Students should do science

- Observation
- Measurement
- Collecting, organizing and interpreting data

Float or Sink?

- Plastic Cubes
- Rock
- Wood
- Clay
- Can of Soda
- Iron

Learning Cycle

Exploration
- Open ended
- Social Interaction

Concept Invention or Formation
- Guided Activities leading to formation of concept

Application
- Use the concept learned

Essential Features of Classroom Inquiry

1. Learners are engaged by scientifically oriented questions.
2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.
3. Learners formulate explanations from evidence to address scientifically oriented questions.
4. Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
5. Learners communicate and justify their proposed explanations.

Formal Level

(Proportional Reasoning)

Concepts

The distance between two points is measured to be 10 dk green rods. What is the distance in terms of
- Lt green
- Red
- Violet
- Yellow

Answer this question by looking at the relationships between rods. Do not actually measure.

This is proportional reasoning

1 dk green = 2 lt gr
10 dk green = ? lt gr
1 dk green = 3 red
10 dk green = ? red
2 dk gr = 3vio
10 dk gr = ?
5 dk gr = 6 yellows
10 dk gr = ? yellows
This is proportional reasoning

1 dk green = 2 lt gr
10 dk green = 1 lt gr

5 dk gr = 6 yellows
10 dk gr = ? yellows

How many 5's are in 10? Each of these is 3 violets

Using Units in Science

5 cm x 2 cm = ?
10 cm

If you have 20 cubes, and they weigh 40 g all together, how much does one cube weigh?

What is heavier?

- A pound of wood or a pound of iron?
- Wood or iron?
Finding mass of 1 cube

```
\[
\begin{array}{c|c|c|c|c|c}
\text{Total Mass} & \text{Total Volume} \\
500 \text{ gm} & 100 \text{ cm}^3 \\
\hline
\text{Ratio} & 5 \text{ gm} \quad 1 \text{ cm}^3 \\
2 \text{ cm}^3 = \_ \_ \_ \text{ gm}, 5 \text{ cm}^3 = \_ \_ \_ \text{ gm} \\
10 \text{ gm} = \_ \_ \_ \text{ cm}^3, 25 \text{ gm} = \_ \_ \_ \text{ cm}^3 \\
\end{array}
\]
```

Density

- The density of a substance of uniform composition is defined as its mass per unit volume:
  \[ \text{Density} = \frac{m}{V} \]
- Units are kg/m\(^3\) (SI) or g/cm\(^3\) (cgs)
  - 1 g/cm\(^3\) = 1000 kg/m\(^3\)

Density of water = 1 g/cm\(^3\) = 1000 kg/m\(^3\) = 32 lbs/ft\(^3\)

How much does the Earth weigh?

An average piece of the earth like a rock has a density of \(D=2.5\ \text{gm/cm}^3\).

The earth has a volume of approximately \(V = 10^{27} \text{ cm}^3\).

Since every cube weighs about 2.5 gram and we have \(10^{27}\) cubes.

The mass of the earth is about \(2.5 \text{ gm/cm}^3 \times 10^{27} \text{ cm}^3\)\(=2.5 \times 10^{29} \text{ grams}\).

Float or Sink? Why?

- Plastic
- Wood
- Clay
- Metal

Densities of different materials

<table>
<thead>
<tr>
<th>Solids</th>
<th>Density (gm/cm(^3))</th>
<th>Liquids</th>
<th>Density (gm/cm(^3))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>2.7</td>
<td>alcohol</td>
<td>0.8</td>
</tr>
<tr>
<td>Copper</td>
<td>8.96</td>
<td>mercury</td>
<td>13.6</td>
</tr>
<tr>
<td>Iron</td>
<td>7.87</td>
<td>oils</td>
<td>0.9</td>
</tr>
<tr>
<td>lead</td>
<td>11.4</td>
<td>Salt water</td>
<td>1.025</td>
</tr>
<tr>
<td>ice</td>
<td>0.92</td>
<td>Water at 4</td>
<td>1.0</td>
</tr>
<tr>
<td>stone</td>
<td>2.4-3.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>wood</td>
<td>0.6-0.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Properties of Matter

<table>
<thead>
<tr>
<th>Mass</th>
<th>Density</th>
<th>Melting Point</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid 1</td>
<td>38 g</td>
<td>0.93 g/cm3</td>
<td>-98 °C</td>
</tr>
<tr>
<td>Liquid 2</td>
<td>38 g</td>
<td>0.79 g/cm3</td>
<td>26 °C</td>
</tr>
<tr>
<td>Liquid 3</td>
<td>21 g</td>
<td>13.6 g/cm3</td>
<td>-39 °C</td>
</tr>
<tr>
<td>Liquid 4</td>
<td>16 g</td>
<td>0.93 g/cm3</td>
<td>-98 °C</td>
</tr>
</tbody>
</table>

Are any of the liquids the same substance?

Write a scientific explanation that answers the question.
Identifying the Features of Inquiry

Where in the previous activity was each of the five features exemplified?

- Questions
- Evidence
- Explanations
- Connections to scientific knowledge
- Communication and justification

The Graduated Cylinder

If a stone is dropped, water level goes up

Archimedes uncovered a fraud in the manufacture of a golden crown commissioned by Hiero II, the king of Syracuse. Suspecting that the goldsmith might have replaced some of the gold given to him by an equal weight of silver, Hiero asked Archimedes to determine whether the wreath was pure gold because gold has a density of 19.3 grams/cubic-centimeter.

