AMAZON ORIGINAL

THE AERONAUTS

5E Instructional Planning Model

DENSITY LESSON 4: RELATIONSHIP BETWEEN VOLUME AND DENSITY

OVERVIEW: Compare the density of blocks that vary in volume. Mass held constant.

LEARNING TARGETS:

Students can:

- Use a digital simulation to collect science data;
- Use displacement to determine the volume of an object;
- Calculate density;
- Explain the relationship between volume and density;
- Model the relationship between volume and density with a diagram; and
- Explain why all blocks tested in the simulation represent different materials.

NEXT GENERATION SCIENCE STANDARDS

High School Structure and Property of Matter		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Cross Cutting Concepts**
Developing and Using Models ♦ Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-8) **Planning and Carrying Out Investigations** ♦ Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence; and in the design, decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time) and refine the design accordingly. (HS-PS1-3)	**PS1.A: Structure and Properties of Matter** ♦ Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) ♦ The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1)	**Structure and Function** ♦ Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2- 6)

Obtaining, Evaluating and Communicating Information ♦ Communicate scientific and technical information (e.g., about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually and mathematically). (HS-PS2-6)		

ENGAGEMENT: *THE AERONAUTS* MOVIE TRAILER AND REAL-WORLD CONNECTIONS

Materials	Procedures	Sample Questions / Teacher Hints
♦ Computer ♦ Projector ♦ Volume and Density PowerPoint Presentation (Slides 1-11) ♦ Volume and Density PowerPoint Guide (provides teaching information and talking points for each slide, almost like a script)	***The Aeronauts* Movie Trailer**	
	Show trailer for *The Aeronauts* movie. https://youtu.be/fgyTRhDZNbk?t=21 ♦ (See PowerPoint Slide 2)	See PowerPoint guide for Slide 2.
	Introduce learning targets and lesson agenda. (See PowerPoint Slides 3-4.)	See PowerPoint guide for Slides 3-4.
	Real-World Connections and Career Connections	
	(See PowerPoint Slides 6-11.)	See PowerPoint guide for Slides 6-11. ♦ Teacher Hint: If you and your students did any of the previous density lessons in this series, use these slides for a quick review of real-world and career connections.

EXPLORATION: DENSITY LAB SIMULATION

Materials	Procedures	Sample Questions / Teacher Hints
♦ Computer ♦ Projector ♦ Volume and Density PowerPoint Presentation (Slides 12-21) ♦ Volume and Density PowerPoint Guide (provides teaching information and talking points for each slide, almost like a script) ♦ Student Data Recording Worksheet—Relationship Between Volume and Density ♦ Key: Student Data Recording Worksheet—Relationship Between Volume and Density ♦ Sim Bucket Density Lab Simulation—https://pbslm-contrib.s3.amazonaws.com/WGBH/arct15/SimBucket/Simulations/densitylab/content/index.html	**States of Matter and Density Discussion**	
	(See PowerPoint Slides 12-13.) ♦ Teachers use molecular model pictures of a solid, liquid and gas to remind students of the molecular structure of solids, liquids and gases, and to explain why liquids and gases are considered fluids.	(See PowerPoint guide for Slides 12-13.) ♦ Teacher Hint: If you and your students any of the previous density lessons in this series, use this slide for a q quick review.
	Interact with Digital Simulation	
	(See PowerPoint Slides 14-22.) Students will use the digital simulation to gather volume and mass data of various materials. Students will record simulation data on the student data recording worksheet. The steps for this part of the lesson are: ♦ Students interact with the simulation to learn how it works. (Slides 14-15) ♦ Students are introduced to the purpose for doing the lab (Slide 16) ♦ Experimental procedure overview (Slide 17) ♦ Identification of variables (Slide 18) ♦ Students collect data from the simulation, completing data table, calculating the density of the materials as they go. (Slide 19) ♦ Students graph simulation data. (Slide 20) ♦ Students make a claim based on the evidence gathered from the simulation (Slide 21)	(See PowerPoint guide for Slides 14-22.) The slides that show students how to complete the data table and graph the data are animated. ♦ Teacher Hint 1: If you and your students did any of the previous density lessons in this series, skip Slides 14-15. ♦ Teacher Hint 2: Sometimes there is a glitch in the simulation. When this happens, the materials that students are testing disappear. Refresh the simulation if necessary. ♦ Teacher Hint 3: Make sure students understand that every time we adjust the volume in the simulation, we have chosen a new test material. In the sample, the test material will always look like the same red box, which could trick students into thinking it is the same substance with a different volume. Density is a property of materials. ♦ Every sample of gold, no matter what the volume, will be 19.3 g/cm3. ♦ Every sample of lead, no matter what the volume, will be 11.3 g/cm3. ♦ Every sample of iron, no matter what the volume, will be 7.87 g/cm3. The only way we can test the relationship between volume and density of a given volume is to use samples of different materials.

