

ELEMENTARY SCIENCE PROGRAM
MATH, SCIENCE & TECHNOLOGY EDUCATION

A Collection of Learning Experiences

Density

Revised July 2006



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NOTE: This kit has been divided into two sections and can be completed in several ways. For 4th graders, Learning Experiences 1 – 5 should be completed to meet the state standards. In 6th grade, students should review Learning Experiences 1 – 5 and continue on with Learning Experiences 6 – 8 in order to reach a better understanding of density. It is believed that by 6th grade, students will have a strong enough math base to calculate density and the skills necessary to comprehend density at a higher level.

Density

GRADE 4

Unit Overview

This unit provides students with the opportunity to observe the property of density. Students will engage in inquiry about why and how some objects (solids and liquids) display the property of density. Students will measure the mass of solids and liquids. Students will experiment with solids and liquids of different densities. Students will also calculate the density of solids and liquids using hand-held calculators. The science skills emphasized in Density are collecting data, manipulating, observing, and predicting. Accuracy of measurement is critical to the success of this unit.

Scheduling

This unit may take from two to four weeks to complete depending upon the goals of the teacher and interests of the students. Use of the section included in this manual called More Ideas may extend the time span of this kit.

Materials to be obtained locally:

Please make **one** student activity book for **each** student.

paper towels

water

chart paper

felt tip markers

notebooks

folders

calculator

metric ruler

Caution

The rubbing alcohol in this kit is the type that is commonly available in the drug store. This rubbing alcohol cannot be made safe to drink. Students should be instructed not to place any of the alcohol in their mouths and to avoid prolonged contact with the skin. Remind students to wash their hands after handling any of the materials in the kit. For eye or skin contact, flush with water. For ingestion, seek appropriate medical attention. Use caution if liquids are spilled near electrical outlets.

About the Format

Each learning experience is numbered and titled. Under each title is the objective for the learning experience.

Each learning experience page has two columns. The column on the left side of the page lists materials, preparations, basic skill processes, evaluation strategy, and vocabulary. The evaluation strategy is for the teacher to use when judging the student's understanding of the learning experience.

The right column begins with a "Focus Question" which is typed in italicized print. The purpose of the "Focus Question" is to guide the teacher's instruction toward the main

idea of the learning experience. The “Focus Question” is not to be answered by the students. The learning experience includes direction for students, illustrations, and discussion questions. These discussion questions can be used as a basis for class interaction.

A **Student Assessment** has been included in the **Teacher’s Manual** and the **Student Activity Manual**. If you do not want the students to have the assessment beforehand, remove it from the **Student Activity Manual** before printing a class set of the student manuals.

Background Information

The learning experiences in the density kit are designed to help students confront some of their “understandings” through scientific inquiry. During the inquiry, it is important to focus students, through discussions, on the question of “What is density?” and perhaps “How does the property of density interact in our environment?”

The focus of inquiry should be on student-generated questions or explanations in the student’s own language rather than defining them in specialized scientific terms. There is much agreement in science literature that an early focus on scientific terms often short circuits the development of student understanding. However, specialized language is very important. It facilitates deeper understanding after one has developed ideas in their own terms. Scientific terms should be presented for labeling, consolidating, and extending understanding.

The **Properties** of an object are determined by its material and its condition.

Everything you see and touch is **matter**. You are made of matter. The air you breathe is made of matter. So what is matter? Matter is anything that takes up space, and may have the observable properties that include color, texture, shape, volume and hardness. However, just because you might not be able to see all types of matter does not mean they are not there. Think of a balloon. If you pumped air into a balloon you would be able to see the volume of the air by the way it stretches and shapes the balloon. You cannot see air, but it is made of matter.

Mass is a measure of the amount of matter in an object, while the **weight** of an object is a measure of the gravitational pull on the object. Generally, a balance scale of some sort is used to measure mass, and a scale is used to measure weight. Students use a spring scale to measure the force of gravity on the object’s mass, in Newton’s, and that force is the weight of the object. Weight is the result of the effect of gravity on the mass that stretches or compresses a spring. Mass is measured by comparing the gravitational pull to a standard mass. Therefore, some sort of a balance scale is needed to measure mass. Weight will vary with gravitational force, while the mass will remain constant. Therefore, if you measure a weight on earth and then measure the weight on the moon, you would find a difference because the force of gravity is different on the moon. However, if you find the mass on earth or the moon, it will be the same.

To Summarize:

Mass:

Amount of matter in the object
Measured with a balance
Does not change based on the gravitational pull
Units are in grams and kg

Weight:

Measure of the gravitational pull on the object
Measured with a scale
Depends on and changes with gravitational pull
Units are in Newton's (N)

Density is the measure of the “compactness” of a material. It is the ratio of mass to volume for any material. It is usually measured in grams per cubic centimeter (g/cc, g/cm³) and tells how much matter is packed into a given space. Density is not a simple comparison of the “heaviness” or “lightness” of materials. It is instead, a comparison of the “heaviness” or “lightness” of the same volume (mass per unit volume). The density of a material is determined by the masses of the atoms in the material and the amount of space between the atoms. Gases have a low density not only because the atoms making up the gases have a small mass, but also because there is a large amount of space between the atoms. The heavy metals like gold, lead, and uranium are very dense because the atoms they are composed of are massive and spaced closely together.

Water has a density of one gram per cubic centimeter (1 g/cm³) at 3.98 degrees Celsius, and water is the standard for comparing the density of materials. Materials with a density greater than one gram per cubic centimeter are denser than water and will sink in water; materials with a density that is less will float in water. Lead has a density of 11.3 grams per cubic centimeter (11.3 g/cm³) that tells us it is more than eleven times as dense as water. It also means that a hundred grams of lead would have eleven times less volume than a hundred grams of water (atoms in lead are much more closely packed together so they take up less space.) The densities of ordinary substances here on earth vary from the least dense, hydrogen gas, with a density of 0.000089 grams per cubic centimeter to the element osmium which, at 22 grams per cubic centimeter (22 g/cm³), is only slightly more dense than gold or platinum.

To calculate **density**, we divide the mass of the material in grams by its volume in cubic centimeters. We might just as well divide the mass in kilograms by the volume in liters, or the mass in metric tons by the volume in cubic meters, the answer in each case would be numerically the same. The density of an object equals its mass divided by its volume ($D = M/V$).

Some Effects of Density

- The block of wood will float if the wood is less dense than water. The mass of the volume of water displaced by the floating block of wood is equal to the total mass of the block of wood. Alternatively, the volume of water that has the same mass as the block would occupy less volume than the block of wood.

- The metal cube sinks because the metal in it is denser than water. For equal volumes of metal and water, the metal's mass is more than the mass of the water. Alternatively, for an equal mass of metal and water, the water would have the greater volume.
- Salt water vs. fresh water – salt water is denser than the fresh water because of the mass of the salt that has been dissolved in it. The greater density of salt water increases the buoyancy, or the upward force of the salt water, of objects placed in it. Liquids with a greater density have a greater internal pressure and therefore push upon objects with a greater buoyant force.

