere= $4/3\ \pi\ r3$

STEM Related Careers:

- Marine Biologist
- Meteorologists
- Naval Architect
- Ocean Engineering

Notes

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#SeaworthySTEM

Density Column Exploration Teacher Guide

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

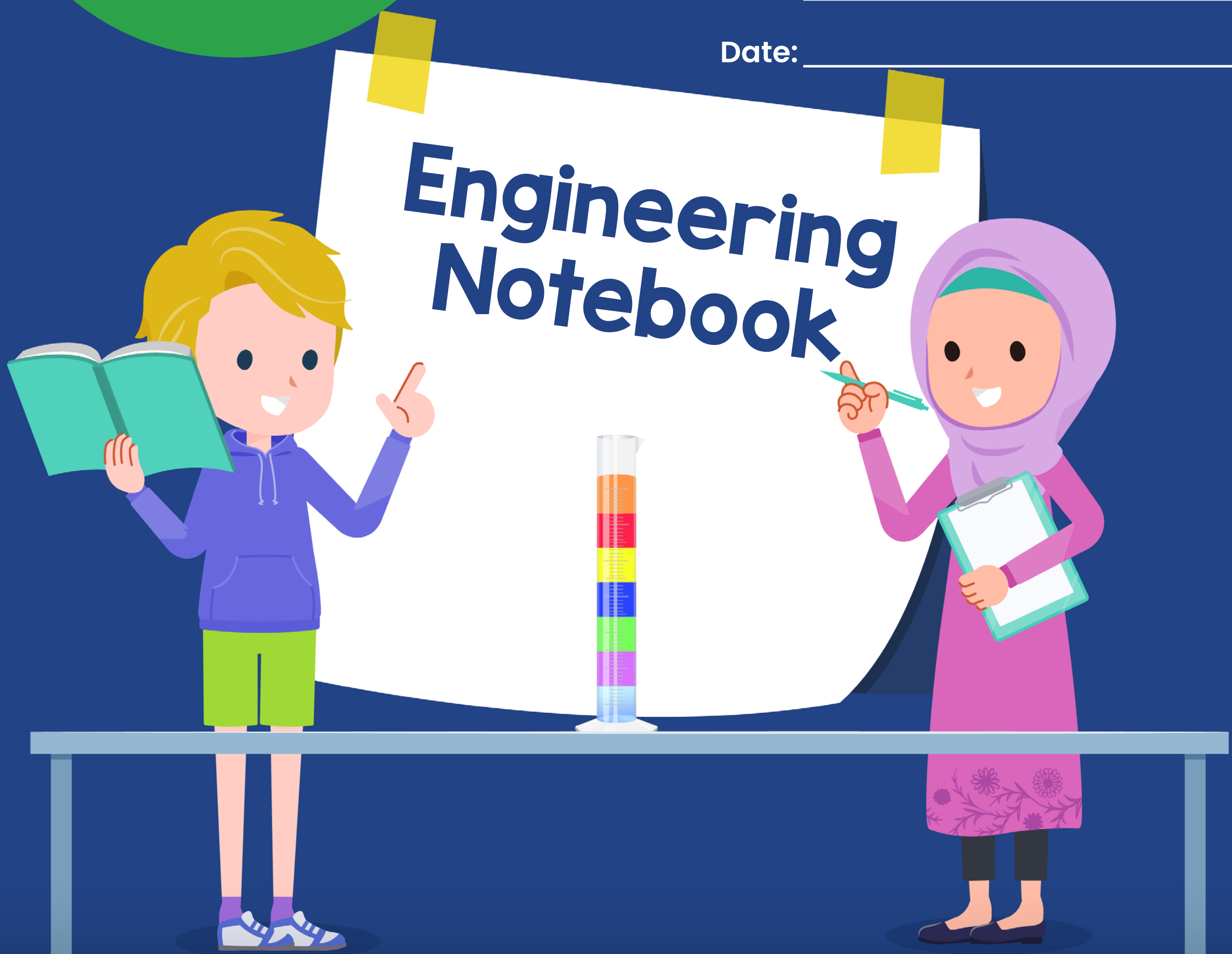
Density Column Exploration

Grades 6-8

Student Activity Workbook

Name: ______________________________

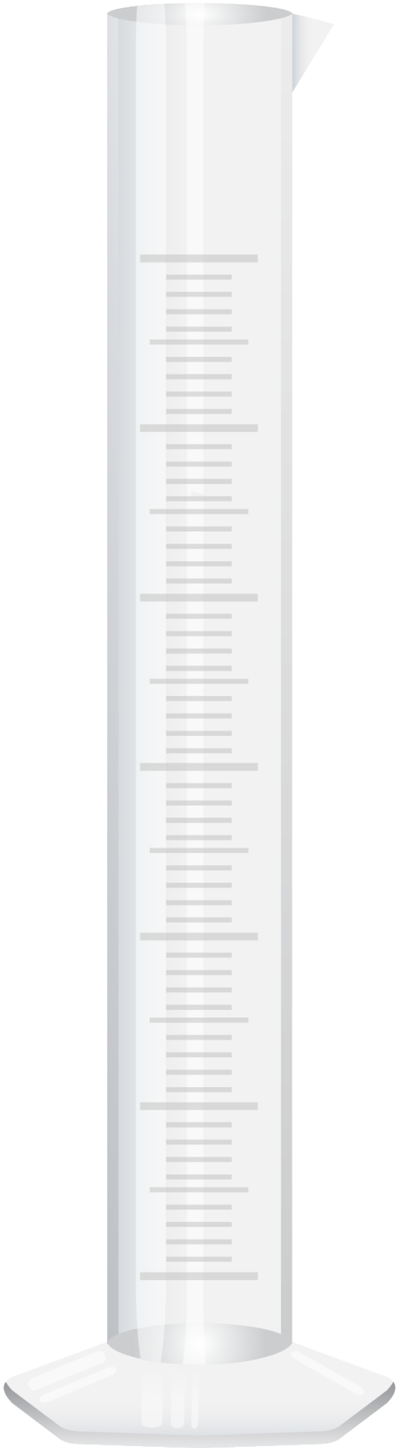
Date: ______________________________



Seaworthy STEM™ in a Box Series

Density Column Exploration

1 Part 1: Sketch and label the Density Column from the Demonstration.



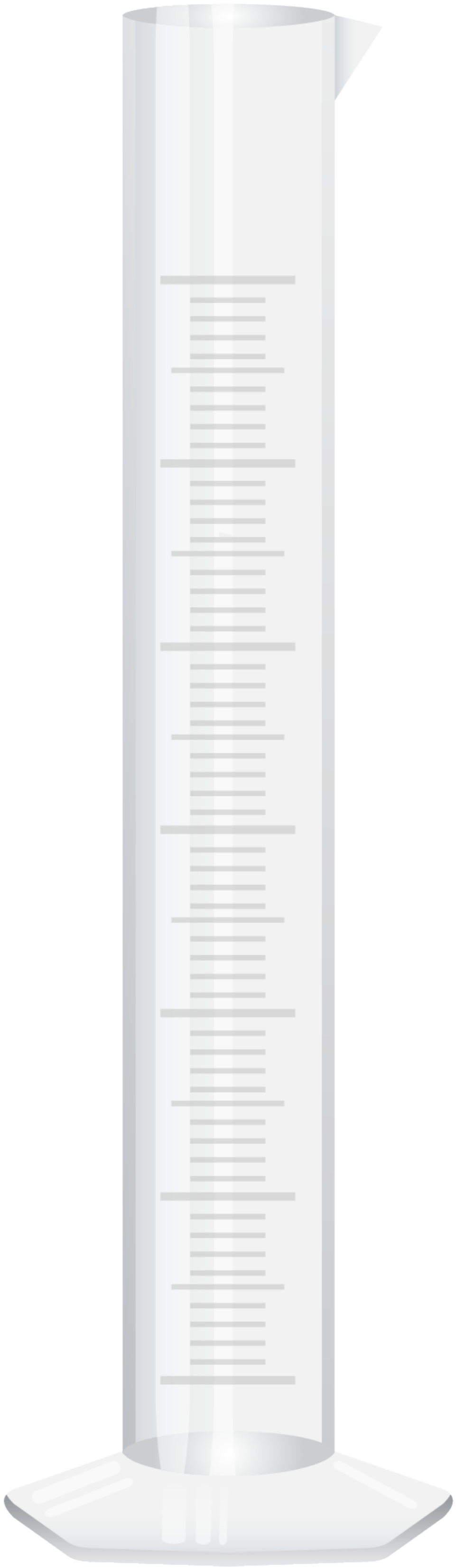
2 Part 2: Prepare 4 different types of solutions. You can experiment with changing the temperature and adding salt and sugar. Use food coloring to tell them apart.

Cup	Color	Description
A		
B		
C		
D		

3 Part 3: Now try layering different combinations. Which combinations are stable? Which ones mix?

Top	Bottom	Result?

4 Part 4: Try to stack at least 4 layers in your tube. Sketch your result here.



5 **Navy Design Challenge:** The Navy wants to set sonar buoys at different depths so they can detect intruders within your 40 ml column of liquids. It is your mission to find a combination of fluids and solids that will allow you to place one buoy at 10ml, one buoy at 20 ml, and one at 30ml.

6 Use your graduated cylinder and digital scale to calculate the densities of your objects (including your fluids). Remember that Density equals Mass/Volume. What do you think your density column will look like once you put all of your objects in the graduated cylinder? Draw your prediction in the box below? Be sure to include labels for both the fluids and the objects.

