WAMC Lab Template

Math Concept(s): Measuring Volume, Calculating Density
Source / Text: CORD Geometry
Developed by: Brian Tervo
E-Mail: tervob@puyallup.k12.wa.us
Date: Summer Conference 2019

Attach the following documents:

- Lab Instructions
- Student Handout(s)
- Rubric and/or Assessment Tool

Short Description (Be sure to include where in your instruction this lab takes place):

Students will take measurements and calculate density of three-dimensional objects to determine whether the object will float when placed in a tub of water. This lesson is sequenced at the end of a unit where students learn how to calculate volumes of three-dimensional figures.

Lab Plan

Lab Title: Will it float?

Prerequisite skills:

- Using rulers, calipers, and other tools to measure distance.
- Using a scale to find the mass of objects in grams.
- Understanding of how to calculate volume of three-dimensional objects.
- Understanding of how to calculate density.

Lab objective: Students will perform measurements on three-dimensional objects to determine whether they will float on water.

Standards: *(Note SPECIFIC relationship to Science, Technology, and/or Engineering)*

Mathematics K–12 Learning Standards:

- G-GMD.3 Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems
- N-Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Standards for Mathematical Practice:

- Makes sense of problems and persevere in solving them
- Reason abstractly and quantitatively
- Use appropriate tools strategically
- Attend to precision

K-12 Learning Standards-ELA (Reading, Writing, Speaking & Listening):

- RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.4 Determine meaning of symbols, key terms, or other domain specific words and phrases as they are used in specific technical context
- RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form and translate information expressed verbally or mathematically into words.

K-12 Science Standards

- HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

Technology

- 1.2.1 Communicate and collaborate to learn with others.
- 1.3.2 Locate and organize information from a variety of sources and media.
- 2.2.1 Develop skills to use technology effectively.
- 2.4.1 Formulate and synthesize new knowledge.

Engineering

- HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Leadership/21st Century Skills:

21st Century Interdisciplinary themes (Check those that apply to the above activity.)

☐ Global Awareness ☐ Financial/Economic/Business/Entrepreneurial Literacy ☐ Civic Literacy
☐ Health/Safety Literacy ☐ Environmental Literacy

21st Century Skills (Check those that students will demonstrate in the above activity.)

LEARNING AND INNOVATION
Creativity and Innovation
☒ Think Creatively
☒ Work Creatively with Others
☒ Implement Innovations
Critical Thinking and Problem Solving
☒ Reason Effectively
☒ Use Systems Thinking
☐ Make Judgments and Decisions
☒ Solve Problems
Communication and Collaboration
☐ Communicate Clearly
☐ Collaborate with Others

INFORMATION, MEDIA & TECHNOLOGY SKILLS
Information Literacy
☐ Access and Evaluate Information
☐ Use and manage Information
Media Literacy
☐ Analyze Media
☐ Create Media Products
Information, Communications and Technology (ICT Literacy)
☐ Apply Technology Effectively

LIFE & CAREER SKILLS
Flexibility and Adaptability
☐ Adapt to Change
☐ Be Flexible
Initiative and Self-Direction
☐ Manage Goals and Time
☒ Work Independently
☐ Be Self-Directed Learners
Social and Cross-Cultural
☒ Interact Effectively with Others
☐ Work Effectively in Diverse Teams

Productivity and Accountability
☐ Manage Projects
☒ Produce Results
Leadership and Responsibility
☐ Guide and Lead Others
☒ Be Responsible to Others

Teacher Preparation: (What materials and set-up are required for this lab?)

Materials –

A large food container or a small tub filled with water

Each lab group needs the following:

- Two rulers
- One plastic tape measure (for measuring clothing)
- Calipers (optional)
- One scales (capable of weighing objects in grams)
- Approximately 10-12 small three-dimensional objects of different shapes, including objects with a density of less than $1\ g/cm^3$ (will float), objects with a density approximately equal to $1\ g/cm^3$ (such that some lab groups will determine they float and other lab groups will determine they do not float), and objects with a density greater than $1\ g/cm^3$ (will not float). A list of possible objects is included below.
    - Less than $1\frac{g}{cm^3}$:
        - Glue stick (new or used)
        - Pencil
        - Rubber baseball (used for t-ball)
        - Plastic food container
        - Sidewalk chalk (Note: This item creates opportunity for discussion since it will initially float, but within seconds will soak up water and sink.)
    - Approximately equal to $1\frac{g}{cm^3}$:
        - Deck of playing cards
        - Pack of gum (5 sticks)
    - Greater than $1\frac{g}{cm^3}$:
        - Dice
        - Rubber eraser
        - Disc magnet
        - Golf ball
        - Starburst candy
        - Nut (the fastener – not the food)

Set-Up Required:

- Assemble all the items above and place them in lab baskets to distribute to each lab group.
- Prepare an answer key by weighing and measuring the volume of each object ahead of time and calculating their density. Ensure that you have enough objects which will float, will not float, and will have a density close to $1\frac{g}{cm^3}$ to create opportunities for discussion on precision requirements.
- Fill the food container with water.

Lab Organization Strategies:

Leadership (Connect to 21st Century Skills selected):

- The objects being weighed and measured are divided among the students in the lab group. Each student is responsible to the others in their group by accurately measuring their assigned objects.

Cooperative Learning:

- Each lab group needs to figure out how to divide up the workload of weighing and measuring 10-12 objects using the resources available (two rulers, a single tape measure, and a single scale).

Expectations:

- For each of the items in the lab basket, each lab group will take measurements, calculate volume in cubic centimeters, find the mass in grams, calculate density, and determine whether the object will float.

