Lab 02.1a  
Determining Density

I. PURPOSE  
To learn various methods for measuring substances and calculating densities.

II. MATERIALS  
1. Balance  
2. Caliper or Ruler  
3. Overflow Can  
4. Graduated cylinders  
5. Beakers  
6. 3 Geometrically Regular Objects  
7. 3 Irregularly Shaped Objects  
8. 2 Unknown Liquids

III. PROCEDURES  
Part A - Geometrically Regular Objects  
1. Measure & record the mass of each geometrically regular object in Data Table A.  
2. Measure & record the dimensions of each geometrically regular object in centimeters.

Part B – Irregularly Shaped Objects  
1. Measure & record the mass of each irregularly shaped object.  
2. Fill the smallest graduated cylinder that will hold the object being tested approximately ½ full. Record the initial volume of the water in Data Table B.  
3. Holding the graduated cylinder at an angle, slide the object into the graduated cylinder. Record the final volume of the graduated cylinder.  
4. Repeat steps 2&3 for each of the irregularly shaped objects.

Part C - Liquids  
1. Measure & record the mass of a clean, dry 10 mL graduated cylinder. Add between 9. & 10. mL of distilled water to the graduated cylinder and record the exact volume in Data Table C. Weigh the cylinder & water and record your data. Dispose of the water, then clean and dry the graduated cylinder.  
2. Repeat the above procedure for unknown liquids A & B.  
3. Return the liquids to the proper containers. DO NOT THROW THEM AWAY!

IV. PRE-LAB QUESTIONS  
1. What is the formula for determining the volume of a cylinder?  
2. What procedure can be used for determining the volume of an irregularly-shaped object?  
3. What is the formula for determining the volume of a block?  
4. Why must the graduated cylinder in Part C be dried before each trial?

V. DATA & CALCULATIONS  
A. DATA  

Data Table A - Geometrically Regular Objects  

<table>
<thead>
<tr>
<th>Object Description</th>
<th>Mass (g)</th>
<th>Length (cm)</th>
<th>Width (cm)</th>
<th>Depth (cm)</th>
<th>Diameter (cm)</th>
</tr>
</thead>
</table>

Data Table B - Geometrically Irregular Objects  

<table>
<thead>
<tr>
<th>Object Description</th>
<th>Mass (g)</th>
<th>Initial Volume (mL)</th>
<th>Final Volume (mL)</th>
<th>Displacement (mL)</th>
</tr>
</thead>
</table>

Data Table C - Liquids  

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Mass (g)</th>
<th>Volume (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empty Grad Cylinder</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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B. CALCULATIONS
1. Calculate the volume of each of the geometrically regular objects using the appropriate formula.
2. Calculate the density of each substance using the relationship:
   \[ \text{density} = \frac{\text{mass (g)}}{\text{volume (cm}^3\text{)}}. \]
3. Summarize the density calculations in a table. In the first column record the object and in the second column record the density.

VI. QUESTIONS & DISCUSSION OF ERROR
A. QUESTIONS
1. Explain in detail why the rods in part A have similar volumes, but different densities.
2. Describe situations in which using geometric calculation of volume is appropriate and situations in which displacement is appropriate.
4. Why is it necessary to indicate temperature when giving density values for fluids?

B. DISCUSSION OF ERROR

VII. CONCLUSION