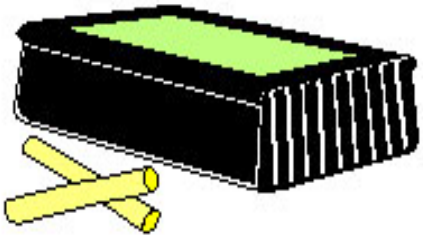
Teacher Information
Lesson Title: Density labs



Lesson Description: These labs are hands on exercises that will allow the students to measure and calculate the densities of different types of objects. The procedure for calculating willow densities will be taught and the students will practice making their own calculations. The importance of density as a concept will also be discussed and how this applies to willow biomass.

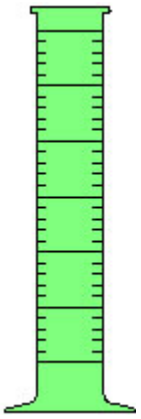
Learning Outcomes:
The students will be able to:
- Make accurate measurements in length, mass, and volume to the nearest tenth of a unit
- Calculate the density of a regular and irregular shaped object
- Calculate the dry density of two different clones of willow twigs
- Calculate the density of another type of tree twig
- Explain the importance of density and how it relates to Willow as a biomass fuel source

Materials:
*Lab worksheets
*Graduated cylinder
*Metric ruler
*2 to 3 regular shaped object
*2 irregular shaped objects
*Medium beaker filled with water
*Sink or a basin
*Paper towels
*Several triple beam balances for the class
*Oven dried willow stems
*aluminum bar, and aluminum cube (or two objects made of the same material but different sizes)

Method: Follow the directions provided on the lab sheets
Time Requirements:
45 minutes per lab (3 different labs provided)
MST standards: See the overview chart
Assessment: Every student will complete the three labs for the instructor's analysis. This would be a good skill to put in a practice lab practical as well.

Teacher Information
Density of trees or woody materials:

Density is a ratio of the mass to volume of a quantity of substance. It is expressed in terms of a mass per unit of volume. Since wood swells or shrinks, depending on how much water is absorbed in the structure, density for wood can be determined in several ways. The manner in which the density is determined should be recorded next to the units. The following definitions are given by the TAPPI TEST Methods 1991.



As-Received density: Simply determine the mass and volume of the material as received

Green density: Take the maximum swollen weight and divide it by the maximum swollen volume (Presoak the wood before measuring either the mass or volume)

Basic Density: Oven dried weight divided by the swollen maximum volume

Oven-dry density: Determine both the mass and volume from the oven-dried matter

Bulk density: Take the mass and the volume of the material at specified temperature and moisture content conditions

Swollen: Refers to the woody material being submerged in water for at least an hour and usually overnight.

Oven Dried: The stems or green wood are placed in an oven at 105 degrees Celsius until the mass is constant.

Note: 1 cm^3 of water is equivalent to 1gram of water. When the wood disk or stem is submerged a certain amount of water is displaced. The amount of water displaced is recorded in grams by the triple beam balance. The conversion to volume is easily completed because 1 cm^3 of displaced water is equivalent to 1 gram mass. The set up measures the mass of water displacement and not the mass of the wooden dowel submerged.

What value is there in knowing the density of wood?

The density of wood help determine the amount of energy a certain volume of wood will provide. The denser the willow clone the less volume of wood needed to provide a certain amount of energy. The lower the bulk need, the lower the cost for storage or transport etc. This information can help guide the process in selecting willow clones that are denser and have higher energy yields per volume of material used.

The chart below provides density values for several species of wood. You can check your student's results from lab 3 with these values. For an extended lab activity give each student team a copy of the chart below and have them calculate their percent error using their results.

Willow Biomass Energy Value

Species	Density (g/cm^3)	Heat Value (GJ/Ton)	Yield (Tons/ha/yr)
Willow	0.379	16.1	11.3 – 16.8
Red Maple	0.549	16.1	1.1 – 2.3
Sugar Maple	0.626	16.1	1.1 – 2.3
Beech	0.626	16.5	1.1 – 2.3

(Volk 1996)

Name _____ Date _____
Period _____

Lab 1: Density Lab

 **= Regular shaped object**

 **= Irregular shaped object**

1a) Problem/Question a: How is the density of a regular shaped object determined?

_____

_____

b) Problem/Question b: How is the density of an irregular shaped object determined?

_____

_____

Listed below are the skills you will need to use during this lab. If you are unsure of any of them ask your instructor for assistance before completing the activity.