Volume is the amount of space occupied by a three-dimensional object as measured in cubic units, i.e., cubic centimeters, cubic meters, milliliters or liters.

It is important to note that when measuring the volume of a liquid, the person reading the volume must be eye-level with the liquid, or a false value will be obtained.

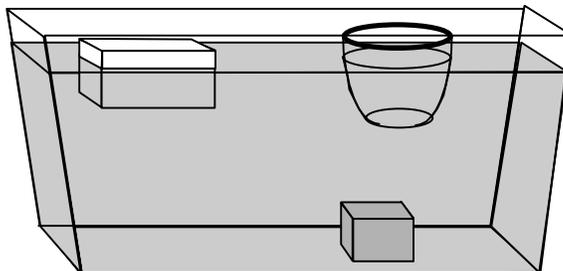


Displacement: An object floats if it displaces an amount of liquid equal to its own weight (otherwise it sinks).

In order for an object to be submerged in a liquid, the object must push aside or displace some of the liquid in which it is placed. This is called displacement. Volume of an object can be determined by displacement. Let's say that 10 mL of liquid is placed in

a graduated cylinder. If an object is dropped into the cylinder, the water level appears to go up, even though no more water was added to the cylinder. This is due to the fact that the object has “displaced” or pushed aside some of the liquid when it was put into the container. If the object is submerged, it will displace the object’s volume. Therefore, if there was 10 mL of liquid before the object was placed in the fluid and the measurement of the liquid in the cylinder is 14 mL after the object is placed in the fluid then subtracting 10 mL from 14 mL would equal the space that the object took up in the cylinder. Since the definition of volume is “the amount of space taken up by an object” it can be concluded that the volume of the object placed in the fluid is 4 mL.

- The block of wood floats because the water *displaced* by the portion of the block in the water equals the total weight of the block.
- The metal cube sinks because the “cube” of water it *displaced* weighs less than the cube of metal.



The empty glass cup floats because its weight and the air it contains is less than the weight of the water it displaced, that is, the water that occupied the space which the cup presently takes up in the water.

Gravity affects everything on earth. This includes bodies of air and water and the things in them. Gravity pulls the air or water and the things in them toward the center of the earth because the earth has the most mass of anything on earth. Only the solid surface beneath the air or water prevents them from being drawn further toward the center of the earth.

Gravity interacts with the double-pan balance. If one side of the balance has more mass than the other, that side will be attracted more toward the center of the earth. Plasticine has been provided to equalize the mass on each side of the balance arm. (Adding Plasticine to one side will accomplish this.) This process is called calibration or zeroing the balance.

In some situations, a buoyant force is able to overcome the force of gravity. The result is that those objects float. We recognize objects such as styrofoam and wood as being able to overcome the force of gravity when placed in water. The buoyant force of the water on the materials that are less dense than water overcome the force of gravity and, therefore, the object can float.

Archimedes Principle

A buoyant force is an upward force exerted on an object by a fluid in which the object is immersed. When an object is placed into a liquid, the object displaces some of the liquid. The volume of the liquid that is displaced is equal to the volume of the object. The amount of buoyant force is equal to the weight of the displaced fluid. Archimedes concluded that an object in a fluid is acted on by a force equal to the weight of the fluid displacing the object. This statement describes Archimedes Principle.

Densities

The following densities have been provided as a general reference. The actual density of each material may vary with its purity and condition. Densities have been rounded to the nearest hundredth. The density chart serves to identify which material will float in which liquid. For example, all materials with a density less than one will float in water. In the chart below, all material from vegetable oil to hydrogen will float in water. All materials from seawater to osmium will sink in water. Mercury is a liquid metal with a density of 13.57 g/cc. All materials with a density above 13.57g/cc will float in Mercury. Lead will float in Mercury but Gold will not.

Densities sorted by Material and Density

<u>Category</u>	<u>Material</u>	<u>Density (g/cc or g/cm³)</u>
Gas	Hydrogen	0.00009
Wood	Red Oak	0.67
Wood	Sugar Maple	0.69
Chemical	Gasoline	0.72
Other	Ice	0.90
Other	Paper	0.93
Liquid	Rubbing Alcohol	0.76
Liquid	Vegetable Oil	0.93
Liquid	Water, 4 °C	1
Plastic	Polyurethane	1
Liquid	Water, Seawater	1.03
Mineral	Coal, Coke	1.20
Mineral	Coal, Anthracite	1.55
Ceramic	Glass	2.6
Metal	Aluminum	2.7
Metal	Titanium	4.5
Metal	Steel, tool	7.72
Metal	Brass	8.55
Metal	Tool Steel	8.75
Metal	Copper,	8.9
Metal	Nickel,	8.9
Metal	Silver,	10.5
Metal	Lead	11.37
Metal	Mercury	13.57
Metal	Uranium	18.74
Metal	Tungsten	18.82
Metal	Gold, Pure	19.32
Metal	Platinum	21.3
Metal	Osmium	22.

Learning Experience 1: Mass, Volume, and Density

Objective: Students will use their background knowledge to describe their understanding of mass, volume, and density.

Materials:

For the class:

- Chart paper*
- Felt tip markers*
- Notebooks*
- Folders*

*provided by teacher

Preparation:

Read background information on mass, volume and density on pages 4-6. Each student should obtain a notebook and a folder with pockets to hold the activity sheets for this unit. Create a KWHL chart to post in the classroom.

Basic Skills Development:

- Discussing
- Brainstorming

Evaluation Strategy:

Students will use their background knowledge to communicate their understanding of mass, volume, and density of various objects.

Vocabulary:

- mass
- density
- volume
- s

What do we know about mass, volume and density?

Using the KWHL Strategy, students will explore their understandings of mass, volume, and density and then expand on it throughout the unit. Brainstorm what students already **know** about mass, volume, and density. Ask students to brainstorm words or ideas that come to mind when they think about the density, mass, volume of various objects. Record their ideas on a class size **K-W-H-L** chart. Ask students what they would like to know more about concerning mass, density, and volume and record their ideas under the “**want to know**” column. Ask students to describe “**how they might find out**” answers to the questions they have. After the hands-on activities, maintaining journals, and discussion, students should then record information into the “**what we learned and still want to learn**” column. This process can be done in cooperative groups where students gather information in small groups then share their ideas with the class.

KWHL Strategy			
<i>What do we know about mass, volume or density?</i>			
What do we know	What do we want to know	How might we find out	What we learned and still want to learn

Learning Experience 2: Measuring the Mass of Solids

Objective: Students will assemble and use a double pan balance to measure the mass of three balls: a super ball, black rubber ball, and a glass ball and serial order the balls by mass.