7 Draw a labeled picture your completed density column.

8 Did your density column turn out as planned? Why? Why not? How is knowing the densities of objects useful in the real world?

#SeaworthySTEM

Density Column Exploration Engineering Notebook

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Film Canister Boat Float

Grades 6-8

Teacher Guide

Seaworthy STEM™ in a Box Series

Film Canister Boat Float

Teacher Guide for 6-8

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NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

Table of Contents

Lesson Title: Film Canister Boat Float

Time:

1 class period

Student Objectives:

The students will take accurate measurements (both mass and volume) and use the appropriate mathematical formulas to attempt to solve an engineering design challenge.

Lesson Overview:

The students will use math to design a "boat" that will hold mass without sinking. The end goal is to create the heaviest possible film canister (using sand) and still have it float on the surface of the water. An extension activity is provided whereas students will go through the iterative design process to get their boat to become submerged in the water without touching the bottom.

Next Gen Science Standards (NGSS):

MS-PS2-2

MS-ETS1-1

MS-ETS1-2

Materials and Equipment List

For each pair of students:

- ☑ Film canister
- ☑ Ruler

One per approximately 4 students:

- ☑ Sand container with scoop
- ☑ Electronic balance

For entire class:

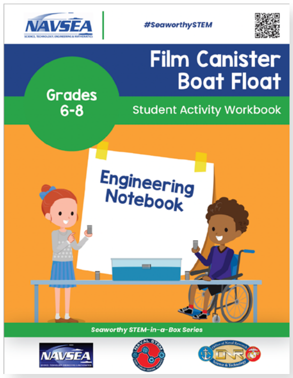
- ☑ Large container of water for floating boats

Optional:

- ☑ Materials to make film canisters look like boats

Student Activity Sheets/Handouts:

Student Activity Workbook:
Film Canister Boat Float



Procedure:

1 **Set up.** Each pair of students needs a ruler and a film canister. Set up several stations around the room with containers of sand, scoops, and electronic balances. Set up a water container and balance in the front of the room where students will test their boats.

2 Introduce challenge to students. The goal is to use a film canister boat hull and add enough sand to it to produce the heaviest boat that still floats. Boats will be built then tested individually with whole class data collection.

3 Provide background information (or let students use the internet to find background). Brainstorm problem solving strategies and information that will be needed to complete this challenge. Allow students to ask questions, but do not give direct procedures. Key ideas to emphasize:

A. For a floating boat, the upward buoyant force acting on the boat equals the weight of the water that the boat displaces. In other words, a floating boat will displace its weight in water. Since mass and weight are proportional, this means that a 500 g floating boat will displace 500 g of water.

B. Since the density of water is 1 g / cm3, the volume of water displaced (in cm3) equals the mass of the water displaced (in grams).

C. Putting a) and b) together... a 500 g floating boat displaces 500 g of water which is equal to 500 cm3 of water.

4 Pairs of student will work together to measure their canister:

- **Calculate the Volume**
    - Formula for volume of a cylinder: $V = \pi \times r^2 \times h$

EXAMPLE:
What is the volume of a cylinder that has a radius of 5 cm and a height of 10 cm?

Solution
We have the following values:

Radius= 5
Height = 10
Using the volume formula with these values, we have:

$V = \pi \times r^2 \times h$
$V = \pi \times 5^2 \times 10$
$V = \pi \times (25) \times 10$
$V = 785.4\ cm^3$

The volume is equal to $785.4\ cm^3$

- **Calculate the Mass**
    - Use the balance to record the mass in grams.

      **Make sure they put the lid on the container, so they can find the correct mass.*

EXAMPLE:
For this example we will use 1000g

Solve using Density= Mass/Volume
$D = 1000g/785.4cm^3$
$D = 1.27g/cm^3$

5 Once they have calculated their mass, they should go to a sand/balance station and load sand to get to their mass. Students who finish early may be given supplies to decorate their canister to look more like a boat (optional).

6 Once all students are ready, bring groups to the front 1 at a time to test their boat in front of the class. Place their boat on a balance and record its official mass on the board.

7 Allow students to place their boat in the container of water to determine if it floats or sinks. Record results.

8 The “winner” is the group that has the heaviest boat that still floats.

Teacher Background Information / Notes:

- This is a great "self-checking" activity that emphasizes mass and volume and the relationship of density to floating.
- Some boats may actually appear to float a bit below the water's surface due to the surface tension of the water causing a bead of water to build up higher than the rim of the canister.
- Containers of other shapes can be used to alter the difficulty level of the challenge or to allow students a 2nd trial with the procedures. Cubic prisms, plastic spheres, test tubes, plastic eggs, and different sized cylinders could be used.

