Causal Patterns in Density

Physical Science, Grade 6

(Revised July 2018)

**Standards addressed in this unit:**

**6.MS-PS1-7(MA).** Use a particulate model of matter to explain that density is the amount of matter (mass) in a given volume. Apply proportional reasoning to describe, calculate, and compare relative densities of different materials.

Each section of this unit introduces a challenge in thinking about causality that helps students understand density. In each lesson, a background information section describes the difficulties that students typically have in learning about density, and shows how the various causal understandings, if not mastered, contribute to those difficulties. Embedded within the lessons are special activities designed to REveal CAusal STructure, or help students RECAST their understandings so that they fit with the causal patterns that scientists use. RECAST activities typically have outcomes that don't fit with what students typically think, so they may serve as an impetus for students to restructure their understandings. Lessons typically begin by asking students to examine their current beliefs and invite opportunities for students' ideas to evolve as they engage in inquiry-based activities that ask them to observe and construct understandings.

This unit was developed by the Understandings of Consequence Project at Project Zero of the Harvard Graduate School of Education with funding from the National Science Foundation Grant No. REC-0106988 and REC-9725502 to Tina Grotzer and David Perkins, Co-Principal Investigators. Any opinions, findings, conclusions or recommendations expressed here are those of the authors and do not necessarily reflect the views of the National Science Foundation.

The entire unit (accessed as section links or downloaded as an entire unit as a PDF) including the appropriate attributions is available at: <http://www.causalpatterns.org/resources/resources_overview.php>

*This Model Curriculum Unit is designed to illustrate effective curriculum that lead to expectations outlined in the 2016 Science and Technology/Engineering Curriculum Frameworks (*[*www.doe.mass.edu/STEM/STE*](http://www.doe.mass.edu/STEM/STE)*) as well as the MA Curriculum Frameworks for English Language Arts/Literacy and Mathematics. This unit includes lesson plans, a Curriculum Embedded Performance Assessment (CEPA), and related resources. In using this unit it is important to consider the variability of learners in your class and make adaptations as necessary.*

This document was prepared by the Massachusetts Department of Elementary and Secondary Education. Mitchell D. Chester, Ed.D., Commissioner

The Massachusetts Department of Elementary and Secondary Education, an affirmative action employer, is committed to ensuring that all of its programs and facilities are accessible to all members of the public. We do not discriminate on the basis of age color, disability, national origin, race, religion, sex, or sexual orientation.

© 2015 Massachusetts Department of Elementary and Secondary Education (ESE).ESE grants permission to use the material it has created under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License. Additionally, the unit may also contain other third party material used with permission of the copyright holder. Please see Image and Text Credits for specific information regarding third copyrights.

Every effort has been made to acknowledge copyright. Any omissions brought to our attention will be corrected in subsequent editions.

Image and Text Credits:

The entire unit (accessed as section links or downloaded as an entire unit as a PDF) including the appropriate attributions is available at: <http://www.causalpatterns.org/resources/resources_overview.php>

The contents of this Model Curriculum Unit were developed under a grant from the U.S. Department of Education. However, those contents do not necessarily represent the policy of the U.S. Department of Education, and you should not assume endorsement by the Federal Government.

Massachusetts Department of Elementary and Secondary Education, 75 Pleasant St, Malden, MA 02148-4906. Phone 781-338-3300, TTY: N.E.T. Relay 800-439-2370, [www.doe.mass.edu](http://www.doe.mass.edu)

**Table of Contents**

[Unit Assumptions and Comments on Sequence 4](#_Toc3379145)

[Unit Plan 7](#_Toc3379146)

[Curriculum Embedded Performance Assessment (CEPA) 12](#_Toc3379147)

[Unit Resources 15](#_Toc3379148)

Section 1: VISUALIZING DENSITY: DENSITY IS NON-OBVIOUS

<http://www.causalpatterns.org/resources/density/density_section_1.php>

Lesson 1: How Can Objects of the Same Volume Differ in Mass?

Lesson 2: What Are Some Models That Help Us Think About Density

Section 2: DEFINING DENSITY AS A RELATIONSHIP

<http://www.causalpatterns.org/resources/density/density_section_2.php>

Lesson 3: What Patterns Can Be Found Between Mass, Volume, and Density?

Lesson 4: How Can We Calculate Density From the Relationship Between Mass and Volume?

Lesson 5: Why is Density Considered a Property of a Particular Kind of Material?

Lesson 6: Do Liquids and Gases Have Density?\*

\*The DESE version of the unit combines lessons 6 and 7 from the original document into lesson 6.

Section 3: THE ROLE OF DENSITY IN SINKING AND FLOATING: RELATIONAL CAUSALITY

<http://www.causalpatterns.org/resources/density/density_section_4.php>

Lesson 7: Dropping an Object into a Liquid: How Does Density Affect Sinking or Floating?\*\*

Lesson 8: Layering Liquids: How Does Density Affect Sinking or Floating?\*\*

\*\*The DESE version of the unit only uses three of the original sections and therefore lessons 7 and 8 are listed as 13 and 14 in the original document.

