Lesson Title	Density of Metals
Length of Lesson	1 class period (50 min)
Created By	Charles Vaughan
Subject	General Science
Grade Level	8
State Standards	1c, 1d
DOK Level	2 - Compare, Distinguish, Make Observations
DOK Application	Solve routine multiple-step problems.
National Standards	Science as Inquiry - A, Physical Science - B
Graduate Research Element	Density is an important quantity for studying the comae of comets. The density of this gaseous region directly relates to the concentration of volatile gasses, which are of interest to cometary scientists.

Student Learning Goal:

MS 8th Grade:

Inquiry (1c): Summarize data to show the cause and effect relationship between qualitative and quantitative observations (using standard, metric, and non-standard units of measurement).

Inquiry (1d): Analyze evidence that is used to form explanations and draw conclusions.

National Standards for Grades 5-8:

A: Science as Inquiry: Identify questions that can be answered through scientific investigation. Use appropriate tools and techniques to gather, analyze, and interpret data. Use mathematics in all aspects of scientific inquiry.

B: Physical Science: Properties and changes of properties in matter.

Materials Needed (supplies, hand-outs, resources):

Large graduated cylinder, water, rulers, balances/scales, various metal objects with simple geometries (e.g., rectangular- or cylinder-shaped blocks), metal objects with irregular or non-simple shapes (e.g., bolts, nuts, or beads), calculators (non-scientific will suffice), table of densities for metals (file name: INSPIRE_Vaughan_07_13_12_DensityTable.doc). Note that a variety of metal substances is needed for this lesson (such as aluminum, copper, and steel).

Lesson Performance Task/Assessment:
Density is an intrinsic property of matter. Regardless of how much material is present, the density of an object should remain the same (under constant temperature and pressure). This makes density a very useful quantity for identifying substances. Students will conduct several experiments in which they measure the mass and volume of different metals, and they then calculate the density using D = M/V. They will then compare the calculated density to known densities to identify the metal.

Lesson Relevance to Performance Task and Students:
Understanding density will facilitate understanding matter as a whole. The goal of the lesson is for students to better understand the quantity of density and how it relates to different materials.

Anticipatory Set/Capture Interest:
"Many metals look very similar. With the exception of some (such as gold, copper, and brass), nearly all metals have a grayish or silver-colored luster. What is a simple way to figure out the type of metal? If I take a piece of metal and cut it in half, what changes when I cut it, and what remains the same?"

An excellent means of capturing interest is to bring in a piece of brass. Many youths will immediately think it is gold. Begin by having the students find the density of this metal, and have them determine if it is actually gold or brass based on its density.

Guided Practice:

- Begin with anticipatory questions and show students the equation for density, D=M/V. Give handouts with a brief table of densities for the students to use during the lesson. To make calculations simple, the units for density should be in g/mL or g/cm^3 (note that 1 mL = 1 cm^3). Indicate to students that density is an intrinsic property of a material, meaning that it will not change even when the amount or size of the material changes.
- As an example, show how to find the density of a regular-shaped object. First, find mass of the metal, in grams, using a scale/balance. Then, calculate the volume of that object using geometry. Use the centimeters side of the ruler for making measurements. Last, calculate the density by dividing mass by volume. Compare the result to the expected value in the table. It is normal for some precision error to cause slight deviation from the expected value.
- Next, show how to find density for an irregular object. As before, find the mass first, in grams. Using a graduated cylinder filled with a known quantity of water, immerse the metal object in water, measure the new volume of water, and take the

difference to find the volume displaced by the metal, in mL. This will be the volume of the object. Calculate the density and compare to the expected values.

- Proceed to allow students to individually find mass, volume, and density for all their objects, but monitor their procedures and calculations during the lesson.

Independent Practice:
If the class size is large, it is recommended that the students work in groups of 2 or 3.

- As shown in the example procedure, the students should find the mass of each object using the scale/balance. If the metal object has a regular, easily-calculated volume, students should measure the object's sides using centimeters, and then calculate the volume. If the object is irregular, students should immerse it in a known quantity of water in the graduated cylinder and calculate the difference in volume. The calculated density should have units of g/mL or g/cm^3.
- The students should compare the value to the list of given densities to identify the metal. They should write down what they believe is the type of metal of the object.

Remediation and/or Enrichment:
Remediation – IEP

Enrichment – For higher performing classes with good precision instruments, give your students a metal that is an alloy of two metal elements. If the two constituent metals are known, have your students find the density and then approximate the ratio of these two elements using algebra. This will only work well if the alloy ratio is no more extreme than about 80/20 (i.e., steel would not be a good metal to use since it is typically over 90% iron).

Check(s) for Understanding:
The instructor needs to walk around the room, checking to see that they are performing calculations correctly. This is the most common source of error during the lesson.

Closure:
"What would happen to the density of an object if it was heated? What would happen if it were compressed under a great amount of pressure? Does the density of a substance change if it melts from solid to liquid?"

In all of these cases, it is likely that the density will change. Metals generally expand when heated as a solid, thereby increasing volume, but because the mass is conserved, the density must decrease. Likewise, an object under pressure will shrink in size (even

slightly), so the density would increase. Many substances will decrease in density when they are heated from a solid to a liquid, but water is an exception; solid ice is actually less dense than liquid water, which is why ice floats. The instructor should elaborate on this, explaining that the so-called intrinsic property of density only applies under constant temperature and pressure.

Density is a very important quantity for scientists to know since it reveals information about the constituent materials of an object. The materials present within comets, for example, are known through density approximations through spectroscopic data.

Possible Alternate Subject Integrations:
Chemistry, Physical Science

Teacher Notes:
The metals used in this lesson were borrowed from the physics department at a partner university. However, many are common enough that they could be obtained as scrap from a workshop.

The precision when measuring with the graduated cylinder is generally low. These measurements are only good if the cylinder is large and the accompanying metal objects are large as well (but not so large that they cannot fit in the cylinder!). Overall, do not ask your students for more than three significant figures when performing calculations.

Be sure to include the densities of the metals used in the handout. Steel is composed primarily of iron, so the density of iron will suffice given the level of precision in this lesson.