Vocabulary Terms and Mathematical Formulas:

- Buoyant Force: The upward force exerted by any fluid upon a body placed in it
- Density: The amount of space an object or substance takes up (its volume) in relation to the amount of matter in that object or substance (its mass) Density = M/V
- Displacement: The volume of water displaced by an object is also equal to its immersed volume, which, in the case of a floating boat, will be its underwater hull volume.
- Liquid: A state of matter where particles are free to flow. It has a definite volume, it does not have a definite shape
- Mass: The amount of matter in an object
- Volume: The amount of space occupied by an object
- Formula for volume of a cylinder: $V = \pi \times r^2 \times h$

STEM Related Careers:

- Marine Biologist
- Meteorologists
- Naval Architect
- Ocean Engineering
- Mechanical Engineering

Need a lift?

This heavy lift ship is used to carry large loads that goes beyond the size and weight of regular traveled cargo. These ships can even carry another ship!

Notes

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#SeaworthySTEM

Film Canister Boat Float Teacher Guide

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

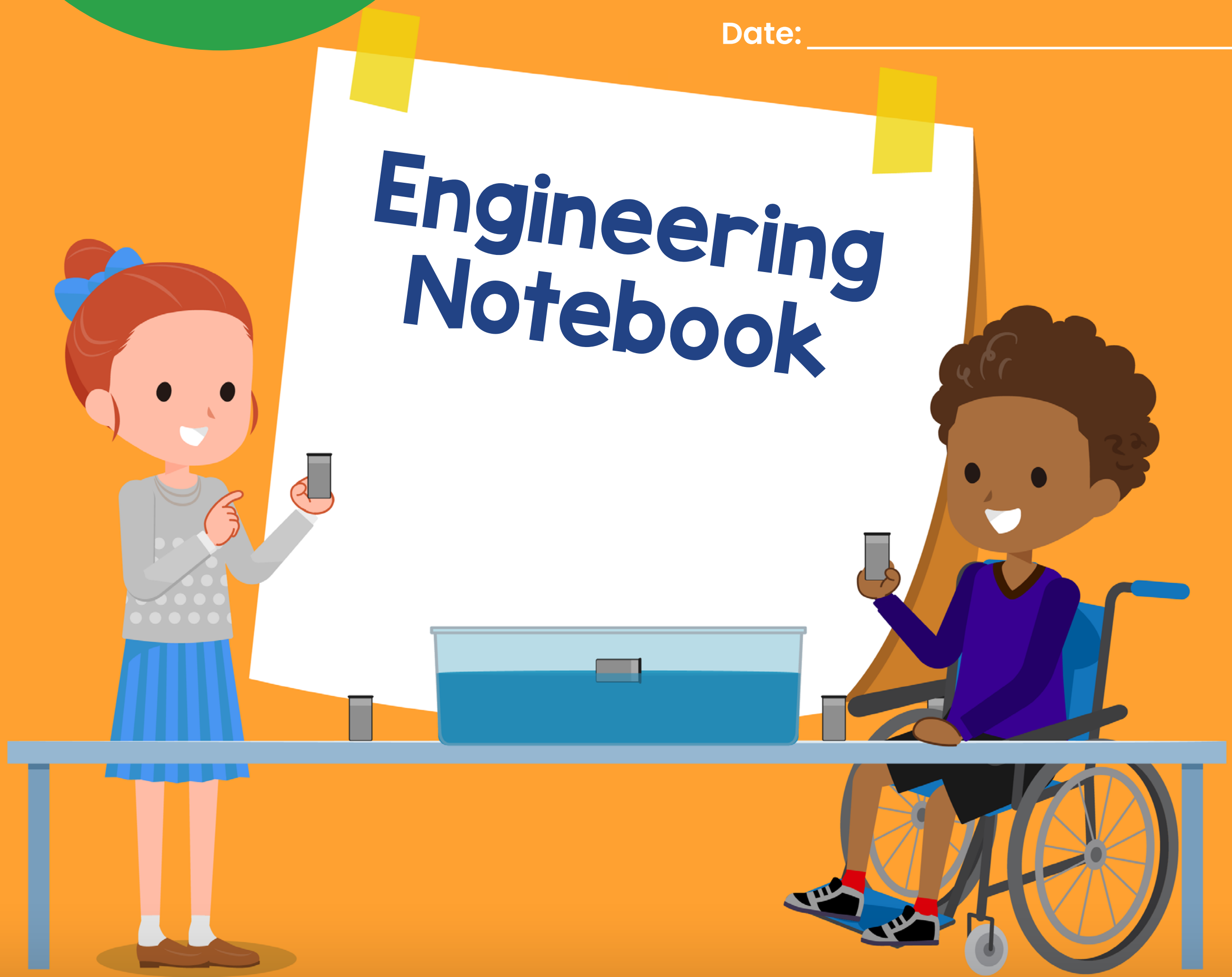
Film Canister Boat Float

Grades 6-8

Student Activity Workbook

Name: ______________________________

Date: ______________________________



Seaworthy STEM™ in a Box Series

Film Canister Boat Float

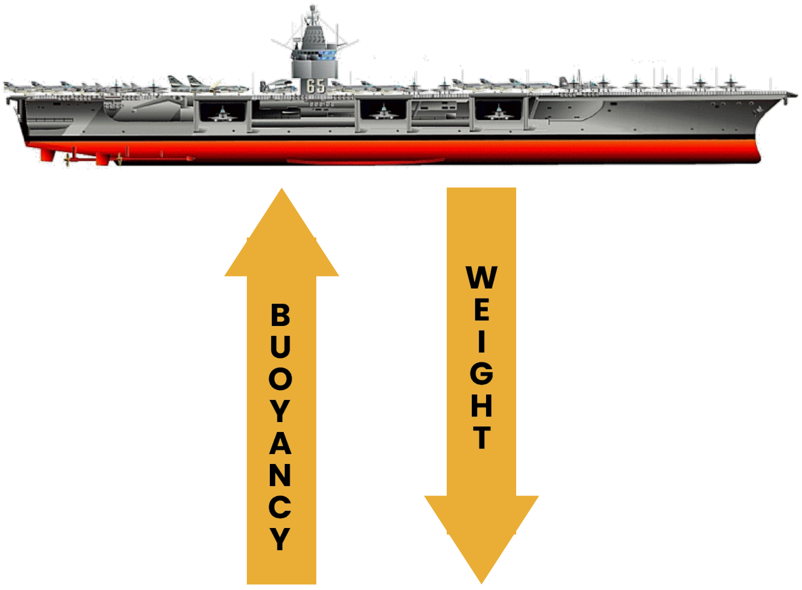