Unit Assumptions and Comments on Sequence

**This unit assumes students already know:**

• Matter is composed of atoms, or “particles,” between which there is empty space.

• Volume is the amount of space that matter takes up.

• Mass is the amount of matter that makes up an object.

• All gases and liquids are matter.

• We can measure the volume and mass of a sample of matter.

• Matter exists in different phases.

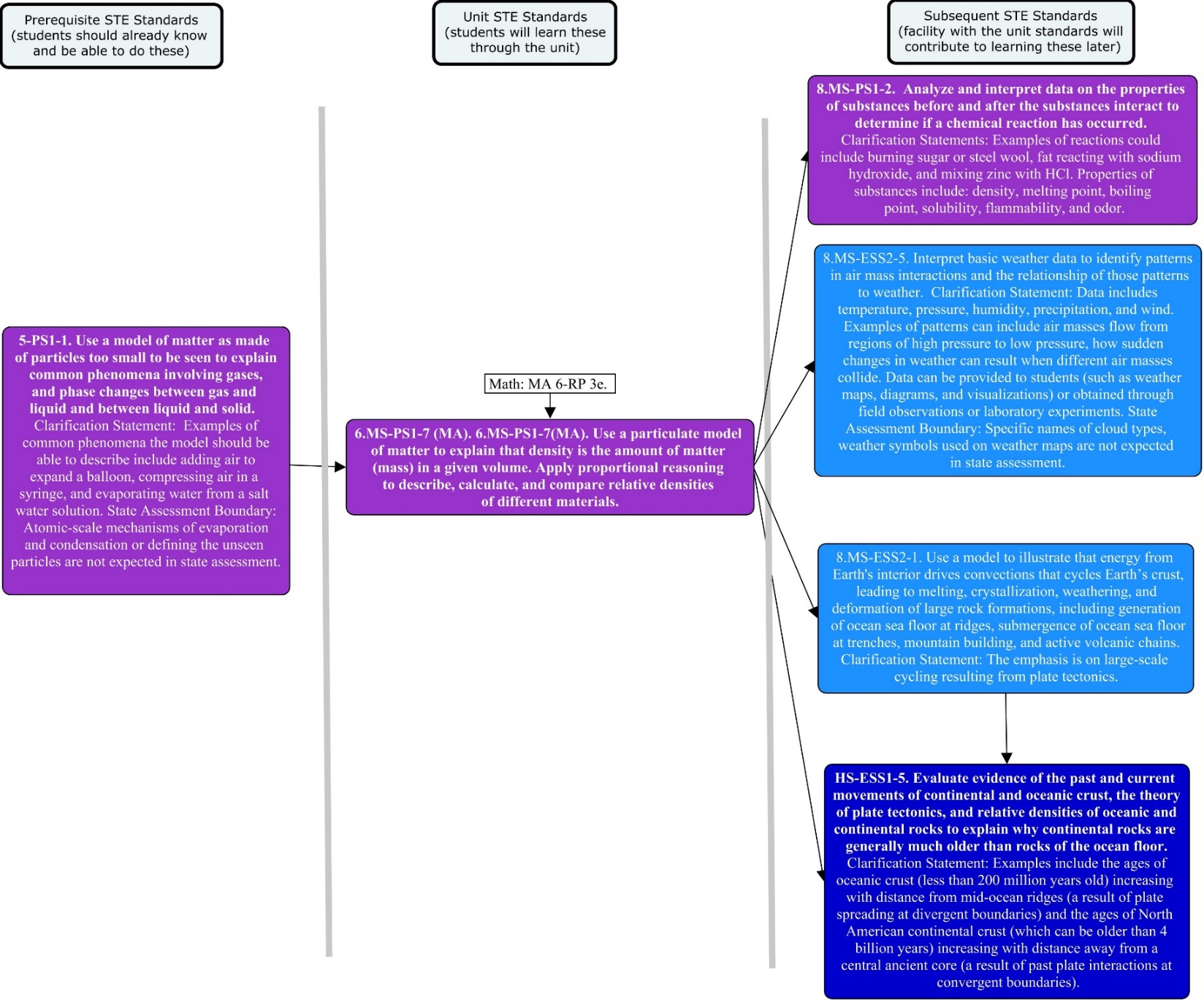
• Temperature affects how particles behave. When the temperature is increased, molecules in solids, liquids, and gases move faster. Solids and liquids expand a little when heated. Gases expand a lot when heated.

• Matter is conserved.

This unit is most effective when it follows units on those concepts so students can effectively apply their understanding of matter, volume, mass, and weight in a broader context. A strong understanding of density is crucial to understanding and explaining many natural phenomena explored in subsequent topics, such as phase change, chemical reactions, gas laws, plate tectonics, weather, and ocean circulation. See strand map, next page for an overview of the science standards that precede this unit and how the standards learned in this unit contribute to students learning in later grades.

