NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

#SeaworthySTEM

Density Column Exploration

Grades 6-8

Teacher Guide

Seaworthy STEM™ in a Box Series

NAVSEA
SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS

NAVAL STEM
SCIENCE · TECHNOLOGY · ENGINEERING · MATHEMATICS

Office of Naval Research
ONR
Science & Technology

Density Column Exploration

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:

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

Notes

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

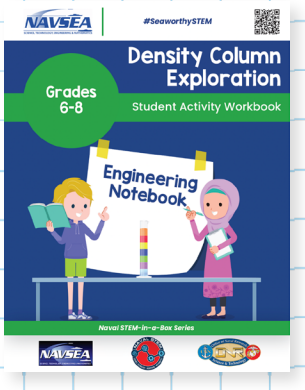
Materials and Equipment List:

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.

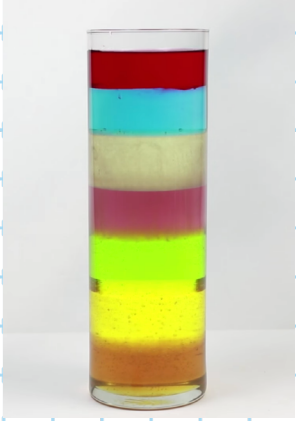
1. There is no need to start with dense materials. Each material will find its way to the proper level in the column based on its density.

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:

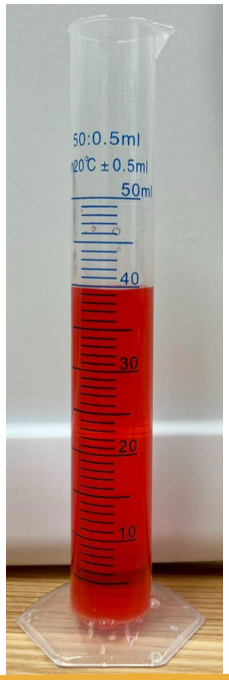
1. Review related terms and math concepts with the students

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.

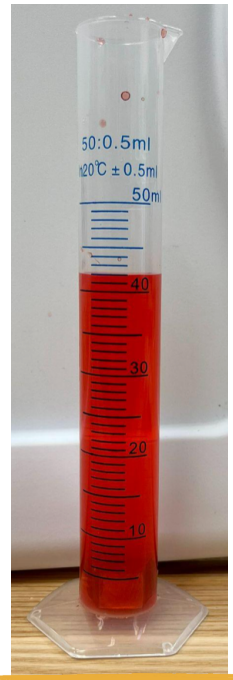
3. Share that an object's density is its mass divided by its volume

    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 π r3

STEM Related Careers:

- Marine Biologist
- Meteorologists
- Naval Architect
- Ocean Engineering

Notes

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

Density Column Exploration Teacher Guide

Seaworthy STEM™ in a Box Series