#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

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:

Comparing Mass and Density

Time:
1 class to gather data
1 class to analyze

Notes

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!"

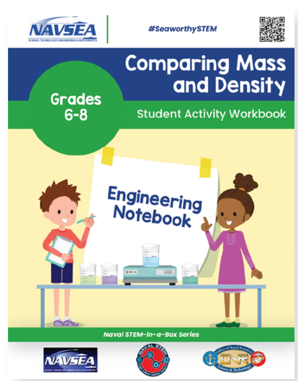
Notes

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.

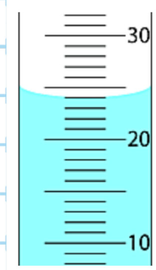
3. Use two points on your best fit line to calculate the slope for each data set.

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.

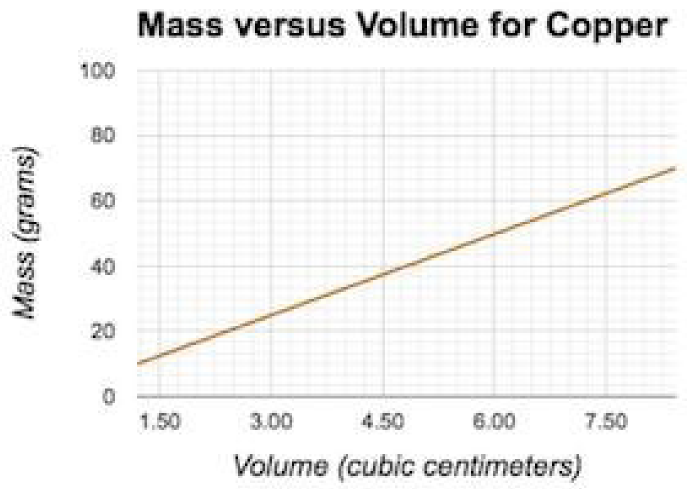


NOTE: Teacher should be sure that students discover the idea that higher density materials will sink in lower density fluids

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.

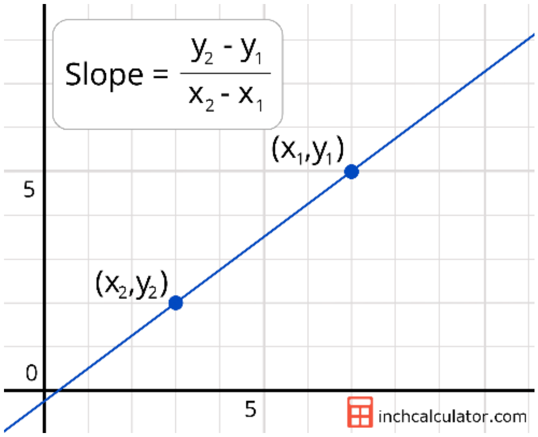
3. **Basics of Statistical Analysis:** This data collection and graphing exercise provides a good opportunity to discuss real world data vs. textbook data. Since this is real world data, it will have some variation (unlike textbook data that is generally idealized). This will show up in the graph as 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

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.

#SeaworthySTEM

Comparing Mass and Density Teacher Guide

Seaworthy STEM™ in a Box Series