**Notes about the unit:**

* The entire unit (accessed as section links or downloaded as an entire unit as a PDF) including the appropriate attributions is available at: <http://www.causalpatterns.org/resources/resources_overview.php>
* Accompanying components included in this document were developed by the Department of Secondary and Elementary Education includes the Unit Plan, rubrics for lessons and the Curriculum Embedded Performance Assessment (CEPA).
* Each lesson takes about 45 minutes.
* The rubrics for select lessons are located in the Unit Resources Section.
* **Materials**
  + Many of the materials needed for the lessons are easy to find at science supply stores and/or at the local supermarket. You may also find substitutions for the materials that work and still communicate the lesson ideas.
    - Examples include:
      * using ping pong balls and golf balls instead of marbles
      * plastic baby food contains instead of clear baby food jars
      * plastic pipettes
      * 10 ml graduated cylinders for the layering of liquids
      * Borrowing density blocks from the High School Chemistry department
  + Use the link below to find suggestions on how to locate some of the more difficult to find materials for unit. <http://www.causalpatterns.org/resources/pdfs/Density_Materials.pdf>



|  |  |  |
| --- | --- | --- |
| Unit Plan  **Stage 1 Desired Results** | | |
| **ESTABLISHED GOALS G**  **6.MS-PS1-7(MA).** Use a particulate model of matter to explain that density is the amount of matter (mass) in a given volume. Apply proportional reasoning to describe, calculate, and compare relative densities of different materials.  **Mathematics:**  **6.RP.3.** Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.  **6.RP.A.3e.** Solve problems that relate the mass of an object to its volume.  **English Language Arts and Literacy:**  **ELA.6-8.WCA.1.01**  1. Write arguments focused on discipline-specific content.   1. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims/critiques, and organize the reasons and evidence logically in paragraphs and sections. 2. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources. 3. Use words, phrases, and clauses with precision to create cohesion and clarify the relationships among claim(s), counterclaims/critiques, reasons, and evidence. 4. Establish and maintain a style appropriate to audience and purpose (e.g., formal for academic writing). 5. Provide a concluding statement or section that follows from and supports the argument presented. | ***Transfer*** | |
| ***Students will be able to independently use their learning to…***  Analyze mechanisms of cause and effect in natural and designed systems based on physical and chemical principles.**T** | |
| ***Meaning*** | |
| **UNDERSTANDINGS U**  ***Students will understand that…***  U1 All matter has density.  U2 Density can be inferred and calculated by knowing the relationship between mass and volume; density cannot be measured directly.  U3 Density is not affected by the size or shape of the object.  U4 Density is non-obvious. Differences in density can only be detected by controlling for mass or for volume.  U5 Density is a relational concept. It requires considering two variables—mass and volume—and their relationship.  U6 The role of density in sinking and floating is described by relational causality. | **ESSENTIAL QUESTIONS Q**  Q1 How can we best measure what we cannot directly see?  Q2 Do all materials, including liquids and gasses, have density?  Q3 Can we control whether something sinks or floats in a liquid? |
| ***Acquisition*** | |
| ***Students will know…* K**  K1 Objects that are made of different materials can have the same mass and different volumes, or the same volumes but different mass. This is because of a property of all matter called "density."  K2 Density can be calculated by knowing the relationship between mass and volume and is measured in units of mass per volume: g/cm3 (grams per cubic centimeter) or g/ml (grams per milliliter).  K3 Different models can be used for visualizing density. Different models involve different trade-offs and capture different aspects of the concept.  K4 Changes to the liquids or objects can result in changes in the system and in the outcome of sinking or floating.  K5 The density of water is 1.0 grams per milliliter (g/ml).  K6 Solids, gases and liquids have density. | ***Students will be skilled at…* S**  S1 Using and constructing different models for density and applying them in appropriate situations.  S2 Calculating density from mass and volume, and deriving both mass from density and volume or volume from density and mass, using appropriate units.  S3 Making comparisons about the causal relationship between two materials.  S4 Constructing graphs that show the relationship between mass and volume for different materials.  S5 Measuring density by massing a graduated cylinder, pouring in a specific volume of liquid, measuring the mass of the liquid and graduated cylinder, and subtracting the mass of the graduated cylinder. |
| **Stage 2 - Evidence** | | |
| **Evaluative Criteria** | **Assessment Evidence** | |
| **(see the CEPA rubric)** | **CURRICULUM EMBEDDED PERFORMANCE ASSESSMENT PT**  **Explaining Thermal Inversion**  Students will develop a segment for the local weather station to explain why there is sometimes clouds or fog in a valley in the morning but not on surrounding hills. Their task is to develop a brief segment the local weather station can use on the news to explain this phenomenon to city and town residents of the area. They must include the following in their segment: An explanation using relative density of why thick fog or clouds are seen in the morning surrounding the city, below clear air above it, and why it clears out after a couple of hours of sunlight; Use of a particulate model to illustrate the phenomenon; And include image(s) of what this phenomenon looks like from different locations in the area (from the city; from surrounding towns on surrounding hills). | |