Your Goal: Build the heaviest boat that still floats in water.

Materials:

- Film canister
- Sand
- Ruler

Some possibly useful information about floating boats...

- The water applies an upward buoyant force equal to the weight of the boat.
- The water's buoyant force is equal to the weight of the water that the boat displaces.
  - So the hull of a 50 Newton boat displaces 50 Newtons of water.
- Weight and mass are proportional – so these forces can be related to masses.
  - Meaning a 5000 g boat displaces 5000 g of water.
- Also... water's density is approximately 1 gram per cubic centimeter.
  - So our 5000g of displaced water takes up 500 ml of volume.



Film Canister Boat Float Challenge!

Which group can fill their canister with the most sand and still have it float?

Objective: We know that the design of a boat will allow it to hold mass without sinking. Fill your film canister with as much sand as you dare. Your goal is to create the heaviest possible film canister (using sand) and still have it float.

1 Put sand into your film canister (Replace the lid)

Find the density of your film canister boat:

Calculate the volume of your container using the formula: V= π x r^2 x h

Record your volume: ______cm

Calculate the mass of your container using the balance

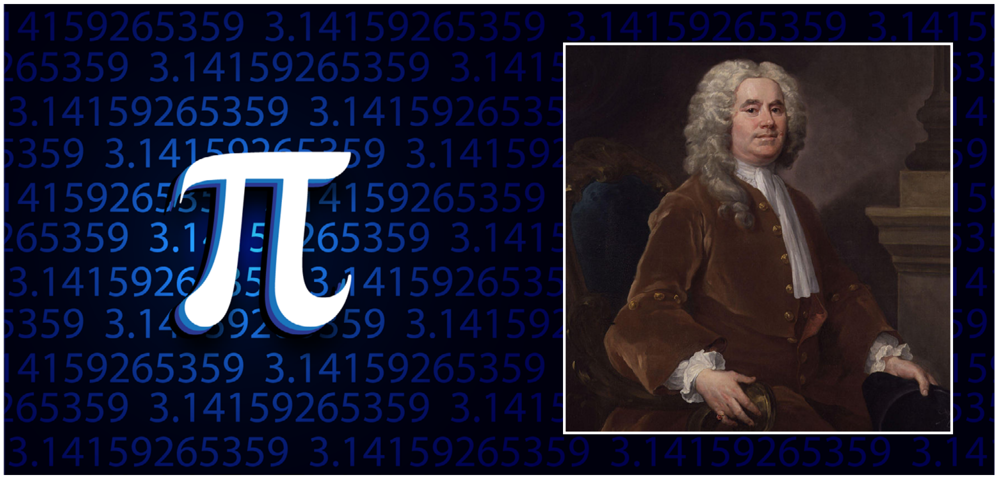
Record your mass: ______g

Calculate the density of your container using the formula: D= m/v

Record your density: ______g/cm^3

Fun Fact!