Materials:

For each group of three students:

3 Density Student Activity Books

Balance stand

Balance arm

Pin for balance

Balance base

2 paper clips

2 baskets for balance

Modeling clay

2 medicine cups

Super ball

Black rubber ball

Glass ball

Plastic jar of gram centimeter cubes

For the class:

Wooden ball

Steel ball

Note:

The gram centimeter cubes are designed to have a mass of one gram each. In turn, they measure one centimeter on each side ($1\text{ cm} \times 1\text{ cm} \times 1\text{ cm} = 1\text{ cm}^3$.) Therefore, they have a mass of one gram and a volume of one cubic centimeter or 1cc or 1 g/cm^3 . **The mass of similar balls might not be the same as those in other groups.**

Preparation:

Read background information on pages 4 and 5. Demonstrate the set up of the double pan balance and its calibration with plasticine.

Basic Skills Development:

Measuring

Collecting Data

Discussing

How is a double pan balance assembled and how can it be made level or calibrated? How can we determine the mass of a solid object?

Session 1:

Provide students the activity sheet for Learning Experience #2 in the Density Student Activity Book that illustrates the assembly of the double pan balance. After assembling the double pan balance, students may discover one side of the balance is higher than the other. Discuss with students that the balance must be level or calibrated before it can be used to measure objects. Provide students with a piece of modeling clay to help level the double pan balance. Emphasize that this process is called “calibration.” It also is referred to as “zeroing the balance.”

Discussion Questions:

Why do you think that the double pan balance should be level?

What do you think the plasticine does to the unbalanced side of the double pan balance when it is added?

Session 2:

Begin this session by demonstrating for students how to use the balance by finding the mass of the wooden ball and the steel ball using the double pan balance and gram cubes. Record your findings somewhere in the room so they are visible to all students. They will need the data later. Provide student groups with the gram centimeter cubes,

Learning Experience 2 continued

Page 2

Evaluation Strategy:

A group of three students will assemble a double pan balance using the materials provided, level their double pan balance by using the modeling clay provided, and serial order the super ball, black rubber ball, and glass ball by mass (smallest mass to largest mass).

Vocabulary:

balance
level
calibrate
mass
plasticine
zeroing
serial order
centimeter cube

medicine cups, and the super, black rubber, and glass balls. Have students measure the mass of each ball by placing one medicine cup in each pan of the balance. Use the gram cubes to determine the mass of each of the balls by placing the gram cubes in one medicine cup and the balls in the other medicine cup. Use of the medicine cup in each basket eliminates the effect of the mass of the cup.

Students should record all measurement on their activity sheets for Learning Experience #2 in the Density Student Activity Book.

Discussion Questions:

Why do you think that you obtained a different measurement for each ball? (Because each ball has a different mass. i.e. A different amount of matter contained in it.)

Why did you place a medicine cup in each pan of the balance? (Because that eliminates the effect of the mass of the cup.)

Learning Experience 3: Measuring the Mass of Liquids

Objective: Students will measure the mass of 20 cubic centimeters of three liquids: rubbing alcohol, water, and salt water and serial order the liquids by their mass.

Materials:

For each group of three students:

3 Density Student Activity Books

Double pan balance

4 medicine cups – (each one filled with 20 cc of rubbing alcohol, water, salt water, and one empty medicine cup)

Plastic jar of gram centimeter cubes

Cardboard tray

Paper towels*

Water*

For the class:

3 measuring cups

Yellow food coloring

Red food coloring

*provided by teacher

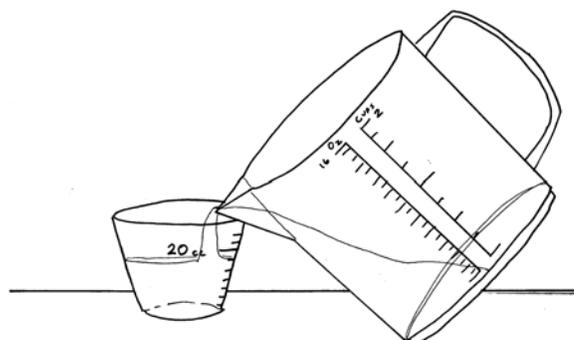
Preparation:

Read background information on pages 4 and 5. Determine if student groups will fill the medicine cups or the teacher will pre-fill the cups before beginning this learning experience. Cardboard trays have been provided to prevent spills of liquids. Each medicine cup must be filled accurately to the 20 cc mark. A 25% salt solution is required for this learning experience. Measure 100 cc of warm water into one of the plastic jars with the yellow top. Measure with gram cubes 25 grams of salt in the double pan balance. Add the 25 grams of salt to the 100 cc of warm water in the plastic jar and shake until the salt is dissolved. Add a drop of yellow food coloring to the saltwater. Repeat this process until you have two jars full or about 400 cc of 25% salt water. Store the saltwater in jars with yellow tops.

Can we determine the mass of a liquid?

Session 1:

To demonstrate for students how to find the mass of rubbing alcohol, place the medicine cup filled with 20 cc of rubbing alcohol on one side of the double pan balance and an empty medicine cup on the other side. Place gram cubes in the empty medicine cup and note the results.



Provide student groups with four medicine cups, one filled with 20 cc of rubbing alcohol, one with 20 cc of water, and one filled with 20 cc of salt water (see teacher preparation on how to make this), and an empty medicine cup for gram cubes. Or, you can have your students measure out the volumes of each liquid themselves. Have students measure the mass of each liquid by placing one empty medicine cup in one basket of the double pan balance and placing the medicine cup with the 20 cc of liquid in the other basket of the double pan balance.

Learning Experience 3 continued

Page 2

Preparation (continued):

The rubbing alcohol, premade in your kit, is a 70% mixture. It contains seven parts alcohol (70%) and three parts water (30%). Use the red food coloring provided in the kit to tint the rubbing alcohol for easy identification of the two liquids. This should be stored in jars with red tops.

Note:

For students to recognize the different types of liquids provided alcohol should be tinted pink with the red food coloring and the salt water tinted yellow with the yellow food coloring. Return the liquids to the proper jars with their proper lids. For a challenge, do not tell students what each color is. They should be able to determine this by their densities. For students who may find this learning experience too challenging an alternative student activity page has been provided in your teacher's manual with the liquids identified on it.

Basic Skills Development:

Measuring
Collecting Data
Interpreting Data
Observing
Discussing

Evaluation Strategy:

Students will serial order by mass (smallest mass to largest mass) the 20 cc medicine cups of rubbing alcohol, water, and salt water.

Vocabulary:

balance
calibrate
level
mass
zeroing

Use the gram cubes to determine the mass of the liquid by placing the gram cubes in the empty medicine cup. Determine how many gram cubes it takes to balance out the mass of the liquid in the other pan.

Student should record their measurements on their activity sheet for Learning Experience #3 in the Density Student Activity Book.

Discussion Questions:

Why do you think that the liquids had different masses? (Various acceptable answers.)