| * Well-illustrated, thought out, and descriptive of thinking * Mathematically accurate/sound computations * Correct graphing techniques (units, spacing) * Full, robust explanations | **OTHER EVIDENCE: OE**   1. *Worksheet:* Finding and Graphing the Density of Pure Substances – Students will measure the mass and volume of 4-5 samples of two different pure substances and graph the mass vs. volume of these materials, to show their knowledge of graphing and their ability to measure mass and volume. 2. *Worksheet:* Mapping Relational Causality – Density: Given an example, students will learn how to determine relational causality using a diagram that they will then fill in for Density. (Optional: *Linear Causality:* Students will contrast relational causality with examples of linear causality). 3. *Worksheet:* Calculating Density – students will gain practice with calculations of density, mass, and volume. Students will also gain general practice with the relationship between mass, volume, and density (separate sheet). 4. *Task:* Students will make a hypothesis about whether or not an object’s density changes when cut in half, and then will test their prediction. 5. *Worksheet:* Archimedes and the Golden Crown – students will demonstrate both scientific literacy and application by reading about Archimedes’ “eureka” moment and attempting to follow his reasoning based on what they have learned about density. 6. *Lab:* Find the density of common liquids by measuring the mass of 10mL of different liquids and comparing their densities. 7. *Drawing:* Students will draw a model of the molecular layout of solids, liquids, and gases. 8. *Worksheet:* Does Air Have Mass? – Students will be asked questions pertaining to whether or not Air has mass and therefore density. 9. *RECAST Activity:* *Two Candles* – Students will communicate the results of a demonstration and provide a model of what happened. 10. *Worksheet:* Students will use what they have learned about density and Relational Causality to answer questions 11. *Journal:* Students will show their understanding of relative density by picking 4 examples of it from everyday life and writing 3-4 sentences about each explaining how it is about relative density. 12. *Lab:* *Sinking and Floating Fluids* – Students will conduct an investigation to determine the relationship between density and floating with different liquids. 13. *Worksheet – Liquid Layers*: Students will use atoms, molecules, and bonds to model how density determines how liquids layer. | |
| **Stage 3 – Learning Plan** | | |
| ***Summary of Key Learning Events and Instruction***  **Section 1: Visualizing Density: Density is Non-obvious (2 class periods)**   * Lesson 1: How Can Objects of the Same Volume Differ in Mass? (1st class period)   Students will illustrate how they believe two objects that are the same size can have different masses.   * [Lesson 2: What Are Some Models That Help Us Think About Density?](http://pzweb.harvard.edu/ucp/curriculum/density/s1_lesson2.htm) (2nd class period)   Students learn how to make models about density.  **Section 2: Defining Density as a Relationship (4 class periods)**   * [Lesson 3: What Patterns Can Be Found Between Mass, Volume, and Density?](http://pzweb.harvard.edu/ucp/curriculum/density/s2_lesson3.htm) (1st class period)   Students will graph mass vs. volume from measurements of real objects and discover how to recognize relational causality.   * [Lesson 4: How Can We Calculate Density From The Relationship Between Mass and Volume?](http://pzweb.harvard.edu/ucp/curriculum/density/s2_lesson4.htm) (2nd class period)   Students will use their models and relational causality diagrams to learn how to calculate density.   * [Lesson 5: Why Is Density Considered a Property of a Particular Kind of Matter?](http://pzweb.harvard.edu/ucp/curriculum/density/s2_lesson5.htm) (3rd class period)   Students will make hypotheses about the effects of density when an object is cut in half and will read and write about Archimedes and the Golden Crown.   * [Lesson 6: Do Liquids and Gases Have Density?](http://pzweb.harvard.edu/ucp/curriculum/density/s2_lesson6.htm) (4th class period)   Part A: Students will make density measurements of liquids to affirm what they learned in Lesson 5 and to compare the densities of common household liquids.  Part B: Students will learn about gases and the properties of gases by exploring if and how a gas can have density.  **Section 3: The Role of Density in Sinking and Floating: Relational Causality (2 class periods)**   * [Lesson 7: Dropping an Object into a Liquid: How Does Density Affect Sinking or Floating?](http://pzweb.harvard.edu/ucp/curriculum/density/s1_lesson1.htm) (1st class period)   Students investigate the relative density of an object dropped in a liquid to explain sinking and floating.   * [Lesson 8: Layering Liquids: How Does Density Affect Sinking or Floating?](http://pzweb.harvard.edu/ucp/curriculum/density/s1_lesson2.htm) (2nd class period)   Students investigate the relative densities of liquids.  **Section 4: Curriculum Embedded Performance Assessment (CEPA) (1 class period)**  **Explaining Thermal Inversion:** Develop a weather segment using relative density to explain the common phenomena of clouds in a valley. | | |
| Adapted from Understanding by Design 2.0 © 2011 Grant Wiggins and Jay McTighe Used with Permission | | |

