Lesson Title	Density Experiments
Length of Lesson	1 day
Created By	Kimberley Leggett
Subject	Science
Grade Level	10^{th}, 11^{th}, 12^{th} (Chemistry)
State Standards	Chemistry: 1c, e, g; 2a
DOK Level	DOK 3
DOK Application	Compare; formulate; critique; hypothesize; draw conclusions
National Standards	9-12: A: Science as Inquiry; B: Physical Science; E: Science and Technology; G: History and Nature of Science
Graduate Research Element	Density is a property of matter; properties of matter are relevant to my everyday research

Student Learning Goal:

Inquiry: 1. Apply inquiry-based and problem-solving processes and skills to scientific investigations: (c) Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development); (e) evaluate procedures, data, and conclusions to critique the scientific validity of research; (g) collect, analyze, and draw conclusions from data to create a formal presentation using available technology (e.g., calculators)

Physical Science: 2. Demonstrate an understanding of the atomic model of matter by explaining atomic structure and chemical bonding: (a) describe and classify matter based on physical and chemical properties and interactions between molecules of atoms. Physical properties (e.g.; densities) of a variety of substances

National Science Education Standards of Content 9-12

A: Science as Inquiry: Use technology and mathematics to improve investigations and communications:

- **A variety of technologies, such as hand tools, measuring instruments, and calculators, should be an integral component of scientific investigations. Mathematics plays an essential role in all aspects of an inquiry. For example, measurement is used for posing questions, formulas are used for developing explanations, and charts and graphs are used for communicating results.**

B: structure and properties of matter

E: implement a proposed solution; evaluate the solution and its consequences; communicate the problem, process, and solution

G: historical perspectives

Materials Needed (supplies, hand-outs, resources): Calculator, metric ruler (0.1 cm markings), scale, plastic blocks (can be purchased from Flinn Scientific Inc.), beakers, density hand-out (Inspire_LP_KimLeggett_07_16_10_handout1), density data sheets (Inspire_LP_KimLeggett_07_16_10_handout2), density experiment questionnaire (Inspire_LP_KimLeggett_07_16_10_handout3)

Lesson Performance Task/Assessment:
Use data collected from the experiments to calculate mass, volume, and density. Compare calculated results with actual results and determine the accuracy of the mass calculation. Not all objects can be easily measured so water displacement will be used to determine the volume of an irregular object. The summative assessment is a density experiment questionnaire given after the activity.

Lesson Relevance to Performance Task and Students:
To enhance student measuring skills, calculations, and accuracy by physically doing an experiment involving these skills.

Anticipatory Set/Capture Interest:
Facilitate a discussion of Archimedes Principle on testing the gold crown and water displacement to determine density

Guided Practice:
Instructor will review formulas used in the experiment and explain the experiment. As shown:
Density is a ratio that compares the mass of an object to its volume. The units for density are often grams per cubic centimeter (g/cm^3).
The equation for density is:

$$\text{Density} = \frac{mass\ (g)}{volume\ (cm^3)} \qquad \text{Equation 1}$$

Volume of a cube is: length X width X height (L)(W)(H) Equation 2

Mass = Volume X Density Equation 3

$$Percent\ Error = \frac{|Calculated\ Mass - Actual\ Mass|}{Actual\ Mass} \times 100 \qquad \text{Equation 4}$$

Next the procedures and data sheets will be distributed. The instructor will also determine the accuracy of each student's measurements and calculations.

Independent Practice:
Experiment #1- Finding Density for a Regular Object
Procedure:

1. Obtain a plastic block from the teacher. Record the block number and color of the block on the data table.
2. Use the scale to find the mass of the block. Record this value on the "Density Data Table."
3. Use the metric ruler to measure the length, width, and height of the block. Record the values on the data table.
4. Calculate the volume (equation 2) of the block using the values determined in step 2. Record the volume on the data table.
5. Calculate the density (equation 1) of the block by dividing the mass value by the volume value. Record the density on the data table.
6. Repeat steps 1-5 for two additional blocks, being sure to obtain blocks of different colors. Record all data on the data table.
7. Check with the instructor to determine the accuracy of your measurements and calculations.

Experiment #2 - Finding Density for an Irregular Object
Procedure:

1. Use the same three blocks from previous experiment and record the block number, color of the block, and mass on the data table.
2. Pour water into a graduated cylinder up to an easily-read value, such as 50 milliliters and record the number.
3. Carefully drop the block into the cylinder and record the new value in milliliters.
4. The difference between the two numbers is the block's volume. Remember that 1 milliliter is equal to 1 cubic centimeter. Record the volume on the data table.
5. Calculate the density (equation 1) of the block by dividing the mass value by the volume value. Record the density on the data chart.
6. Repeat steps 2-5 for the other two blocks and record all data on the data table.
7. Check with the instructor to determine the accuracy of your measurements and calculations.

Experiment #3 - Finding Mass for an Object given its density
Procedure:

1. Obtain a plastic block from the teacher. Record the block number and color of the block on the data table. The block number must be different from any of the block numbers used in experiment #1 and #2.

2. Use the metric ruler to measure the length, width, and height of the block. Record the values on the data table.
3. Calculate the volume of the block using the values determined in step 2. Record the volume on the data table.
4. Use the known density value and the volume calculated in question 3 to predict the mass of the plastic sample. The known density values for each different type of colored plastic are shown on the data table for experiment 3. The density equation can be rearranged to solve for the mass as shown in equation 3. Record the calculated mass on the data table.
5. When the mass of the plastic block has been calculated, bring the block to the instructor. The instructor will measure the actual mass of the block using the digital scale. The instructor will inform the student of the actual mass to be recorded on the data table.
6. Determine the accuracy of the mass calculation by comparing the calculated mass with the actual mass. Calculate the percent error in the mass calculation using equation 4.

Remediation and/or Enrichment:
R: Individual IEP; partner help throughout lesson; shorten parts of the assignment; focus on few samples
E: More cubes and do percent error on all calculations

Check(s) for Understanding:
Density experiment questionnaire

1. Did the volume of the blocks change from experiment 1 to experiment 2?
2. If so, why do you think it did?
3. In experiment 3 was your calculated mass close to the actual mass?
4. If not, what do you think happened?
5. In experiment 3 what was your percent error?
6. What does the percent error tell you?

Closure:
Explain why accuracy is needed when taking measurements and calculations.

Possible Alternate Subject Integrations:
Physical Science – when discussing measurements, mass, volume, and density
Math – when teaching significant digits and measurements.

Teacher Notes:
A Density Laboratory kit can be purchased from Flinn Scientific Inc. It includes the blocks and a similar density experiment.