

SCORING GUIDE

CUBES & LIQUIDS

The following are the **practical learning goals** to be assessed:

- Distinguishes Observation from Inference
- Technical Description
- Density of Solid Objects — Coordinates Mass and Volume
- Density of Liquids — Coordinates Mass and Volume
- Classification Scheme (2X2) to Organize Relevant Factors
- Uses Ratios — Uses ratios, fractions, division or multiplication in coordinating Solid and Liquid Densities

Each **Learning Goal** contains a **Definition**, Rating **Criteria**, examples of performance characterizing the various levels and directions for **Where to Look** for making judgments. Descriptions and examples of *levels of attainments* are provided. The Scoring Guide begins with some points concerning **Density** that must be considered to understand the activity and rating process as a whole.

Density – General Considerations

Criteria:

- Any term referring to mass, weight, heaviness, amount of matter etc. is acceptable as an indicator that **mass** is being considered. However, the student must be speaking of the mass of one of the objects under consideration - not just in the abstract.
- Any term referring to shape, size, volume, surface area etc. is acceptable as an indicator that **volume** is being considered. However, the student must be speaking of the volume of one of the objects under consideration - not just in the abstract.
- “Container of Liquid,” “Beaker,” “Container,” “Jar,” “Liquid,” or any other words of that nature are to be considered equivalent and acceptable responses for “Beaker of Liquid.”
In the case of volume, it is important however to distinguish between *size when used to distinguish between the two cubes* and the consideration of *size as a factor in floating and sinking*. Only the second is acceptable in rating performance on this objective. Example: “The smaller one looks lighter and so I think it will float.” Here size is used as a distinguishing property but not with reference to volume as a causal factor.
- The use of a formula, e.g. $D=M/V$ or the term 'density' is unacceptable for either mass or volume unless the student decomposes the formula and refers to the actual mass and volume of the objects under consideration.

Distinguishes Observation from Inference

Where to Look: OBSERVATIONS 1, 2, 3, 4

Definition:

- The ability to distinguish what one has observed from inferences, explanations and interpretations of that observation.

Criteria:

- Student must respond to all 4 OBSERVATION sections
- Student responses in the OBSERVATION sections must strictly be descriptions of what was observed. They should contain no inferences, explanations or beliefs. A typical unwarranted inference is that the liquid in the beakers is *water*.

Level 1: Records observations; makes no unnecessary inferences

- Student must respond to all 4 OBSERVATION sections, *and*
- Student responses in the OBSERVATION section are strictly descriptions of what was observed. They contain no inferences, explanations or beliefs.

Level 0: Makes inferences where only observations are called for

- Student fails to record 4 observations, *or*
- Student's inferences go beyond the simple descriptions required in the OBSERVATION section:
 - "The cube sank to the bottom because it is heavy"
 - "The liquid pushes the object up"
 - "The smaller cube was placed in the 'water'"

Technical Description

Where to Look: OBSERVATIONS 1, 2, 3, 4

Definition:

- The ability to describe critical components of the demonstration/experiment in a way that permits a person who was not present to reconstruct the event.

Criteria:

- *Where appropriate* the student must identify which cube and which beaker of liquid were involved in each experiment. This to assist someone who did not witness the event to able to reconstruct and replicate the experiment based the student's description. In Experiment 1, only one cube and 1 liquid are involved and so no distinction is needed. By experiment 2 the student must identify which of two cubes is involved. By Experiment 3 and 4, two cubes and two liquids are potentially involved and therefore must be distinguished and identified in the description. How the student chooses to identify the objects of interest (e.g., large cube, first cube, second beaker, beaker on the experimenters right) is not important, only that the identifications are internally consistent.

Level 3: Distinguishes between different cubes and liquids in all cases

[except Experiment 1 where only 1 cube & 1 liquid are in play]

Level 2: Distinguishes between different cubes and liquids in at least 1 case

Level 1: Distinguishes between different cubes or liquids in at least 1 case

Level 0: Does not distinguish between different cubes or liquids

Density of Solid Objects – Coordinates Mass and Volume

Where to Look: PREDICTIONS, REASONS FOR PREDICTIONS, THOUGHT EXPERIMENT 1

Definition:

- The ability to conceptualize and apply the concept of density of solid objects in a practical setting.

Criteria:

- Student explicitly and correctly relates the mass and the volume of the solid objects in predicting and explaining the behavior of cubes in liquids.