Curriculum Embedded Performance Assessment (CEPA)

Explaining Thermal Inversion

Students will develop a segment for the local weather station to explain why there are sometimes clouds or fog in a valley in the morning but not on surrounding hills. Their task is to develop an explanation of the phenomenon that the local weather station can use on the news for city and town residents of the area. They much include the following in their segment: An explanation using relative density of why thick fog or clouds are seen in the morning surrounding the city, below clear air above it, and why it clears out after a couple of hours of sunlight; a particulate model to illustrate the phenomenon; and image(s) of what this phenomenon looks like from different locations in the area (e.g., from the city and from surrounding towns on surrounding hills).

**Materials:**

* Access to internet and/or media with relevant illustrations and images of thermal inversion
* CEPA rubric

**Explanation of CEPA**

**Goal:** Develop a segment for the local weather station to explain why there is sometimes clouds or fog in a valley in the morning but not on surrounding hills.

**Role:** Consulting scientist.

**Audience:** Local weather station and the residents of a city in a valley and towns in the surrounding area.

**Situation:** The city of Metropolis is situated in a valley. On some mornings, particularly in the fall, city residents wake to find they are surrounded by thick fog or clouds while those in the towns on surrounding hills wake and see thick fog or clouds below them, covering the city. Those that are in the valley, in the city, experience colder temperatures, while those on the surrounding hills experience warmer temperatures. The thick fog or clouds in the valley typically lasts just a couple of hours until the sunlight warms the air in the valley so that temperatures in all areas are similar.

**Product, Performance, and Purpose:** Your task is to develop a brief segment the local weather station can use on the news to explain this phenomenon to city and town residents of the area. Include the following in your segment:

1. An explanation of why thick fog or clouds are seen in the morning surrounding the city, below clear air above it, and why it clears out after a couple of hours of sunlight.
2. The explanation should be based on relative density, use a particulate model to illustrate differences, and include illustrations of what this phenomenon looks like from different locations in the area (e.g., from the city and from surrounding towns on surrounding hills).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **RUBRIC FOR CEPA:**  ***Weather Consultation*** | | | | | | | | | | | E: |  | | | X 2 |  |  |
| PM: |  | | |  |  |  |
| IP: |  | | |  |  |  |
|  |  | | |  |  |  |
| **Student:** |  | | **Scorer:** |  | | **Date:** |  | | |  | Total: |  | | |  |  | /12 |
|  | |  |  | |  |  | |  | | |  |  | | |  |  |  |
|  | | **ADVANCED - 4** | | | **PROFICIENT - 3** | | | **NEEDS IMPROVEMENT – 2** | | | | | **WARNING - 1** | | | | |
| **EXPLANATION**  **(E)**  *The student uses density to explain why thick fog or clouds are seen in the morning surrounding the city, below clear air above it, and why it clears out after a couple of hours of sunlight.* | | 1. My explanation appropriately uses relative density and relates this to some other situation I am familiar with. | | | a. My explanation appropriately uses relative to explain all observations. | | | a. My explanation uses relative density but is somewhat incorrect or does not address all the observations. | | | | | a. My explanation does not use relative density or does so incorrectly. | | | | |
| 1. N/A | | | b. My explanation is clear, concise, and uses appropriate vocabulary for the task. | | | | b. My explanation is somewhat clear, and/or overly descriptive, and/or uses some inappropriate vocabulary. | | | | | b. My explanation is not clear or concise and does not use appropriate vocabulary. | | | |
|  | |  | | |  | | |  | | | | |  | | | | |
|  | | **ADVANCED - 4** | | | **PROFICIENT - 3** | | | **NEEDS IMPROVEMENT - 2** | | | | | **WARNING - 1** | | | | |
| **PARTICULATE MODEL (PM)**  *The particulate model illustrates relative densities to support his/her explanation.* | | 1. I have used both an accurate particulate model and an additional model showing air masses. | | | a. I have correctly used a particulate model to illustrate relative densities for all observations. | | | 1. I have used a particulate model to show relative densities, but it is incomplete or there are some errors. | | | | | 1. I did not use a particulate model to show relative densities or did so incorrectly. | | | | |
| b. N/A | | | b. My model is clearly and correctly labeled and includes correct captions and symbols. | | | b. My model is clearly and correctly labeled and includes correct captions or symbols. | | | | | b. My model is either not labeled or labeled incorrectly, and is missing captions and symbols, or includes them but they are incorrect. | | | | |
|  | | **ADVANCED - 4** | | | **PROFICIENT - 3** | | | **NEEDS IMPROVEMENT - 2** | | | | | **WARNING - 1** | | | | |
| **IMAGE(S) OF PHENOMENON (IP)**  *The student’s images of what this phenomenon looks like from different locations in the area.* | | a. My chosen images are linked to a model showing air masses. | | | a. My chosen images are accurate and show views from multiple locations. | | | a. My chosen images of the phenomenon is accurate but shows the view from only one location. | | | | | 1. My chosen image(s) does not illustrate the phenomenon. | | | | |
|  | | |  | | |  | | | | |  | | | | |