Pi is a variable that represents the ratio of a circle's circumference to its diameter. Pi was devised by British mathematician William Jones in 1706 to represent the ratio and help us understand how a circle's dimensions work.



2. Assuming that the density of your water is 1 g/ml, do you predict that your boat will float or sink? Why?

3. Test your boat.

4. If you were doing this test in salt water, do you think that your boat would be able to hold more, less, or the same amount of sand? Why?

5 **Super Challenge:** Try to get your boat to become a submarine by engineering it to become suspended in the water column. Can you design it to be below the surface while at the same time not touching the bottom?

#SeaworthySTEM

Film Canister Boat Float Engineering Notebook

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Golf Ball Float

Grades 6-8

Teacher Guide

Seaworthy STEM™ in a Box Series

Golf Ball Float

Teacher Guide for 6-8

Seaworthy STEM™ in a Box Educator Kit description:

Seaworthy STEM™ in a Box activities are a Navy initiative to provide enhanced Naval-relevant, standards aligned, hands-on activities to K-12 teachers and students. Components of this program include, curated sets of classroom activities that aim to build deep conceptual understanding in Naval-relevant content areas. The kits also includes comprehensive lesson plans, material lists, scientific background information, STEM related literacy books, and student activity sheets. The Seaworthy STEM™ in a Box program is designed to support teachers as they select content, acquire materials, and implement more hands-on STEM activities in their classrooms. Increasing student access to hands-on STEM activities, also increases awareness of STEM career paths, engage students in STEM, and support development of student's abilities in STEM content.

The Seaworthy STEM™ in a Box kits were designed to guide students through the scientific inquiry-based theory and the engineering design process. The content and Naval-relevant activities are aligned with the Next Generation Science Standards. The topics and content covered within the lessons are connected and scaffolded based on distinct grade bands (K-2nd, 3rd-5th, 6th-8th, and 9th-12th).

NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

Table of Contents

Lesson Title: Golf Ball Float

Time:

45-60 minutes

Student Objectives:

The students will take accurate measurements (both mass and volume) and use the appropriate mathematical formulas to attempt to solve an engineering design challenge.

Lesson Overview:

The students will use math to better understand how to calculate density and also have a better understanding of the impact of that density on a mixed group of objects. They will also understand that the density of a substance can change if it is mixed with another substance.

Next Gen Science Standards (NGSS):

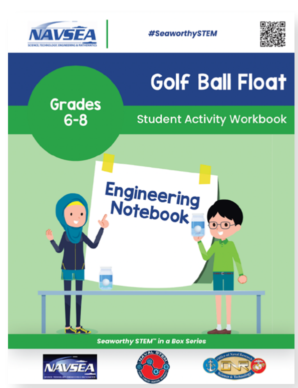
- MS-PS1-2
- MS-PS2-2
- MS-ETS1-1
- MS-ETS1-2

Materials and Equipment List (For groups of 3-4 students):

- ☑ Jar with tight-fitting lid (for example, tennis ball tube, or large peanut butter jar, etc.)
- ☑ Golf ball
- ☑ 1 cup of water softener salt pellets
- ☑ Blue food coloring
- ☑ Pitcher
- ☑ Water
- ☑ Trays, towels, sink for clean up
- ☑ Graduated Cylinder
- ☑ Beaker
- ☑ Pipette
- ☑ Digital Scale

Student Activity Sheets/Handouts:

Student Activity Workbook: Golf Ball Float



Technology Tools:

Digital Scale

Procedure:

1 Demo Set-up:

Prepare a sample of the system pictured. It consists of a golf ball that is floating at the interface between a blue-colored freshwater layer and a colorless salt water layer. There are undissolved water softener salt pellets in the bottom of the jar.

To make this system:

1. Place a cup of salt pellets and the golf ball in the jar. Add water to fill it about half way and tightly screw on the lid.
2. Shake the salt and water vigorously for several minutes until the salinity of the water has increased its density enough that the golf ball floats.
3. Add blue-dyed freshwater from a pitcher, taking care to pour slowly down the side of the tilted jar so that the water layers do not over mix. Adding water incrementally with a large pipette is another good way to ensure that the layers do not mix."

Tip: it will take longer than you think!

2 Set up for activity, prior to class:

Place salt pellets and golf balls in jars. Provide pitchers of un-dyed and blue-dyed water. Do not label any of these since part of this activity involves students reasoning about the materials without knowing for sure what they are.

Fun Fact!

Designing a ship can be quite complicated for naval ship designers. A ship designer needs to make sure that the ship is never more dense than the water to make sure it floats. For example, did you know that the USS Zumwalt not only looks cool but weighs almost 16,000 tons!