EXPLANATION: MODELS

Materials	Procedures	Sample Questions / Teacher Hints
♦ Computer ♦ Projector ♦ Volume and Density PowerPoint Presentation (Slide 23) ♦ Volume and Density PowerPoint Guide (provides teaching information and talking points for each slide, almost like a script) ♦ Student Data Recording Worksheet—Relationship Between Volume and Density ♦ Key: Student Data Recording Worksheet—Relationship Between Volume and Density	**Model Comparing Density and Volume** (See PowerPoint Slide 23.) ♦ Students draw diagrams to communicate the relationship between volume and density in blocks of equal volume.	(See PowerPoint guide for Slide 22.) ♦ Teacher Hint: Make sure students understand that every time we adjust the volume in the simulation, we have chosen a new test material. The only way we can test the relationship between volume and density of a given volume is to use samples of *different* materials.

ENRICH: POST-LAB DISCUSSION

Materials	Procedures	Sample Questions / Teacher Hints
♦ • Computer ♦ • Projector ♦ • Volume and Density PowerPoint Presentation (Slides 24-28) ♦ • Volume and Density PowerPoint Guide (provides teaching information and talking points for each slide, almost like a script) ♦ • Whiteboards—one for every group of students that tested the same volume.	**Post-Lab Whiteboard Discussion** (See PowerPoint Slides 24-28) ♦ Students reflect on the lab using post-lab discussion question. Discussion points include: ♦ Summary of procedure; ♦ Reason scatter plot was the appropriate choice for this data; ♦ How the graph, data table and diagram help us compare the density of material; ♦ Comparison of data between students who tested blocks with different masses; and ♦ Other research questions that can be answered by the simulation.	(See PowerPoint guide for Slides 34-35.) ♦ Teacher Hint 1: Don't show students the discussion questions ahead of time. Use the questions to guide a discussion and comparison of the data. Additional discussion points not on the slide include: ♦ Reason volume of blocks is the independent variable; ♦ Reason density of blocks is the dependent variable; and ♦ Strengths and weaknesses of the simulation as a model to investigate the relationship between volume and density.