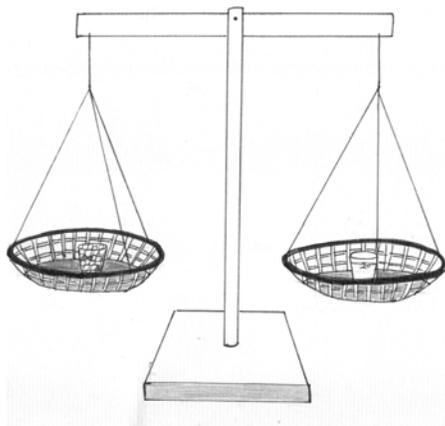
Why did we have to be sure that all the medicine cups accurately measured 20 cc? (Because that is the only way we can really make a comparison.)

MEASURING THE MASS OF UNKNOWN LIQUIDS

Water is an example of a liquid. Liquid matter has no definite shape, but it does have a definite volume. The mass of a liquid can be measured with a balance, just like a solid. Liquid volume is usually measured in milliliters, and solid volume is usually measured in cubic centimeters (cc), or cm^3 . 1 ml of water would exactly fill a 1cm cube.

Use these steps to measure the mass of three different liquids:

1. Get four medicine cups from your teacher. Find the 20 cc mark on each cup.
2. Pour rubbing alcohol (red liquid) into one medicine cup to the 20 cc mark if it is not already done for you.
3. Pour water (colorless liquid) into another medicine cup to the 20 cc mark if it is not already done for you.
4. Pour salt water (yellow liquid) into another medicine cup to the 20 cc mark if it is not already done for you.
5. Place an empty medicine cup in one basket of the balance.
6. Carefully place the cup with the rubbing alcohol into the other basket of the balance scale.
7. Add gram cubes to the empty medicine cup side of the balance scale until both sides are equal. Count the gram cubes to determine the mass of the rubbing alcohol. Record your data on the activity sheet.



8. Repeat steps 5 through 7 for the water and salt water.

Data:

1. What is the mass of the rubbing alcohol? _____ g
2. What is the mass of the water? _____ g
3. What is the mass of the salt water? _____ g
4. Order the liquids from the smallest mass to the largest mass.
1. _____ 2. _____ 3. _____

Questions:

1. Why do you think you had different measurements for each liquid? _____

 2. How did the masses of the liquids compare to the masses of the balls from Learning Experience #2? _____

 3. Why did you have to be sure that all of the different liquids had the same volume of 20 cc? _____

-

Learning Experience 4: Measuring the Volume of Solids and Liquids

Objective: Students will measure the volume of solids and liquids.

Materials:

For each group of three students:

3 Density Student Activity Books
Plastic jar of gram centimeter cubes
Medicine cup
Plastic spoon
Super ball
Black rubber ball
Glass ball
Water*
Metric rulers*
Paper towels*

For the class:

Steel ball
Wood ball

*provided by teacher

Preparation:

Session 1:

Read background information on pages 5 and 6. Demonstrate the characteristic of the gram centimeter cube's volume. The formula for volume of a cube is to multiply its length times width times height. A single cube has the volume of $1\text{ cm} \times 1\text{ cm} \times 1\text{ cm} = 1\text{ cm}^3$ equals 1 cc where cc is the abbreviation for cubic centimeter, cm is the abbreviation for centimeter. 1 ml of water would fit in 1 cubic cm. Students may add the number of cubes to obtain the total volume contained in the total number of cubes.

Can we determine the volume of solids and liquids?

Session 1:

Students should examine the gram centimeter cubes with a metric ruler. Direct students to stack eight cubes together to form a larger cube. Guide the students in calculating the total volume of the larger cube and have them record their results on the activity sheet for Learning Experience #4 in the Density Student Activity Book. Direct the students to rearrange the cubes in different shapes. Guide the students in calculating the volume of each new shape.

Session 2:

Provide the student groups with a medicine cup and direct them to fill the medicine cup to the 20 cc mark. Emphasize that the water must be filled accurately to the line when the medicine cup is held at eye level. Place gram centimeter cubes, five at a time, in the medicine cup filled with 20 cc of water. Place two sets of five gram centimeter cubes in the medicine cup. Note the new volume as you add each set of cubes. This volume change is called displacement. You find the displacement by subtracting the original volume, 20 cc, from the final volume.

The answer you get is the volume of the cubes. Have students record their answers on the activity sheet for Learning Experience #4 in the Density Student Activity Book.

Learning Experience 4 continued

Page 2

Session 2:

Teacher should demonstrate accurately filling the medicine cup with 20 cc of water. Teacher should demonstrate the process of placing gram centimeter cubes in the water and recording the new volume. This volume change is called displacement. You find the displacement by subtracting the original volume, 20 cc from the final volume.

Basic Skills Development:

Measuring
Collecting Data
Interpreting Data
Discussing

Evaluation Strategy:

Student groups will find the volume of each ball and assemble gram centimeter cubes of volume equal to the volumes that they have identified for the black rubber ball, the super ball, and the glass ball. Students will compare the volume of the cube for each ball to the number of grams found for each ball in Learning Experience #2 and explain the differences.

Vocabulary:

volume
cubic centimeters
displacement

Demonstrate the process of placing the steel ball in the water, determining the new volume of the water and then subtracting the initial 20 cc. Record the volume of the steel ball with the mass you determined earlier. Demonstrate the process of determining the volume of the wooden ball through the same process. However, a plastic spoon is needed to hold the wooden ball underwater so it is completely submerged to get the total volume of the wooden ball.

Discussion Questions:

What characteristic did you observe about the gram centimeter cubes when you placed them in the water in the medicine cup? *(They sank and took up space. They displaced water.)*

What happened to the water in the cup? *(The water in the cup rose equally to the number of cm cubes.)*

What does this tell us? *(1 cm cube has a volume of 1 cc. 10 cm cubes have a volume equal to 10 cc.)*

Direct students to remove the cubes from the medicine cup and to, again, fill the medicine cup to the 20 cc mark. Emphasize that the water must be filled accurately to the line when the medicine cup is held at eye level. Place the glass ball in the water and record the change in volume on the activity sheet in the Density Student Activity Book.

Remove the glass ball and check the volume in the medicine cup. It should read 20 cc. Add additional water if some has been lost. Place the black

Learning Experience 4 continued

Page 3

rubber ball in the water in the medicine cup. Record the change in volume on the activity sheet for Learning Experience #4 in the Density Student Activity Book. Remove the black rubber ball and check the volume in the medicine cup. It should read 20 cc. Add additional water if some has been lost. Place the super ball in the water in the medicine cup. You will need to use the plastic spoon to push the super ball just under the water level to obtain the total volume of the super ball. Record the change in volume on the activity sheet for Learning Experience #4 in the Density Student Activity Book.



Discussion Questions:

Did your measurements of the volume of each ball agree with other groups? *(They may or may not agree with other groups. There may be slight differences in the sizes of the balls or errors in measuring might have been made.)*

If there were differences, what reasons might help explain the differences? What do you now think about the density of each ball? *(The density of the superball, rubberball and glassball are different from one another. The differences can be explained by the differences in mass and volume.)*

Learning Experience 5: Density

Objective: Students will calculate the density of solids and liquids and place the solid and liquid in serial order by density.