3 During class:

1. Have the demo system sitting in a visible location so that you can show it to students without having to move it. Students are to record/brainstorm their observations, inferences, and questions using the student activity worksheet in the engineering notebook. **Do not answer questions at this point – students should not know the exact composition of the contents at this point.**

2. Challenge students to use their hypotheses and science knowledge to recreate the system they observe.

3. Give them materials and allow them time to make and modify their prototypes. This will likely take the rest of the class period and some groups may not have accomplished the task.

4. Have the students mathematically prove why the system works. They can do this by finding the mass of the salt water and the food colored tap water using a graduated cylinder and the scale. Followed by finding the mass of the golf ball by using the beaker (water displacement) and the scale. The students should use their pipette to retrieve samples of the two different types of water. *If the students fail to have clean samples of water, allow them to draw from the demo.* The students will then complete the math section in their workbook.

4 Follow-up:

1. Have students debrief in an independent or group assessment for understanding. Have students complete the activity guided worksheet.

2. Students sketch the system and label it in ways that show their understanding of the phenomena involved.

3. Students extend their thinking by predicting what would happen if the system were allowed to remain undisturbed for several weeks.

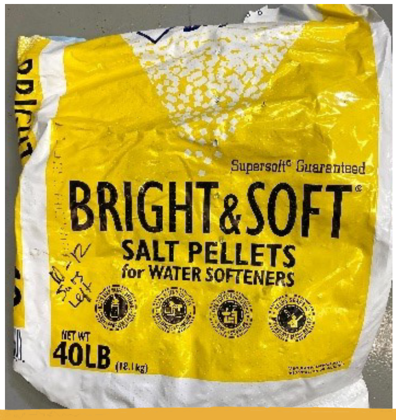
Teacher Background Information / Notes:

Remind students not to touch or taste the materials in this lab. They aren't actually hazardous, but would give away the identity of the materials.

Most students will not be familiar with water softener salt pellets and may assume that they are made of plastic based on their appearance. Students may also assume that the blue liquid is something other than water.

Be prepared to discuss what a water softener is and why it needs salt – this is a side topic, but relevant to students' lives. Water softeners contain materials (zeolite) that absorb "hard water" calcium and iron minerals from home water sources. The salt is used in a regeneration cycle to flush the calcium and iron ions from the zeolite and replace them with sodium so that the zeolite can be reused over and over. Having hard water depends on the source of your water and varies by regions and their geology. Hard water will leave deposits that leave behind residues on shower doors and faucets and, over time, can build up in appliances such as coffee pots and water heaters.

Most water softener pellet bags are sold in 40 pound bags and can be found at local home improvement stores. One bag usually costs less than $10 and can supply more about 40 lab stations.



"water softener pellets"

Extension Activity Ideas:

This system could be kept and monitored for several weeks and months. Students could take quantitative measurements and make qualitative observations about how it changes as time goes on. Data could be graphed for a discussion on dissolving and/or diffusion rates.

1. As time goes on the salt in the bottom will continue to dissolve, increasing the salinity in the bottom of the jar. The salt water and blue water layers will diffuse, resulting in a changing color profile. Over time, the golf ball will rise due to the extra salt dissolving (unless the salt all dissolves before it reaches the top).

Vocabulary Terms and Mathematical Formulas:

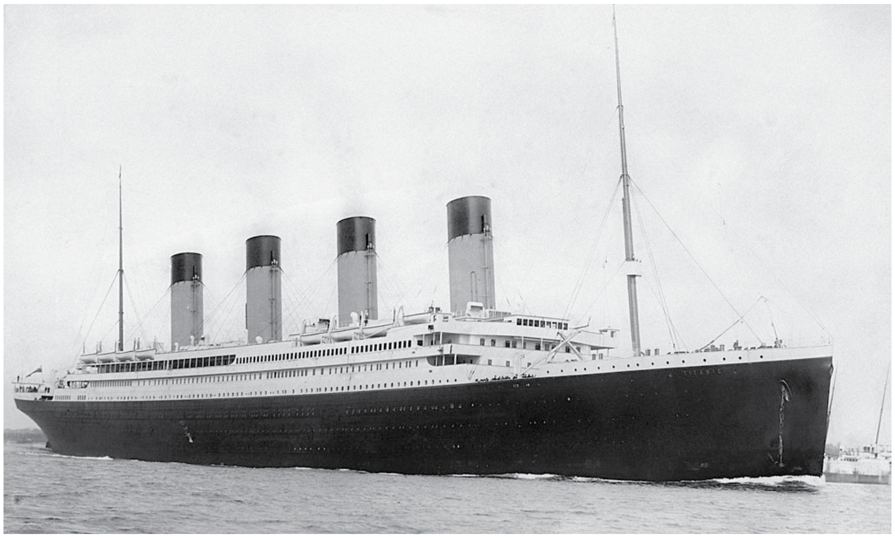
- Buoyant Force: The upward force exerted by any fluid upon a body placed in it
- Density: The amount of space an object or substance takes up (its volume) in relation to the amount of matter in that object or substance (its mass) Density = M/V
- Displacement: The volume of water displaced by an object is also equal to its immersed volume, which, in the case of a floating boat, will be its underwater hull volume.
- Liquid: A state of matter where particles are free to flow. It has a definite volume, it does not have a definite shape
- Mass: The amount of matter in an object
- Volume: The amount of space occupied by an object

STEM Related Careers:

- Chemical Engineer
- Mechanical Engineering

Fun Fact!