Unit Resources

**Lesson 3**

* Finding and Graphing Mass and Volume of Pure Substances Rubric

**Lesson 5**

* Archimedes and the Golden Crown Rubric

**Lesson 6**

* Does Air Have Mass? Rubric

**Lesson 7**

* RECAST Activity: Two Candles Rubric

**Lesson 8**

* Sinking and Floating Fluids Rubric

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **RUBRIC FOR OE1:**  **FINDING AND GRAPHING MASS AND VOLUME OF PURE SUBSTANCES** | | | | | | | | | | GR: |  | | x2 = |  |  |
| ME: |  | |  |  |  |
|  |  | |  |  |  |
|  |  | |  |  |  |
| **Student:** |  | | **Scorer:** |  | | **Date:** |  | |  | Total: |  | |  |  | / 9 |
|  | |  |  | |  |  | |  | |  |  | |  |  |  |
|  | | **ADVANCED - 4** | | | **PROFICIENT - 3** | | | **NEEDS IMPROVEMENT – 2** | | | | **WARNING - 1** | | | |
| **GRAPHS (GR)** | | ***I’ve done everything to earn a score of proficient, plus 2 of 3:*** | | |  | | |  | | | |  | | | |
| *(weighted x2)* | | 1. My graph utilizes the entire grid, leaving little to no space to the top or sides unused. | | | a. My graph uses an accurate scale. | | | a. My graph uses a reasonable scale with few to no errors. | | | | a. My graph uses an unreasonable scale, has errors in the numbering, or I inverted my axes. | | | |
|  | | 1. My data points are all clearly placed. | | | b. My data points are correctly placed. | | | b. My data points are mostly correctly placed, with only one or two off. | | | | c. My data points contain many errors. | | | |
| *The actual graphs of MASS vs. VOLUME.* | | 1. My lines are best-fit using a straight edge. | | | c. My lines are accurate, pass by most of my points, and are clearly labeled. | | | c. My lines pass by most of my points and are labeled, though may have slight curves to fit data. | | | | c. My lines are either unlabeled or are connected dots with no consistency. | | | |
|  | |  | | |  | | |  | | | |  | | | |
|  | | **ADVANCED - 4** | | | **PROFICIENT - 3** | | | **NEEDS IMPROVEMENT - 2** | | | | **WARNING - 1** | | | |
| **MEASUREMENTS (ME)** | | ***I’ve done everything to earn a score of proficient, plus 2 of 3:*** | | |  | | |  | | | |  | | | |
|  | | a. My measurements include the proper number of significant figures. | | | a. My measurements are mostly correct; with 0-2 errors/omissions. | | | a. My measurements are mostly correct; with 3-5 errors/omissions. | | | | a. My measurements contain 6 or more errors/omissions. | | | |
| *The actual measurements.* | | b. My measurements are neat and clearly written. | | | b. My measurements include units. | | | b. Some of my measurements include units, at least the first Mass and Volume. | | | | b. My measurements do not include units. | | | |
| 1. My measurements are clearly labeled by substance. | | |  | | |  | | | |  | | | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **RUBRIC FOR OE5:**  **ARCHIMEDES AND THE GOLDEN CROWN** | | | | | | | | | | ID: |  | | x2 = |  |  |
| SE: |  | |  |  |  |
|  |  | |  |  |  |
|  |  | |  |  |  |
| **Student:** |  | | **Scorer:** |  | | **Date:** |  | |  | Total: |  | |  |  | / 9 |
|  | |  |  | |  |  | |  | |  |  | |  |  |  |
|  | | **ADVANCED - 4** | | | **PROFICIENT - 3** | | | **NEEDS IMPROVEMENT – 2** | | | | **WARNING - 1** | | | |
| **IDEA DEVELOPMENT (ID)** | | ***I’ve done everything to earn a score of proficient, plus 2 of 3:*** | | |  | | |  | | | |  | | | |
|  | | 1. My description includes a definition or clear description of density. | | | a. My description clearly describes how Archimedes will use the concept of density to prove if the crown is gold. | | | a. My description mentions how Archimedes will use density but is not clear. | | | | a. My description does not link density to the problem at hand. | | | |
| *The main thesis the student conveys to his/her audience and the way the thesis and analysis are presented.* | | 1. My description also explains a method to determine the mass of the crown. | | | b. My description clearly shows how Archimedes can use water displacement to measure the volume of the crown without ruining it. | | | b. My description mentions how Archimedes can use water displacement to measure the volume of the crown without ruining it. | | | | 1. My description mentions using water displacement but does not mention that this prevents the crown from being ruined. | | | |
| 1. My description contains the equation for density. | | |  | | |  | | | |  | | | |
|  | |  | | |  | | |  | | | |  | | | |
|  | | **ADVANCED - 4** | | | **PROFICIENT - 3** | | | **NEEDS IMPROVEMENT - 2** | | | | **WARNING - 1** | | | |
| **SUPPORTING EVIDENCE (SE)** | | ***I’ve done everything to earn a score of proficient, plus 2 of 3:*** | | |  | | |  | | | |  | | | |