ENRICH: POST-LAB DISCUSSION CONT'D

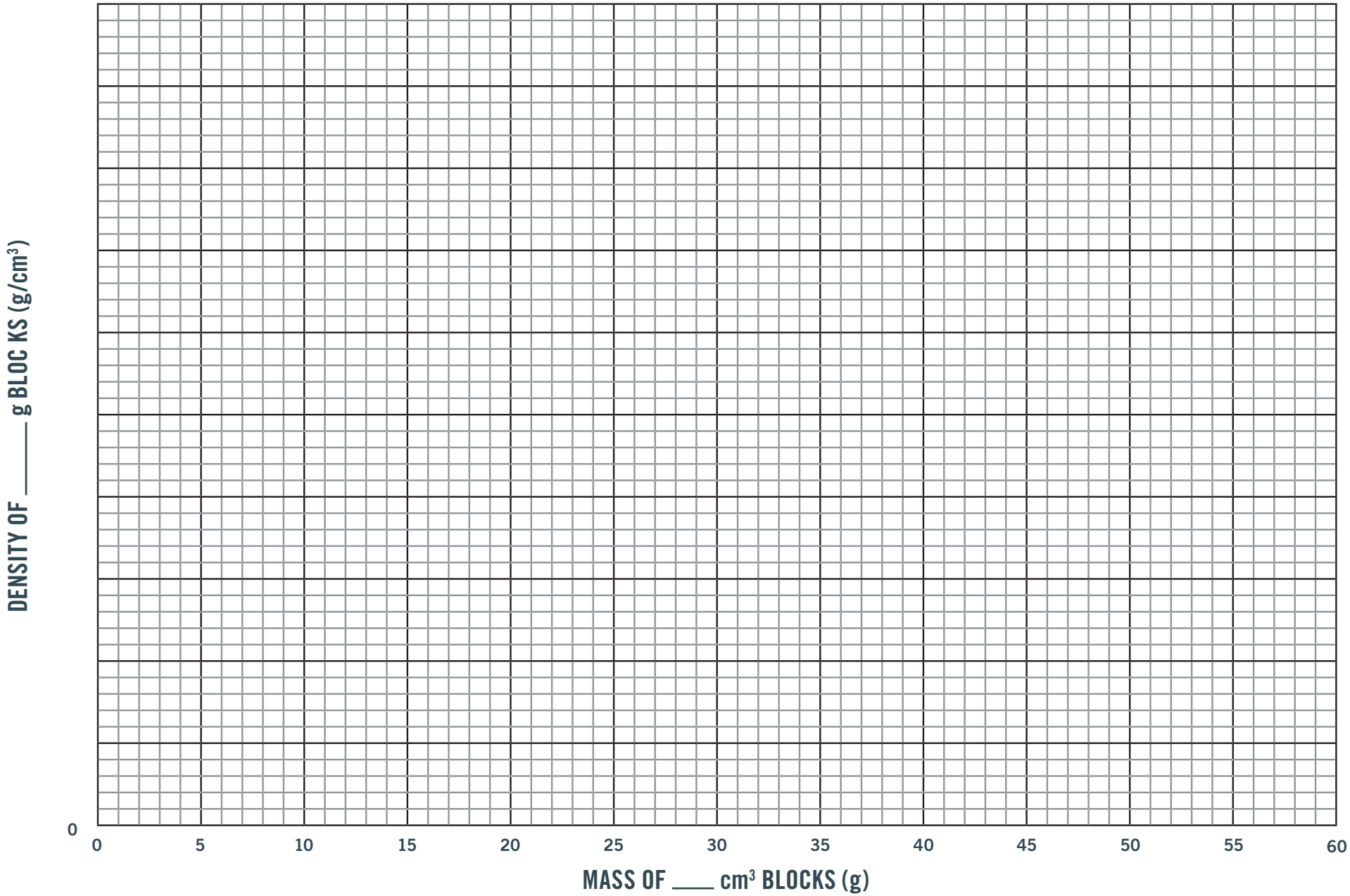
		♦ Teacher Hint 2: If you have a high level of comfort with inversely proportional mathematical relationships, and student discourse, skip Slides 26-27 and use whiteboard discussion to help students uncover what a graph with this shape curve tells us about the variables.

EVALUATION

❖ The grading guide provides suggested point values and grading criteria for the various components of the student data recording worksheet.

THE RELATIONSHIP BETWEEN VOLUME AND DENSITY

GRAPH PAPER



NAME: _____

WORKSHEET

THE RELATIONSHIP BETWEEN VOLUME AND DENSITY

PURPOSE / VARIABLES

Purpose: _____

Independent: _____

Dependent: _____

Constant: _____

DATA TABLE

blocks note: each block is a different substance	mass of the object	Volume of displaced fluid			volume of object	density $\rho = m/v$
		final volume (v_f)	initial volume (v_i)	volume of displaced fluid $v_f - v_i$		

NAME: _____

WORKSHEET

CLAIM

_____

_____

DIAGRAM

low density _____ g solid medium density _____ g solid high density _____ g solid

NAME: _____

WORKSHEET KEY

THE RELATIONSHIP BETWEEN VOLUME AND DENSITY

PURPOSE / VARIABLES

Purpose: To determine the relationship between volume and density.