Level 2: Successfully coordinates mass and volume of solid objects

- The answers listed below are a guideline. What's important is not that the student gets all of their predictions right, but that they provide answers and reasoning consistently demonstrating understanding of the concept of density.
 - **Version A** (Large cube first and sinks—alcohol in 1st beaker)
 - Prediction 1* – Not enough information
 - Prediction 2* – The cube will sink
 - Prediction 3* – Not enough information
 - Prediction 4* – Any answer with appropriate reasoning
 - **Version B** (Large cube first and floats—water in 1st beaker)
 - Prediction 1* – Not enough information
 - Prediction 2* – Any answer with appropriate reasoning
 - Prediction 3* – Not enough information
 - Prediction 4* – The cube will sink

Level 1: Refers to both mass and volume of the cubes

- A blank response to one or more REASONS for PREDICTIONS means the student can earn no higher than a rating of '1.'
- Almost any consideration of volume is acceptable for this level. What matters is that the student is aware of the concept that density is dependent on volume.
- "Larger things weigh more, so the cube will sink, " is invalid because, while it addresses size, gives no indication that size is being related to the notion of density.

Level 0: Does not consider volume of solid objects

- **Examples:**
 - "It's floating because it has air in it."
 - "I don't know if it's made of metal or wood, so I can't tell if it will float or sink."
 - "The cube weighs more than the liquid, so it will sink to the bottom."

Density of Liquids – Coordinates Mass and Volume

Where to Look: THOUGHT EXPERIMENT 2

Definition:

- The ability to conceptualize and apply the concept of density of liquids in a practical setting

Criteria:

- Student coordinates conceptualizations of the mass and the volume of the liquid in predicting and explaining the behavior of cubes in liquids.

Level 3: Successfully coordinates mass and volume of the liquid

e.g. Considers the mass of the liquid in relation to a given volume of liquid

Level 2: Considers both mass and volume of the liquid

- Explicitly relates mass and volume of the liquid in predicting and explaining the behavior of cubes in liquids

Level 1: Considers either the mass or the volume of the liquid

- Does not relate the mass and volume of the liquid in predicting and explaining the behavior of cubes in liquids

Level 0: Does not consider the mass or the volume of the liquid

- A blank response to THOUGHT EXPERIMENT #2 automatically constitutes a score of '0' on *Conceptualizes Density of Liquids*.

Classification Scheme (2X2) to Organize Relevant Factors

Where to Look: THOUGHT EXPERIMENT 1

Definition:

- The ability to form and utilize a two by two classification scheme to organize the four possible conditions of the experiment.

Criteria:

- Student specifies how both a lighter and a heavier mystery cube would behave in each of the two liquids. Four conditions must be referred to for a complete classification scheme.

Level 2: Forms a COMPLETE classification scheme including all levels of both factors

- Specifies how a lighter mystery cube would behave in each of the two liquids AND specifies how a heavier mystery cube would behave in each of the two liquids. Four conditions must be referred to for a complete classification scheme.

Level 1: Forms an INCOMPLETE classification scheme including all levels of 1 factor

- Any one of the following possibilities will constitute an INCOMPLETE classification scheme:
 - The behavior of the lighter mystery cube in both beakers
 - The behavior of the heavier mystery cube in both beakers
 - The behavior of both mystery cubes in one beaker

Level 0: Does not form a scheme to classify objects

Proportional Reasoning

Applying ratios to practical problem solving

Where to look: THOUGHT EXPERIMENT 2

Definition:

- The ability to apply multiplication or division in terms of fractions or ratios in order to coordinate properties of the solid object and liquids.

Criteria:

- Student decomposes the liquid into its mass and volume, and does the following:
 - Relates the mass and volume of the liquid using multiplication or division in terms of fractions or ratios (e.g. “2 gm/cc”).

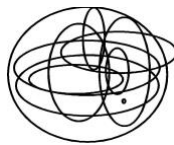
Level 1: Uses ratios

- Uses multiplication or division in terms of fractions or ratios in order to coordinate properties of the solid object and liquids.
- Examples:
 - “If the mass of the cube is 2 g for a cube 1 cm on a side, the liquid would have to have a mass of 2g or more for a 1 ml or 1 cm³ of the liquid.”
 - “The ratio of the mass to volume would need to be more than the metal cube in order for the metal cube to float.”
 - “1000 ml of the liquid would have to weigh more than 2000g.”
 - “For 1 cm³ the liquid must be weighted at more than 2 g.”
 - “The volume and the mass of the liquid would have to be more than the volume and mass of the cube.”
 - “The mystery liquid must have a volume of less than 1 and a mass less than 2 grams” (response form shows various algebraic formulas and ratios).
 - “The liquid must have more atoms in a given volume than the cube.”

Level 0: Does not use ratios

- Either does not form ratios or does not relate the solid to the liquid

- Examples:
 - “The mystery liquid must be thicker so that it can be able to keep the small cube up.”
 - “The liquid would have to be heavier than the cube.”
 - “I believe the cube would have to be a light material and the liquid to be normal. Mercury would be perfect.”
 - “The water must have more volume than the cube.”
 - “The properties must be that the volume is small, and the mass is big. It would have to be a mass of 3 or more and a volume of 2cm^3 .”



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