Materials:

For each group of three students:

3 Density Student Activity Books

Calculator*

*provided by teacher

Preparation:

Read background information on pages 4 and 5. A mini-lesson on using a calculator may be necessary. A mini-lesson on decimal place values and serial order of decimals may be necessary.

Basic Skills Development:

Measuring
Discussing
Gathering Data
Interpreting Data

Evaluation Strategy:

Students will calculate the density of the balls and liquids using the formula $\text{Density} = \text{Mass}/\text{Volume}$ and place the solids and liquids in serial order by their densities.

Vocabulary:

volume
mass
density
formula
float

Can we determine the density of solids and liquids?

In Learning Experience #2, the mass of a wooden and steel ball was found. In Learning Experience #4, the volume of the steel and wooden ball through displacement was found. With the mass and volume of the balls, demonstrate the procedure to calculate the density of the wooden and steel balls using the formula $\text{Density} = \text{Mass}/\text{Volume}$ and a calculator. Students should record the procedure and the density calculation of the wooden and steel ball on the chart on their student activity sheet for Learning Experience #5 in the Density Student Activity Book.

In Learning Experience #2, students recorded the mass of the super ball, black rubber ball, and glass ball. In Learning Experience #4, students measured the volume of the super ball, black rubber ball, and glass ball through displacement. Using the chart on the activity sheet for Learning Experience #5, record the information from these previous learning experiences. Students are to now calculate the density of each ball using the formula $\text{Density} = \text{Mass}/\text{Volume}$ and record the density for each ball on the chart. Students that have just been introduced to the topic of decimals can record the answer as they would for dollars and cents. An answer similar to 1.25 is what should be recorded on their activity sheets. The units are grams per cubic centimeter (g/cm^3).

Learning Experience 5 continued

Page 2

In Learning Experience #3, students measured the mass of three liquids; rubbing alcohol, water, and salt water. The volume of each liquid was 20 cubic centimeters. Students are to, again, use the formula and a calculator to calculate the density of each liquid and record the density on the chart provided on the activity sheet for Learning Experience #5 in the Density Student Activity Book.

Now that students have calculated the density for each liquid and each ball, students are to put the densities in serial order, beginning with the least dense. The order can be listed on their activity sheet.

Discussion Questions:

How did the solids and liquids order by density? (*Rubbing Alcohol, water, salt water*)

How would the wooden balls and steel balls fit in the order? (*Wooden balls, alcohol, water, salt water, steel balls*)

Based on the order you placed the solids and liquids in, predict which balls will sink or float in each of the liquids. For example, will the wooden ball sink or float in rubbing alcohol or water or salt water? Will the rubber ball sink or float in rubbing alcohol or water or salt water? Will the glass ball sink or float in rubbing alcohol or water or salt water? Will the steel ball sink or float in rubbing alcohol or water or salt water? Explain your predictions. (*Make predictions*)

Students can then test their predictions with the materials provided. Discuss the results.

Learning Experience 6: The Density of Clay

Objective: Students will measure and calculate the density of several different size pieces of clay, and conclude that the density of a material is a property that remains constant regardless of the mass and volume of that material.

Materials:

For each group of three students:

Double pan balance
Plastic jar of gram centimeter cubes
Medicine cup
25 grams or more of clay
Plastic knife
Water*
Paper towels*

* provided by teacher

Preparation:

Read background information on pages 4 and 5.

Evaluation Strategy:

Students will test the density of different size pieces of clay to see if the density of an object changes when its mass or volume changes.

Vocabulary:

Mass
Volume
Density
Displacement

Do different size pieces of the same material have the same density?

Students should use the double pan balance to measure out a 25 gram piece of clay. Direct students to roll the clay into a ball. Find the volume of the clay ball by displacement. Measure 20 cc of water in a medicine cup. Squish the ball slightly so that when placing it in the water it is completely covered. How much did the water rise? Record the mass (25 grams) and the volume of the clayball on the activity sheet for Learning Experience #6 in the Density Student Activity Book. Calculate the density of the clayball.

Cut the clayball in half using the plastic knife. Find the mass of the $\frac{1}{2}$ of the clayball. Find the volume using displacement. Remember to check and make sure the water level in the medicine cup is still 20 ccs before you begin. Record the mass and volume of the $\frac{1}{2}$ clay ball on the activity sheet for Learning Experience #6 in the Density Student Activity Book. Calculate the density of the $\frac{1}{2}$ clayball.

Discussion Questions:

What did you find out about the density of the clayball and the $\frac{1}{2}$ clayball? Do you think that the density of clay will be the same regardless of the size of the piece? Take any size piece of clay and repeat the steps for finding mass and volume. Calculate the density of your piece of clay. Did you come up with the same density once again? What can you conclude about the property of density?

Learning Experience 7: Density Rainbow

Objective: Students will layer four colored liquids in a straw and make decisions about the order based on the behavior of the liquid and the densities.

Materials:

For each group of 3 students:

3 Density Student Activity Books

1 pipette

1 clear plastic straw

1 pieces of clay (size of large marble)

Access to the 4 colored liquids

For the class:

4 - 8.5 oz. clear plastic jars with yellow caps

Canning salt

Food coloring

Water (preferably warm)*

*provided by teacher

Preparation:

Read background information on pages 2 –7. Prepare the 4 – 8.5 oz. jars with water, canning salt and food coloring in the following manner:

Jar 1 – Water with 3 drops of blue food coloring

Jar 2 – Water, 1 tblsp. salt, 3 drops of green food coloring

Jar 3 – Water, 2 tblsp. salt, 3 drops of yellow food coloring

Jar 4 – Water, 3 tblsp. salt, 3 drops of red food coloring

*Note – Warm water will help dissolve the salt much faster in the jars. Shake the jars to dissolve the salt.

Evaluation Strategy:

Students will demonstrate their understanding of the density of liquids by layering the liquids in serial order, from most dense to least dense.

Students will do this by trial and error, emptying the straw and starting over until the correct order is shown.

Vocabulary:

Serial order

Can we layer liquids with different densities in serial order?

Session 1:

With increasing confidence students are able to demonstrate their understanding of density. In this Learning Experience, 4 colored liquids of various salt solutions are placed around the room. Students will push a clear straw **at an angle** into a clay base. They will slowly layer the different colored liquids (5 to 10 drops of each color) into the straw. Students should know that the liquids must go into the straw in a certain order for distinct layers to be seen. They should record their results on the activity sheet for Learning Experience #7 in the Density Student Activity Book. If colors seem to mix, then students should try a different order until 4 distinct layers are seen in the straw.

Demonstration of Experimental Procedure:

Put a clear straw in a clay base at a 45-degree angle. Tell the students that it has to be at angle so that the liquid will run down the side of the straw.

Demonstrate how to use the pipettes. Show the students how to put the liquid in to the straw, slowly so that it runs run the side of the inside of the straw. One drop at a time maybe to difficult for them, but emphasize that it should not just be squirted in.