Independent: volume of ___ g blocks

Dependent: density of ___ g blocks

Constant: fluid density, mass of blocks

DATA TABLE

blocks note: each block is a different substance	mass of the object	Volume of displaced fluid			volume of object	density $\rho = m/v$
		final volume (v_f)	initial volume (v_i)	volume of displaced fluid $v_f - v_i$		
example	2.5 g	26.9 mL	25.5 mL	4.12 mL	4.1 cm^3	1.64 g/mL
Block A	2.5 g	26.7 mL	25.5 mL	1.2 mL	1.2 cm^3	2.08 g/mL
Block B	2.5 g	28.5 mL	25.5 mL	3 mL	3 cm^3	0.83 g/mL
Block C	2.5 g	31.9 mL	25.5 mL	6.4 mL	6.4 cm^3	0.39 g/mL
Block D	2.5 g	36.2 mL	25.5 mL	10.7 mL	10.7 cm^3	0.23 g/mL
Block E	2.5 g	40.4 mL	25.5 mL	14.9 mL	14.9 cm^3	0.17 g/mL
Block F	2.5 g	47.2 mL	25.5 mL	21.7 mL	21.7 cm^3	0.12 g/mL
Block G	2.5 g	53.6 mL	25.5 mL	28.1 mL	28.1 cm^3	0.09 g/mL
Block H	2.5 g	60.2 mL	25.5 mL	34.7 mL	34.7 cm^3	0.07 g/mL
Block I	2.5 g	70.8 mL	25.5 mL	45.3 mL	45.3 cm^3	0.06 g/mL
Block J	2.5 g	81.6 mL	25.5 mL	56.1 mL	56.1 cm^3	0.04 g/mL

NAME: _____

WORKSHEET KEY

CLAIM

2.5 g blocks with low volume will have higher densities than 2.5 g blocks with high volume—or—

2.5 g blocks with high volume will have lower densities than 2.5 g blocks with low volume.

DIAGRAM

low density _____ g solid

medium density _____ g solid

high density _____ g solid

NAME: _____

GRADING GUIDE

THE RELATIONSHIP BETWEEN VOLUME AND DENSITY

PURPOSE / VARIABLES (4 points)

Purpose: To determine the relationship between volume and density. 1 point

Independent: volume of ___ g blocks 1 point

Dependent: density of ___ g blocks 1 point

Constant: fluid density, mass of blocks 1 point

DATA TABLE (15 points)

All data points include units (mL, g, cm3, g/cm3)—5 points
Accurate calculation of displaced fluid—5 points (subtract ½ point for each error)
Accurate calculation of density—5 points (subtract ½ point for each error)
All data recorded—subtract 1 point for each missing row

blocks note: each block is a different substance	mass of the object	Volume of displaced fluid			volume of object	density $\rho = m/v$
		final volume (v_f)	initial volume (v_i)	volume of displaced fluid $v_f - v_i$		
example	2.5 g	26.9 mL	25.5 mL	4.12 mL	4.1 cm^3	1.64 g/mL
Block A	2.5 g	26.7 mL	25.5 mL	1.2 mL	1.2 cm^3	2.08 g/mL
Block B	2.5 g	28.5 mL	25.5 mL	3 mL	3 cm^3	0.83 g/mL
Block C	2.5 g	31.9 mL	25.5 mL	6.4 mL	6.4 cm^3	0.39 g/mL
Block D	2.5 g	36.2 mL	25.5 mL	10.7 mL	10.7 cm^3	0.23 g/mL
Block E	2.5 g	40.4 mL	25.5 mL	14.9 mL	14.9 cm^3	0.17 g/mL
Block F	2.5 g	47.2 mL	25.5 mL	21.7 mL	21.7 cm^3	0.12 g/mL
Block G	2.5 g	53.6 mL	25.5 mL	28.1 mL	28.1 cm^3	0.09 g/mL
Block H	2.5 g	60.2 mL	25.5 mL	34.7 mL	34.7 cm^3	0.07 g/mL
Block I	2.5 g	70.8 mL	25.5 mL	45.3 mL	45.3 cm^3	0.06 g/mL
Block J	2.5 g	81.6 mL	25.5 mL	56.1 mL	56.1 cm^3	0.04 g/mL

NAME: _____

GRADING GUIDE

CLAIM (5 points)

2.5 g blocks with low volume will have higher densities than 2.5 g blocks with high volume—or—

2.5 g blocks with high volume will have lower densities than 2.5 g blocks with low volume.

Claim is written in sentence form—1 point
Claim identifies the volume of the blocks tested—1 point
Claim accurately identifies the relationship between mass and density—3 points

DIAGRAM (5 points)

low density _____ g solid medium density _____ g solid high density _____ g solid

Student labeled each box with the mass of the blocks tested in his or her investigation—1 point
The size of the boxes communicates that a low-density solid has the highest volume, a medium-density solid has a medium volume, and high-density solid has the lowest volume—4 points

GRAPH separate page (11 points)

All dots drawn to the correct point on the grid—10 points
(subtract ½ point for each dot not drawn to the correct height)
Line of best fit correctly drawn—1 point