| *(weighted x2)* | | 1. My description explains how seeing his tub overflow led Archimedes to immerse the crown in water. | | | a. My description mentions how the bathtub may have led Archimedes to the solution. | | | a. My description mentions the bathtub but does not explicitly connect it to the solution. | | | | a. My description does not mention the bathtub. | | | |
| *The actual measurements and calculations of density for two cylinders.* | | b. My description includes the density of gold. | | | b. My description uses the fact that substances have different densities to support the use of density to solve the problem. | | | b. My description mentions how the crown may have a different density than expected but does not mention how substances can have different densities. | | | | b. My description does not mention other substances at all. | | | |
| 1. My description includes comparing the crown’s density to that of gold. | | |  | | |  | | | |  | | | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **RUBRIC FOR OE8:**  **DOES AIR HAVE MASS?** | | | | | | | | | | | | | | ID: |  | | |  |  |  | |
| SE: |  | | |  |  |  | |
|  |  | | |  |  |  | |
|  |  | | |  |  |  | |
| **Student:** | |  | | | **Scorer:** |  | | | **Date:** |  | | |  | Total: |  | | | / 6 |  |  | |
|  | | | |  |  | | |  |  | | |  | |  |  | | |  |  |  | |
|  | | | | **ADVANCED - 4** | | | | **PROFICIENT - 3** | | | | **NEEDS IMPROVEMENT – 2** | | | | | **WARNING - 1** | | | | |
|  | **IDEA DEVELOPMENT**  **(ID)** | | ***I’ve done everything to earn a score of proficient, plus 2 of 3:*** | | | |  | | | |  | | | | |  | | | | |
|  | | | | 1. All of my answers have clearly explained reasoning. | | | | a. All of my answers are complete and correct. | | | | a. Only one of my answers is, incomplete or incorrect. | | | | | a. Two or more of my answers are incomplete or incorrect. | | | | |
| *The main thesis the student conveys to his/her audience and the way the thesis and analysis are developed.* | | | | 1. All of my answers are neat and easy to read. | | | | b. All of my answers have explanations. | | | | b. Only one of my answers does not have an explanation. | | | | | 1. Two or more of my answers lack explanations. | | | | |
| 1. My answers to 4 and 5, even if they state air has no mass, have plausible ways to demonstrate and convince. | | | |  | | | |  | | | | |  | | | | |
|  | | | |  | | | |  | | | |  | | | | |  | | | | |
|  | | | | **ADVANCED - 4** | | | | **PROFICIENT - 3** | | | | **NEEDS IMPROVEMENT - 2** | | | | | **WARNING - 1** | | | | |
| **SUPPORTING EVIDENCE (SE)** | | | | ***I’ve done everything to earn a score of proficient, plus 2 of 3:*** | | | |  | | | |  | | | | |  | | | | |
|  | | | | 1. My explanations use evidence from prior classes. | | | | a. My answers to 1, 2, and 3 all site evidence to explain my reasoning. | | | | a. Only one of my answers to 1, 2, or 3 fails to site evidence. | | | | | a. Evidence is lacking from two or more of my first three answers. | | | | |
| *Evidence from classroom demonstrations used to support their case.* | | | | b. My explanations address the particle nature of matter. | | | | b. My answers to questions 4 and 5 use evidence or demonstrations we went over in class. | | | | b. Only one of my answers to questions 4 and 5 uses evidence or demonstrations we went over in class. | | | | | b. My answers to 4 and 5 do not relate to what we did in class. | | | | |
| c. My explanations are clear, concise, and correct. | | | |  | | | |  | | | | |  | | | | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **RUBRIC FOR OE9:**  **RECAST ACTIVITY: TWO CANDLES** | | | | | | | | | | | QE: |  | | | x2 = |  |  |
| DM: |  | | |  |  |  |
|  |  | | |  |  |  |
|  |  | | |  |  |  |
| **Student:** |  | | **Scorer:** |  | | **Date:** |  | | |  | Total: |  | | |  |  | / 9 |
|  | |  |  | |  |  | |  | | |  |  | | |  |  |  |
|  | | **ADVANCED - 4** | | | **PROFICIENT - 3** | | | **NEEDS IMPROVEMENT – 2** | | | | | **WARNING - 1** | | | | |
| **QUESTIONS & EXPLANATIONS**  **(QE)** | | ***I’ve done everything to earn a score of proficient, plus 2 of 3:*** | | |  | | |  | | | | |  | | | | |
| *(weighted x2)* | | 1. My explanations in questions 1 and 2 describe what happened in detail and provide a clear explanation as to why it happened. | | | a. My explanations in questions 1 and 2 are clear, concise, and correct. | | | | a. My explanations in questions 1 and 2 are clear and at least one of them is correct. | | | | | a. My explanations in questions 1 and 2 are either unclear or incorrect. | | | |
| *The main explanations the student conveys & communicates.* | | 1. My rule to predict if something floats in a liquid explicitly mentions the comparison of the density of the object and the liquid. | | | b. I have provided a general rule to predict whether something will sink or float in liquid and provided a clear reason as to why it matters. | | | b. I have provided a general rule to predict whether something will sink or float in liquid. | | | | | 1. I have not provided a general rule to predict if something will float in a liquid. | | | | |