Show students how much of each liquid to put in the straw – 5 to 10 drops (emphasize that it does not have to be

Learning Experience 7 continued

Page 2

the same amount each time, but it should be similar. Tell them that they will need to be able to fit the 4 different liquids into one straw.

Now demonstrate how to put more than one liquid into the straw. Ask the students what they think will happen if they put more than one liquid in the straw. First add some of the blue solution, and then add the red. They should form layers. Ask the students why the two solutions didn't mix. Make sure they understand that the liquid on bottom has a higher density than the liquid on top. Then ask the students what would happen if you put the red liquid in first, and then added the blue one, and why? Do the demonstration so they can see what happens. (The denser blue solution will sink underneath the red one.)

Draw a column on the board, similar to the one in the Density Student Activity Book. Show the students how to record each step they do in the experiment. Start with the first liquid added to the straw – write the first letter of its color in the space provided (Y = yellow, R = red, B = blue, G = green). Repeat with the other liquids in the order they are added.

Discussion Questions:

Why do you think we are able to layer the liquids? *The 4 liquids must have different densities.* What do you think the four liquids could be?

After students have successfully layered the 4 liquids, tell them that the liquids consisted of plain water and salt solutions. How much salt would we have to add to the water to get the layered results? *Students should say different amounts of salt in each liquid would account for the result.*

What can we say about the 4 liquids in terms of density?

Could we determine the density of each colored liquid? How?

As an extension activity – the class can mix together their own salt solutions and calculate their densities.

Learning Experience 8: Using the Property of Density to Measure Mass

Objective: Students will demonstrate an understanding of how the density of fresh water can be used to measure the mass of objects.

Materials:

For each group of three students:

Double pan balance
Plastic jar of gram centimeter cubes
2 medicine cups
Paper towels*
Water*

*provided by teacher

Preparation:

Read background information on page 6.

Basic Skills Development:

Gathering Data
Interpreting Data
Discussing
Measuring

Evaluation Strategy:

Students will accurately find the mass of various objects using water and a double pan balance and explain why water can be used to find mass.

Vocabulary:

mass
balance
compare
contrast

How might we use fresh water to measure the mass of objects?

The purpose of this learning experience is to apply a principle of density. The density of fresh water, at room temperature, is very close to 1g/cc. The effect of this characteristic is that the volume measurement of fresh water very nearly equals the mass. In other words, 20 cc of water nearly equals 20 grams. In this learning experience, a double pan balance with a medicine cup in each basket should be used. The mass of an object can be found by placing a volume of water in one medicine cup that balances the mass of the object in the other basket. Place additional water in the medicine cup until the double pan balance is level. If the object has more mass than one medicine cup of water, place additional medicine cups in each basket for an equal amount. Add the volume of water in the medicine cups and convert the total to grams. This principle could also be used with other liquids. The procedure for doing that would require the volume to be multiplied by the number that represents the density of the liquid.

Direct the student to select five small objects that might have a mass of less than 150 grams. Direct the student to measure the mass of each object using water.

Learning Experience 8 continued

Page 2

Students can then use the gram cubes to find the mass of the objects and see how close they came by using water to find the mass.

Discussion Questions:

How might we measure objects with larger masses using the method described above?

What might we have to do if we used alcohol to measure the mass?

What might we have to do if we used salt water to measure the mass?

Grade 4 Assessment

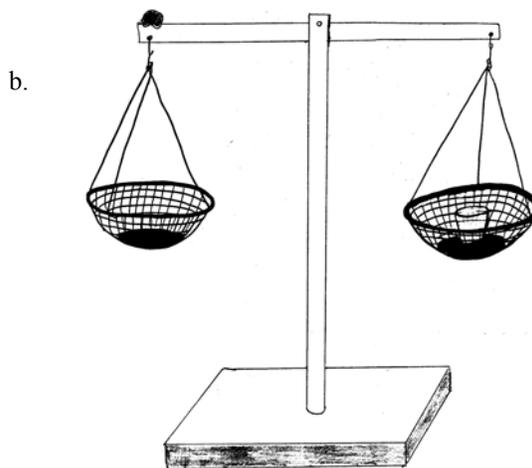
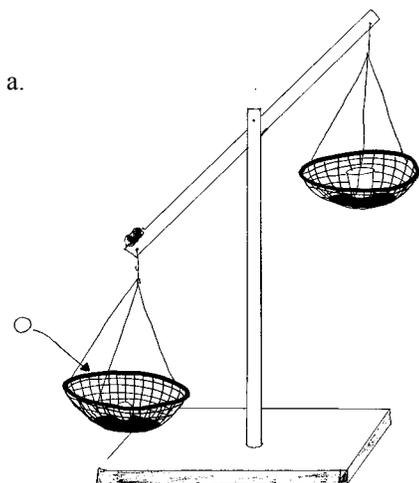
Name: _____
Grade 4 Density Student Assessment

Date: _____

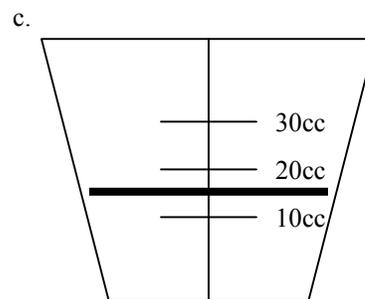
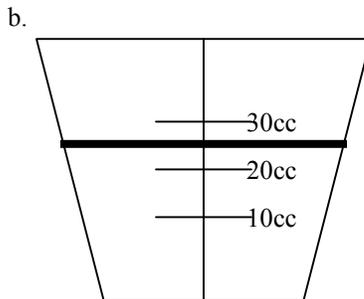
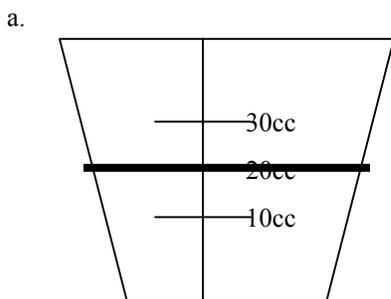
Density

Directions: Read the question carefully and answer based on your knowledge about density.

1. A student was asked to “calibrate” a double pan balance. Which picture accurately shows a calibrated balance?



2. A student was asked to measure 25 cc of liquid using a medicine cup. Which picture accurately shows 25 cc of liquid?



3. A student measured the mass of three same-sized balls: glass, black rubber ball, and a super ball. The following data table was recorded.