Floating Wood

Floating Wood

Can You Predict the Floatation Line for a Block of Styrofoam?

1. Make four measures, each to the nearest estimation of each dimension of your block: length, width, and height. Measure along the four parallel edges in each case.
2. Find the average of each set of measures and enter into the table.
3. Compute the volume using the average measures.
4. Change this volume from cm³ to mL (divide by 1000).
5. Round to the nearest tenth of a cubic centimeter.

<table>
<thead>
<tr>
<th>LENGTH</th>
<th>WIDTH</th>
<th>HEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cm</td>
<td>1 cm</td>
<td>1 cm</td>
</tr>
<tr>
<td>2 cm</td>
<td>2 cm</td>
<td>2 cm</td>
</tr>
<tr>
<td>3 cm</td>
<td>3 cm</td>
<td>3 cm</td>
</tr>
</tbody>
</table>

Volume of block = 1 cm × 1 cm × 1 cm = 1 cm³ = 1 mL
Density of block = mass/volume

I predict the water line will be near the bottom.

Connecting Learning

1. When you compare the data for the objects that will float, what do you notice?
2. What about the data for objects that will sink?
3. Why do we seem to be the magical number?
4. Were any of your calculations incorrect? How could you tell?
5. What might be some reasons for error?
6. What are you wondering now?
Float/Sink At various grade levels

Learning Goal

**Students will**

Learn to design clay boats to discover which shape can carry the most cargo.

Key Questions
1. How can you make 30 grams of clay float?
2. What design will allow you to carry the most cargo?

Changing Density

**Example:** Empty soda can vs full

$$\text{Density} = \frac{m}{V}$$

- Bigger density means the object will float.
- Smaller density means the object will sink.

**Example:**

- Empty soda can: Smaller density, floats.
- Full soda can: Bigger density, sinks.
Mixed Densities

• Metal balls inside jar sink
• What happens if you now put in styrofoam?

Volume is fixed but Mass varies

• What happens if we add mass to the outside of the container?

Changing Density

Density = \frac{m}{V}

Example:
Empty soda can vs full

A bloc of wood floats in water.
If holes are drilled in the wood the block will
• Sink
• Float Higher
• Float Lower.
• Float the same

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Heat and Expansion

Water is an exception

How would this affect the density of water?
• Water is the exception
• Increase the temperature of any common liquid and it will expand.
• But not water at temperatures near the freezing point: Ice-cold water does just the opposite!

At what temperature is water most dense?

Just below 0°C, when water has become solid ice, its volume is considerably larger, and its density smaller

As water cools, it sinks until the entire pond is 4°C. Then, as water at the surface is cooled further, it floats on top and can freeze. Once ice is formed, temperatures lower than 4°C can extend down into the pond.

Misconceptions re Density, F/S

Students focus on only one variable, mass or volume, rather than relationship between these two.

Some common misconceptions
• Size
• Shape
• Material

Variations: Orange, Float or Sink?
Popcorn, Float or Sink?

Real reason for F/S: Archimedes Principal

The increase in water level is the same as that which would occur if, instead of putting the stone in the container, we had poured in a volume of water equal to the stone’s volume
Archimedes Principal: An object in a fluid experiences an upward force equal to the weight of the fluid it displaces.

**Totally Submerged Object**
- The object is pushed up by a force called the buoyant (B) force.
- This force (B) is equal to weight of water displaced.
- B may be bigger than w.
- B may be smaller than w.
- B may be equal to w.

**What is the Buoyant force?**

**Archimedes Principal Demo**

- Iron is much denser than water. A solid chunk of iron sinks, as you would expect, but an iron ship floats. Why?
The Bouncing ball
Variables: Independent and Dependent

Table A
<table>
<thead>
<tr>
<th>Height Dropped</th>
<th>Height of Bounce</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>28</td>
</tr>
<tr>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
</tr>
</tbody>
</table>

\[ HB = \frac{HD}{3} \]

Table B
<table>
<thead>
<tr>
<th>Height Dropped</th>
<th>Height of Bounce</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>32</td>
</tr>
<tr>
<td>40</td>
<td>22</td>
</tr>
<tr>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
</tr>
</tbody>
</table>

Line Going thru origin

\[ Y = mX \] where \( m \) is slope, 2 in this case

Line Not Going thru Origin

\[ Y = mX + b \] where \( b \) is \( y \) intercept

Slope:
\[ \text{Rise} = \frac{14}{40} = 0.35 \]
\[ HB = 0.35 \times \text{HD} \]
Thermometers and Temperature Scales

- The mercury or alcohol-based one you see here relies on the fact that mercury expands at a predictable rate with temperature. The scale of the thermometer measures the amount of expansion.

Y = mX + b
F = mC + b

F vs C

Y = mX + b
F = slope C + 32

Run = 42
Slope = \frac{80}{42} = 1.8

F = 1.8 C + 32
Science Skills

- Observation
- Communication
- Use of measuring instruments
- ANALYSIS AND REPORTING OF DATA

IT IS THE JOB OF THE TEACHER TO PROVIDE A ENVIRONMENT WHERE THIS CAN TAKE PLACE

NSF Standards k-4

From the earliest grades, students should experience science in a form that engages them in the active construction of ideas and explanations

As a result of activities in grades K-4, all students should develop

* Abilities necessary to do scientific inquiry
* Understanding about scientific inquiry

Science Process Skills

- Identify Variables
- Propose Hypothesis
- Plan and conduct controlled experiments
- Collect, organize and present data
- Communication
- Generate conclusions and/or predictions

Motion of Earth