Timeline:

- The lab can be completed within a single 50-minute class period, and time requirements can be adjusted by adding or removing objects from the lab basket.
- It can be helpful to spend 10-15 minutes the day prior to the lab to discuss strategies for measuring volume of certain objects. For example, it might be helpful to have the class problem solve how to use the tools provided to find the radius of the baseball or the golf ball so volume can be calculated.

Post Lab Follow-Up/Conclusions:

Discuss real world application of learning from lab

- How would you determine the maximum occupancy of a life raft?
- Why do helium balloons float in air?

Career Applications

- Freight and shipping – The density of a cargo ship is needed to calculate its maximum freight capacity
- Military/Navy – Submarines submerge and rise to the surface by adding or removing water from ballast tanks.
- Oil spill cleanup – Since oil is less dense than water, it will float which simplifies the cleanup process.

Optional or Extension Activities

- Provide the weight and volume of a life raft. What is the maximum occupancy of the life raft?

Lab Instructions

1. Prep the materials for the lab according to the instructions in the lab plan.
2. Form lab groups of 3-4 students. Distribute a lab worksheet to each student.
3. Walk through the lab procedures using one or two of the objects in the lab basket *(note: it may be helpful to use 10-15 minutes the day prior to the lab for this step)*. If using two objects, make sure one will float and the other will not float.
    a. It may be best to use one of the more challenging objects in the basket and brainstorm as a class how to measure the volume of the object. For example, have the class discuss how they can use the tools provided (a ruler, a tape measure, and/or calipers) to find the volume of a sphere.
    b. Calculate the volume of the object(s) and ask students to write this down on their datasheet.
    c. Using a scale at a teacher station, weigh the object(s) and ask the students to record this weight on their datasheet.
    d. Review the formula for density ($\rho = \frac{m}{V}$) and ask the class to calculate the density and determine whether the object will float. Ask students to record this information on their datasheet.
4. Drop the example object(s) used in step #2 in the tub of water to verify the results.
5. Explain that each lab group needs to examine a total of ten objects and determine whether they will float. Let the lab groups know that they are responsible for figuring out how to divide up the workload using the available resources (two rulers, one tape measure, one caliper, and one scale).
6. Allow time for students to complete the work. During this process, check in with each lab group. Verify all students are engaged and ask the students to explain how they divided up the work. Use this information to assess the teamwork grade for the project.
7. At the end of the lab collect the lab materials and prepare the class for the closing discussion. Be sure to allow at least 10-15 minutes for the closing discussion.
8. For each item in the lab basket, ask each group whether it will float, and place the item in the tub of water to verify the results.
    a. For items which have a density approximately equal to $1\frac{g}{cm^3}$, it is likely lab groups will offer different responses and/or several groups will make the incorrect prediction. Use this as an opportunity to have a discussion when precision in measurement is important. Ask the class if a 20% error is acceptable if the calculated density is $10\frac{g}{cm^3}$ but the actual density is $8\frac{g}{cm^3}$. Ask the class if a 5% error is acceptable if the calculated density is $1.01\frac{g}{cm^3}$, but the actual density is $0.96\frac{g}{cm^3}$.
    b. If the sidewalk chalk is used, ask the class to explain why it initially floats, but then quickly sinks. Ask about what can cause the density to increase, prompting them to recognize that density increases as mass increases or volume decreases. Ask which of these occurred with the piece of chalk. As the chalk soaks up water, it will both increase in mass and decrease in volume.
9. Discuss real world and career applications for calculating density (see the lab plan for examples).

Assessment Criteria (75 points total)

Item	Points Possible	Grading
Teamwork	25 points	Give each student in the group up to 10 points for providing a reasonable explanation for how they divided up the workload. Give each student in the group to 15 points for staying engaged and actively participating throughout the lab.
Lab Prompts	50 points	Each of the blanks on the datasheet are worth one point (10 objects, 5 blanks per object). For measurements, give full credit if the measurement is reasonably accurate (allow error of up to 5 mm per dimension). For density, give full credit if the density is correctly calculated based on the mass and volume recorded. For the "Will it float?" column, give full credit if they made the correct conclusion based on their density even if the answer is incorrect due to minor measurement errors.

Name_____ Date_____

Will it float?

The density of water is $1\frac{g}{cm^3}$. Objects which have a density less than or equal to the density of water will float. Objects which have a density greater than the density of water will sink.

For each of the objects provided:

- Record the name or description of the object.
- Weigh the object and record its mass in grams.
- Take the necessary measurements and calculate the object's volume in centimeters. Attach additional pages of scratch paper to show your work. A list of volume formulas is provided on the reverse side of this page.
- Using the mass and the volume of the object, calculate its density.
- Indicate whether the object will float in water (it floats if its density is less than $1\frac{g}{cm^3}$).

Object	**Mass (g)**	**Volume (cm^3)**	**Density ($\frac{g}{cm^3}$)**	**Will it float?**

Name_____ Date_____

Volume Formulas

Object	**Formulas**
Right Prism	$V = Bh$ V is volume; h is height; B is base area
Cube	$V = e^3$ V is volume; e is edge length
Right Cylinder	$V = \pi r^2 h$ V is volume; r is radius; h is height
Right Regular Pyramid	$V = \frac{1}{3}Bh$ V is volume; B is base area; h is height
Cone	$V = \pi r^2 \frac{h}{3}$ V is volume; B is base area; r is radius; h is height
Sphere	$V = \frac{4}{3}\pi r^3$ V is volume; B is base area; r is radius