<u>Type of Ball</u>	<u>Mass (g)</u>
super ball	9
glass ball	18
black ball	10

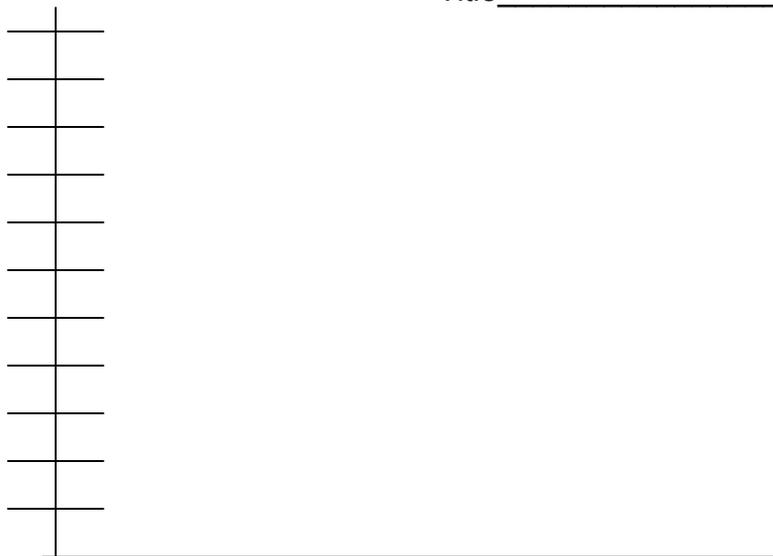
Why do you think the student obtained a different measurement for each ball?

4. A student measured the mass of five different types of liquids and recorded the data.

<u>Type of Liquid</u>	<u>Mass (g)</u>
Water	19
salt water	22
rubbing alcohol	15
blue solution	8
green solution	18

Construct a bar graph displaying the results.

Title _____



5. If you were to put all of the five liquids into a container, which one would raise to the surface? Which would be next? List them in order of placement on the chart.

6. Using eight centimeter cubes, construct two different designs. Carefully outline your design with a pencil, then complete questions 6 A-D.

DESIGN #1

DESIGN #2

6A. What is the volume of Design #1 ? _____ cc

6B. What is the volume of Design #2 ? _____ cc

6C. Based on your observations, what can you conclude about volume?

6D. What is volume? _____

7.) A student wanted to figure out the volume of a large marble. She measured out 20 cc of water in a medicine cup and then placed the enormous marble in the water. The results are shown.

Initial volume: 20 cc **Final volume:** 37 cc

What is the volume of the marble? _____ cc

How do you know that? Explain. _____

Vocabulary

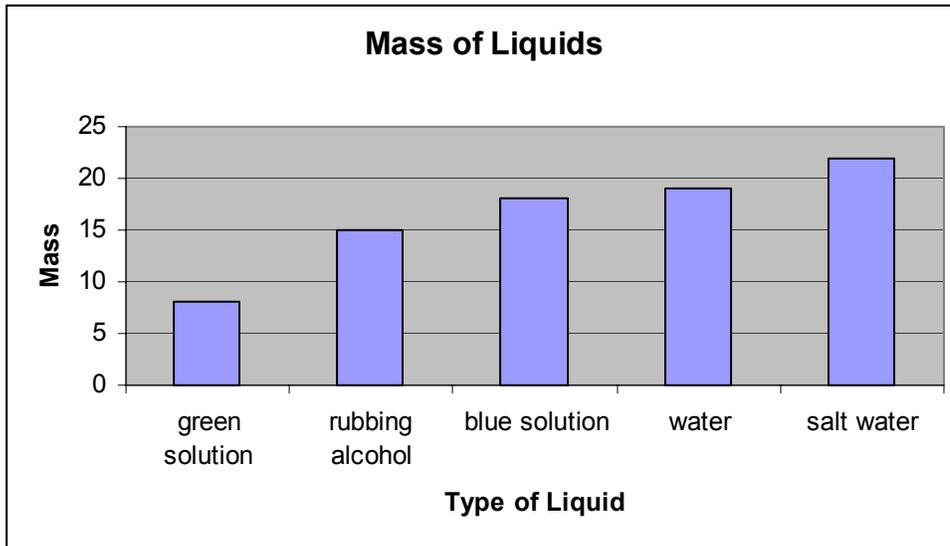
Directions: Match the definition (letter) to the correct term (word).

- 1.) _____ Balance 2.) _____ Calibrate 3.) _____ Density
4.) _____ Displacement 5.) _____ Float 6.) _____ Mass
7.) _____ Serial order 8.) _____ Volume 9.) _____ Weight

- A.) to balance a scale or double pan balance
B.) the ratio of mass of an object to its volume/measure of “compactness” of a material
C.) objects that are less dense than water and overcome the force of gravity
D.) the amount of matter in an object
E.) an amount of space occupied by an object
F.) the measure of gravitational pull on an object
G.) an instrument for determining mass
H.) the amount of liquid pushed aside in a container by an object
I.) arranged “data” in some type of order

Density Student Assessment Key – Grade 4

- a. the balance should be level
- b. the drawing with the line up to the 25 cc mark
- each ball had a different density
-



- top: blue solution
rubbing alcohol
green solution
water
salt water
- answers will vary
- 17cc
Because of Displacement, the amount of liquid pushed aside in a container by an object

Vocabulary Answer Key – Grade 4

- G
- A
- B
- H
- C
- D
- I
- E
- F

Grade 6 Assessment

Name: _____

Date: _____

Grade 6 Density Student Assessment

Directions: Read the question carefully and answer based on your knowledge about density.

1.) A student was asked to “calibrate” a double pan balance. Draw a picture to accurately show a calibrated balance.

2.) A student was asked to measure 25 cc of liquid using a medicine cup. Draw a picture that shows the proper measurement of 25 cc of liquid.

3.) A student measured the mass of three same-sized balls: glass, black rubber ball, and a super ball. The following data table was recorded.

<u>Type of Ball</u>	<u>Mass (g)</u>
super ball	9
glass ball	18
black ball	10

Why do you think the student obtained a different measurement for each ball?

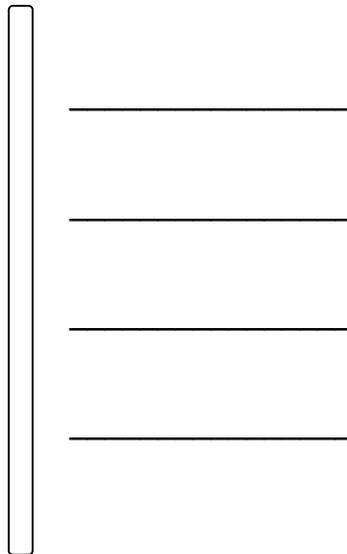
4.) A student layered 4 colored liquids into a plastic straw on a clay base. The 4 liquids contained varying amounts of salt.

	Mass (g)	Volume (cc)	Density (g/cm ³)
Plain water – blue	20	20	_____
Red water	23	20	_____
Green water	22	20	_____
Yellow water	21	20	_____

First, use a calculator and calculate the densities of all 4 liquids above. Remember

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

5.) If you were to layer all 4 of the liquids above into a straw from most dense to least dense, what order would the colors be in?



6.) A student wanted to figure out the volume of a ball of clay. She measured out 20cc of water in a medicine cup and then placed the clay in the water. The results are shown.

Initial volume: 20 cc **Final volume:** 30 cc

6A.) What is the volume of the clay ball? _____ cc

6B.) Show your work and explain why this is the volume of the clayball. _____

6C.) If you cut a 25g clay ball in half, what would you expect the mass, volume and density to be?

