SCORING GUIDE

CUBES & LIQUIDS

The following are the six **practical learning goals** to be assessed. We consider these to be core learning goals, central to success in secondary school mathematics, science and technology as well as to other disciplines:

- 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** is elaborated with a **Definition**, Rating **Criteria**, and directions for **Where to Look** on the Student Response forms for evidence of attainment. Descriptions and examples of *levels of attainments* are also provided. The Scoring Guide begins with some points concerning **Density** that should be carefully considered to understand the assessment 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. Mass must be considered as a property of the objects and not simply as a means for differentiating between objects.

- 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. Volume must be considered as a property of the objects and not simply as a means for differentiating between objects.

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- "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 to distinguish between ***size*** *when used to distinguish between the two cubes* and the consideration of ***size*** *as a factor explaining floating and sinking.* Only the second is acceptable in rating performance on this learning goal. 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 interpretations A typical unwarranted inference is that the liquid in the beakers is *water*.

Level 1: Records observations; makes no inferences

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

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 identification of critical components of the demonstration/experiment in a way that permits a person who was not present to reconstruct the event. The components are the *experimental objects* and the *actions of the presenter*

Criteria:

- There are 4 components that need to be described so that the 4 experiments can be reconstructed/replicated

❏ The Experimenter's Action — The Experimenter used tongs to place the cube at the bottom of the beaker

❏ Specify which of the two cubes was used in the experiment — the large cube or the small cube

❏ Specify Beaker — beaker to the left of the experimenter or beaker to the right of the experimenter

The student has four opportunities to account for each component,

The student can receive a score of 0 to 3 for each component

Density of Solid Objects – Coordinates Mass and Volume

Where to Look: PREDICTIONS, REASONS FOR PREDICTIONS, THOUGHT EXPERIMENT 1, THOUGHT EXPERIMENT NUMBER 2

Definition:

- The ability to conceptualize and apply the concept of density, defined as the coordination of mass and volume 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 is important is not that the students are correct in all predictions, 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 smaller cube will sink because it is denser

    Prediction 3 – Not enough information or any answer with appropriate reasoning

    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 – Not enough information or an answer with appropriate reasoning

    Prediction 3 – Not enough information

    Prediction 4 – The smaller cube will sink because it is more dense

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

- A blank response to one or more (of the four) 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 cognizant that volume plays a role in density.
  - "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: PREDICTIONS, REASONS FOR PREDICTIONS, THOUGHT EXPERIMENTS 1 & 2

Definition:

- The ability to conceptualize the coordination of density (i.e. the coordination of mass and volume) 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 (2 x 2) to Organize Relevant Factors

Where to Look: THOUGHT EXPERIMENT 1

Definition:

- The ability to form and utilize a 2 x 2 classification scheme to organize the four possible results of the experiment into four mutually exclusive and collectively exhaustive categories.

Criteria:

- Organization of the results takes into account two liquids and two cubes. Four results must be referred to for a complete classification scheme. The students' judgments concerning behavior of the cubes in the liquids need not be correct judgments, in fact are irrelevant to this learning goal. The purpose of asking students for their reasoning is to encourage a full response to the task.

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 or without specification of a 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:

- Relating

Criteria:

- Student applies fractions or ratios to uses multiplication or division in terms of fractions or ratios (e.g. "2 gm/cc").

Level 1: Uses ratios

- Uses fractions or ratios, multiplication or division, or relates mass and volume in terms of magnitude in order to coordinate properties of the solid object and liquids.
- Examples:
  - "The ratio of the mass to volume would need to be more than the metal cube in order for the metal cube to float."
  - Mass/Volume of Solid is greater than mass/volume of liquid

"

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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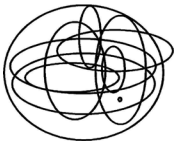

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