_____ a) How to use a balance
_____ b) How to read a graduated cylinder
_____ c) Where to find the density formula
_____ d) How to use the density formula mathematically
_____ e) How to write up a lab report

2) Procedure/Information collection

Procedure for determining the density of a regular shaped object:

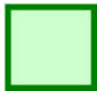
1) Select the regular shaped object
2) Using a triple beam balance, record the mass of the object to the nearest tenth of a gram. (Be sure to do this with a dry object)
3) Using a metric ruler, measure the length, width, and height of the object
4) Write down the formula for calculating the density of the object (refer to the Earth Science Reference tables)
5) Substitute the values you measured into the formula and calculate the density

6) Calculate the density using the density formula. Record the answer as cm^3.

Procedure for determining the density of an irregular shaped object:

1) Select the irregular shaped object
2) Using a triple beam balance record the mass of the object to the nearest tenth of a gram. (Be sure to do this with a dry object)
3) Place water into the graduated cylinder and record the level
4) Without splashing any water, place the irregular shaped object into the graduated cylinder so that it is completely submerged in the water.
5) Record the new water level

6) Subtract the smaller value from the larger and this will be the volume of the object. Record the units as ml.
7) Calculate the density using the density formula.



3a) Data collection/Calculations:
Part a) the regular shaped object
Record measurement of Length = _____ (list all units)

Record measurement of width = _____

Record measurement of length = _____

Calculation for the volume = Formula used = _____

Volume of the regular shaped object = _____

The mass of the object = _____

The formula for density = _____

The density of the regular shaped object is _____

The units for the density of a regular shaped object are _____

b) Data collection/Calculations:
Part b) the irregular shaped object
The volume of water before the object is immersed = _____

The volume of the water after the object is immersed = _____

The difference or displacement of the water = _____

The volume of the irregular shaped object = _____

The mass of the object = _____

The formula for Density = _____

The density of the regular shaped object is _____

The units for the density of a regular shaped object are _____

4) Conclusions/Decisions:

Name _____ Date _____
Period _____

Lab 2: Density Lab

1) Problem/Question: One object is twice the size of the other object but both are made from the same material. How would their densities compare?

Before starting this lab the skills you will need to know are:
_____ a) How to use a balance
_____ b) How to read a graduated cylinder
_____ c) Where to find the density formula
_____ d) How to use the density formula mathematically
_____ e) How to write up a lab report

2) Write a hypothesis based on the problem listed above.

_____

_____

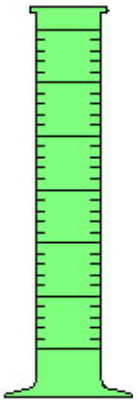
_____

3) Procedure/Information collection:
a) Select one of the two objects and calculate its density using the method from lab density # 1 for a regular shaped object.

b) Select the second object and calculate its density using the procedure from lab density #1 for a regular shaped object.

4) Observations/Data collection/Calculations: Show Calculations and all units

Object 1: Mass of the object = _____



Length of the object = _____

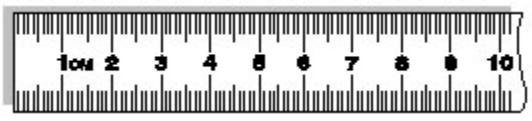
Width of the object = _____

Height of the object = _____

Volume of the object = _____

Formula for density = _____

Density of object 1 = _____



Object 2: Mass of the object = _____

Length of the object = _____

Width of the object = _____

Height of the object = _____

Volume of the object = _____

Formula for density = _____

Density of object 2 = _____

5) Conclusions/ Decisions: Was your hypothesis correct? Explain.

_____

_____

_____

_____

_____

DENSITY LAB # 3

Name _____
Date:
Partner(s) _____

Problem: Determine the density of a portion of a willow stem.

Hypothesis: _____

_____

Procedure: The procedure will be similar to the process for calculating the density of an irregular shaped object. There are different types of densities that can be calculated for trees. For additional information of the types ask the instructor for the "detailed willow density sheet". During this activity you will be calculating the "Basic Density" for the willow stem.

This is completed by taking the mass of the willow twig after it has been oven dried. The stems provided in your kit will be oven-dried stems. Please seal the bag carefully after removing the stems so that it is as air tight as possible. To get the accurate mass reading simply take a stem and using the triple beam balance determine the mass to the nearest tenth of a gram. Record the dry mass.

Once the dried mass of the twig is determined and recorded, soak the stem in water overnight. Be sure that the stem is submerged and will remain completely submerged.

To complete the volume measurement, take the stem from the water remove all the excess water with a paper towel. Prepare a graduated cylinder with water so that when the stem is place into the cylinder it will be covered by water. Record the amount of water displacement (same as lab #1).

Calculate density

Data Collection:

The mass of the oven dried stem = _____
(Leave bark on the stem)

The volume of water in the graduated cylinder before submerging the stem

_____

The volume of water in the graduated cylinder after submerging the stem

_____

Volume of the stem: _____

Density formula = _____

Density of the willow stem = _____

Optional area: Calculate the density of another type of stem: cherry, oak, another type of willow, maple etc. Compare the outcome