| 1. My explanations in question 4 are clear, concise, correct, and clearly labeled or easy to connect to each candle. | | | c. My answer to question 4 clearly explains the results of the experiment and explains what happens with each candle. | | | c. My answer to question 4 either explains the results of the experiment and explains what happens with one candle or explains what happens to each candle. | | | | | c. My answer to question 4 either explains the results of the experiment or explains what happens with one of the candles. | | | | |
|  | |  | | |  | | |  | | | | |  | | | | |
|  | | **ADVANCED - 4** | | | **PROFICIENT - 3** | | | **NEEDS IMPROVEMENT - 2** | | | | | **WARNING - 1** | | | | |
| **DRAWING & MODEL (DM)** | | ***I’ve done everything to earn a score of proficient, plus 2 of 3:*** | | |  | | |  | | | | |  | | | | |
|  | | 1. My models are clearly labeled. | | | a. My model clearly shows my ideas on why these results happened. | | | a. My model shows my ideas on why these results happened. | | | | | a. My model does not show my ideas on why these results happened. | | | | |
| *Evidence from classroom demonstrations used to support their case.* | | b. My models use arrows or other symbols to show movement/action. | | | b. My model explains about each candle and beaker. | | | b. My model is missing only 1 candle or beaker. | | | | | b. My model is missing 2 or more candles/beaker. | | | | |
| c. My model includes captions to explain what is happening. | | |  | | |  | | | | |  | | | | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **RUBRIC FOR OE12:**  **SINKING AND FLOATING FLUIDS** | | | | | | | | | |  |  | |  |  |  |
|  |  | |  |  |  |
| S3: |  | |  |  |  |
| S4: |  | | x2 = |  |  |
| **Student:** |  | | **Scorer:** |  | | **Date:** |  | |  | Total: |  | |  |  | / 9 |
|  | |  |  | |  |  | |  | |  |  | |  |  |  |
|  | | **ADVANCED - 4** | | | **PROFICIENT - 3** | | | **NEEDS IMPROVEMENT - 2** | | | | **WARNING - 1** | | | |
| **STEP 3**  **(S2)** | | ***I’ve done everything to earn a score of proficient, plus 2 of 3:*** | | |  | | |  | | | |  | | | |
|  | | a. My prediction is either a labeled drawing or a clear, concise explanation. | | | a. My prediction includes all three liquids and clearly shows which would float on which. | | | a. My prediction includes all three liquids and shows which would float on which. | | | | a. My prediction is missing one or more liquids. | | | |
| *Students develop a hypothesis involving density and floating/sinking.* | | b. My prediction is correct. | | |  | | |  | | | |  | | | |
|  | | **ADVANCED - 4** | | | **PROFICIENT - 3** | | | **NEEDS IMPROVEMENT - 2** | | | | **WARNING - 1** | | | |
| **STEP 4**  **(S4)** | | ***I’ve done everything to earn a score of proficient, plus 2 of 3:*** | | |  | | |  | | | |  | | | |
| *(weighted x2)* | | a. My explanations or drawings include the measured densities from Step 2. | | | a. My drawing clearly includes all three liquids, shows how they stack, and is labeled. | | | a. My drawing includes all three liquids, shows how they stack, and some of the liquids are labeled. | | | | a. My drawing is either unclear or includes errors. | | | |
| *Students record their observation of what happens when all three liquids are included and draw conclusions.* | | b. My explanations of order and what would happen include the fact that the liquids would need time to settle, but ultimately order based on density. | | | b. I concluded that density determined the order of the liquids in the test tube and explained how the relative densities determined the order. | | | b. I concluded that density determined the order of the liquids in the test tube. | | | | b. My conclusion is either blank or incorrect. | | | |
| c. My explanations include a mention of particles. | | | c. I clearly and correctly explained what would happen if the order of the liquids being added were changed. | | | c. I correctly explained what would happen if the order of the liquids being added were changed. | | | | c. I did not correctly y explain what would happen if the order of the liquids being added were changed. | | | |
|  | | | d. I clearly and correctly explained how the density of the liquids determine d their placement in the test tube. | | | d. I correctly explained how the density of the liquids determine d their placement in the test tube. | | | | d. I did not correctly explain how the density of the liquids determine d their placement in the test tube. | | | |