Ship designers must make sure the ship is secure and watertight. If water gets into a ship, it will make the ship more dense and it will sink. The famous Titanic sank in 1912 due to the amount of water that got into the boat causing it to be more dense than water.



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#SeaworthySTEM

Golf Ball Float Teacher Guide

Seaworthy STEM™ in a Box Series

#SeaworthySTEM

Golf Ball Float

Grades 6-8

Student Activity Workbook

Name: ______________________________

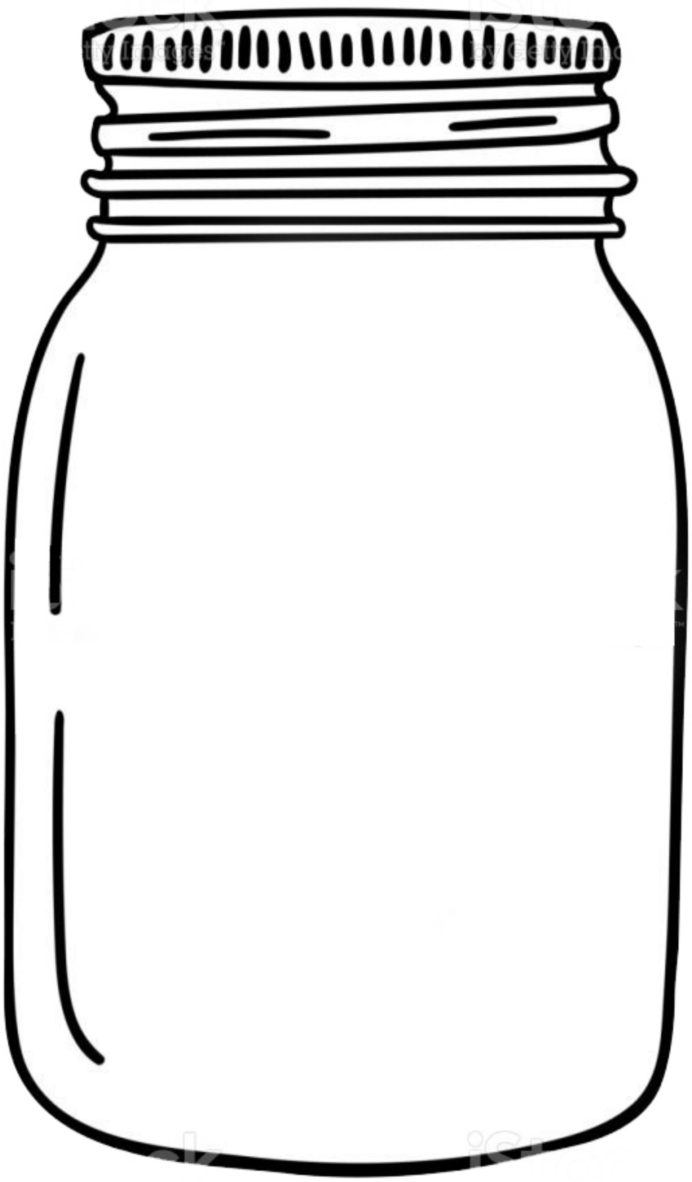
Date: ______________________________

Seaworthy STEM™ in a Box Series

Golf Ball Float!

After completing the golf ball float challenge and gaining understanding of what is going on in this system, explain your ideas by sketching an explanatory model and making predictions as to how this system might change over time.

I What is going on in the golf ball float system? Sketch a visual model of the system and then use labels and/or symbols to demonstrate your understanding of what is happening.



2 Find the densities for the clear fluid, the blue fluid as well as the golf ball using the formula:

Density = Mass/Volume

Clear Fluid: _______g ÷ _______ml= _______g/ml

Blue Fluid: _______g ÷ _______ml= _______g/ml

Golf Ball: _______g ÷ _______ml= _______g/ml

3 What would happen if this system were allowed to sit, undisturbed for a few months? How would it change over time? Write a paragraph and draw a model explaining how you think the system would change and why.

Write

Draw

#SeaworthySTEM

Golf Ball Float Engineering Notebook

Seaworthy STEM™ in a Box Series