Mass of 1/2 of clay ball - _____ g

Volume of 1/2 of clay ball - _____ cc

Density of 1/2 of clay ball - _____ g/cm³

7.) **Vocabulary**

Directions: Match the definition (letter) to the correct term (word).

- | | | |
|------------------------|---------------------|-------------------|
| 1.) _____ Balance | 2.) _____ Calibrate | 3.) _____ Density |
| 4.) _____ Displacement | 5.) _____ Float | 6.) _____ Mass |
| 7.) _____ Serial order | 8.) _____ Volume | 9.) _____ Weight |

- A.) to balance a scale or double pan balance
- B.) the ratio of mass of an object to its volume/measure of “compactness” of A material
- C.) objects that are less dense than water and overcome the force of gravity
- D.) the amount of matter in an object
- E.) an amount of space occupied by an object
- F.) the measure of gravitational pull on an object
- G.) an instrument for determining mass
- H.) the amount of liquid pushed aside in a container by an object
- I.) arranged “data” in some type of order

8.) If the density of plain water is 1 g/cm³, write whether the following objects would sink or float in it:

		<u>Density</u>
_____	Copper Penny	= 8.9 g/cm ³
_____	Block of Wood	= 0.68 g/cm ³
_____	Vegetable Oil	= 0.93 g/cm ³
_____	Piece of Coal	= 1.20 g/cm ³

Density Student Assessment Key – Grade 6

1. the balance should be level
2. the drawing should show liquid up to the 25 cc mark – should be labeled
3. each ball had a different density
4. plain water - blue = 1 g/cm^3
red water = 1.15 g/cm^3
green water = 1.1 g/cm^3
yellow water = 1.05 g/cm^3
5. Red, Green, Yellow, Blue
6. A. 10cc
B. Displacement, the amount of liquid pushed aside in a container by an object
 $30\text{cc}-20\text{cc}= 10\text{cc}$
C. Mass = 12.5 g
Volume = 5 cc
Density = 2.5 g/cm^3
7. 1. G
2. A
3. B
4. H
5. C
6. D
7. I
8. E
9. F
8. Cooper Penny = Sink
Block of Wood = Float
Vegetable Oil = Float
Piece of Coal = Sink

MORE IDEAS

Language Arts

- ◆ Have students investigate (on the internet or in the library) the concept of density and report it to the rest of the class.
- ◆ Give a presentation describing the effect of the density of hot air in a hot air balloon.
- ◆ Research how density is used to identify elements or materials.
- ◆ Research what might effect the density of the same material.

Book Suggestions: Making Things Float & Sink by Gary Gibson
 Sink or Float by Lisa Trumbarer
 Float or Sink by Maria Gordon

Art

- ◆ Have students draw pictures of as many items they can think of objects that float on water and have them discuss why those objects float.

Social Studies

- ◆ Research the history of measurement of density, mass, volume.
- ◆ Research the history of the metric system.

Math

- ◆ Measure the mass of various objects using the double pan balance.
- ◆ Measure the volume of various objects through use of tools and formulas.

Science

- ◆ Formulate different percent solutions of salt water and determine their densities.
- ◆ Formulate different mixtures of percent alcohol and determine their densities.
- ◆ Formulate a salt mixture mixed with an alcohol mixture and determine their densities.
- ◆ Compare the densities of different objects with very similar volumes and predict the masses of each object.

Health

- ◆ Research the human body's ability to float in salt water and describe why this occurs.

INQUIRY AND PROCESS SKILLS

Classifying	Arranging or distributing objects, events, or information in classes according to some method or system.
Communication	Giving oral and written explanations or graphic representations of observations.
Creating Models	Displaying information by means of graphic illustrations or other multi-sensory representations.
Formulating Hypothesis	Constructing a proposition or assumption of what is thought likely to be true based on reasoning, which serves as a tentative testable theory.
Gathering & Organizing	Collecting information about objects and events which show a specific situation.
Generalizing	Drawing general conclusions from information.
Identifying Variables	Recognizing the characteristics of objects or events which are constant or change under different conditions.
Inferring	Making a statement or conclusion based on reasoning or prior experience to explain an observation.
Interpreting Data	Analyzing information that has been collected and organized by describing apparent patterns or relationships in the information.
Making Decisions	Choosing an alternative from among several and basing the judgment on defensible reasons.
Manipulating Materials	Handling or treating materials, equipment or procedures skillfully and effectively.
Measuring	Making quantitative observations by comparing to a standard.
Observing	Becoming aware of an object or even by using any of the senses to identify properties.
Predicting	Making a forecast or estimate of what future events or conditions may occur.

GLOSSARY

Balance:	an instrument for determining mass by the equilibrium weights suspended from opposite ends of a horizontal bar.
Calibrate:	to divide with graduations of measurement.
Compare:	to examine for similarities and differences.
Contrast:	to compare to show differences.
Cubic centimeters:	a unit of linear measurement (centimeters) that is multiplied by itself twice to form a unit of measure for volume.
Density:	the ratio of mass of an object to its volume ($D=M/V$)
Displacement:	an object pushes aside (displaces) amount of liquid in a container by taking up the space the liquid once held.
Fair Test:	to conduct a scientific test where there are specific items that remain constant.
Float:	objects that are less dense than water that overcome the force of gravity.
Formula:	a rule expressed in algebraic symbols.
Level:	a horizontal position or condition.
Mass:	the amount of matter in an object (grams).
Plasticine:	a claylike substance.
Serial order:	arranged in a series of detailed plan for reaching a goal.
Volume:	an amount of space occupied by an object (cm^3).
Weight:	the measure of gravitational pull on an object.
Zeroing:	to aim at the exact center.

TEACHER REFERENCES

Elementary Science Support Center at <http://essc.calumet.purdue.edu/>
Elementary Science Resources at http://www.k12.ut.us/utahlink/lp_res/TRB026.html
Science Mini Lessons at <http://yn.la.ca.us/cec/cecsci/sci-elem.html>

Media Library

Call the media library to order media materials and to check on new materials that are available. The number to be reached is (716) 376-8212.

Web Sites

<http://www.oms.edu/visit/physics/air>
<http://www.nyu.edu/pages/mathmol/textbook/density.html>
<http://www.elmhurst.edu/~chm/vchembook/120Adensity.html>
<http://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=17>

Major Science Concepts To Be Addressed

Objects and events have distinctive properties.

The properties of an object are determined by its material and its condition.

A kind of material may be divided into smaller parts or changed in shape without changing the properties of the materials.

For example: Molding clay

Energy and materials have forms and properties.

For example: The shape of the object
 The position of the object
 The weight of the object
 The type of material in the object

Objects have properties determined by the forms, amounts, and properties of the materials of which they are made.

Properties of a material can be affected by the shape of the material.

For example: Buoyancy of aluminum foil shaped like a boat
 Structural strength – flexibility of aluminum foil pleated.