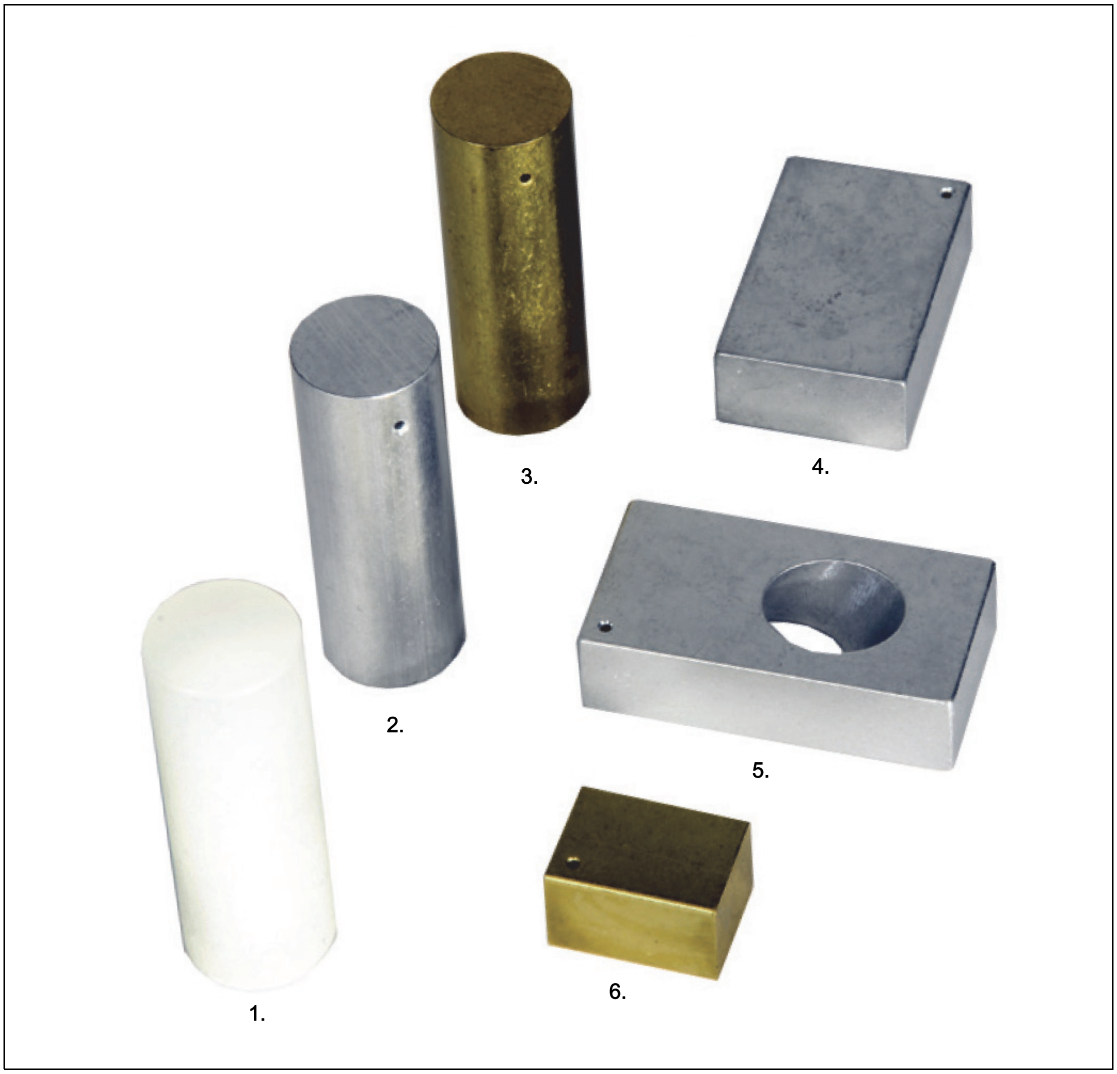
Density Set

ME-8569A



Introduction

The PASCO Model ME-8569 Density Set allows useful experiments in density, buoyancy force, and specific heat as well as providing an effective means of distinguishing between length, volume, and area.

Equipment

The density set consists of six objects:

1. polypropylene cylinder
2. aluminum cylinder
3. brass cylinder
4. aluminum block
5. aluminum irregular shape
6. brass block

Each object has a small hole through which a string can be tied to suspend the object. The objects in this set can be categorized in three different ways: those objects having the same volume, same mass, or same density.

Same Volume

- aluminum cylinder
- aluminum block
- brass cylinder
- polypropylene cylinder
- aluminum irregular shape

Same Mass

- aluminum cylinder
- aluminum block
- brass block
- aluminum irregular shape

Same Density

- aluminum cylinder
- aluminum block
- aluminum irregular shape

Same Density

- brass cylinder
- brass block

Experiments

1. Length, Area, and Volume
2. Density
3. Buoyancy Force
4. Specific Heat

Other Equipment for the Experiments

Calipers*	String*
Overflow Can*	Beaker*
Graduated Cylinder*	Mass Balance^
Styrofoam Cup	Bunsen Burner
Thermometer*	Heating Stand

**See the PASCO catalog or web site at www.pasco.com for more information about equipment.*

Technical Support

Replacements

Contact PASCO Technical Support about possible replacement parts for this product.

For assistance with any PASCO product, contact PASCO at:

Address: PASCO scientific
10101 Foothills Blvd.
Roseville, CA 95747-7100

Phone: 916-786-3800 (worldwide)
800-772-8700 (U.S.)

Web: www.pasco.com

Email: support@pasco.com

Experiment 1: Length, Area, and Volume

Equipment Needed	
Density Set	Calipers
String	Overflow Can
Beaker	Graduated Cylinder, 50 mL

See the PASCO catalog or web site at www.pasco.com for more information about equipment.

Purpose

The purpose of this experiment is to distinguish between length, area, and volume.

Procedure

I. Length

Using the calipers, measure the longest side of each of the five regularly-shaped objects. Record the results in Table 1.1.

II. Area

A. Using the calipers, measure the diameter of each of the three cylinders. Divide the diameter by two to get the radius, r.

Calculate the area of the circular end of the cylinders using:

$$A = \pi r^2.$$

Record the results in Table 1.1.

B. Using the calipers, measure the width and height of one end of each of the blocks. Calculate the area of the end of the block by multiplying the width by the height. Record the results in Table 1.1.

III. Volume

A. By Calculation

For each of the regularly-shaped objects, calculate the volume by multiplying the area of one end by the length of the object. Record in Table 1.1.

B. By Displacement of Water

For each of the regularly-shaped objects, find the volume by finding the volume of water that each one displaces:

1. Put the beaker under the overflow can spout as shown in Figure 1.

2. Pour water into the overflow can until it overflows into the beaker. Allow the water to stop overflowing on its own and empty the beaker into the sink and return it to its position under the overflow can spout without jarring the overflow can.

3. Tie a string to each of the objects (including the irregularly-shaped object).

4. Gently lower the first object into the overflow can until it is completely submerged. Allow the water to stop overflowing and then pour the water from the beaker into the graduated cylinder.

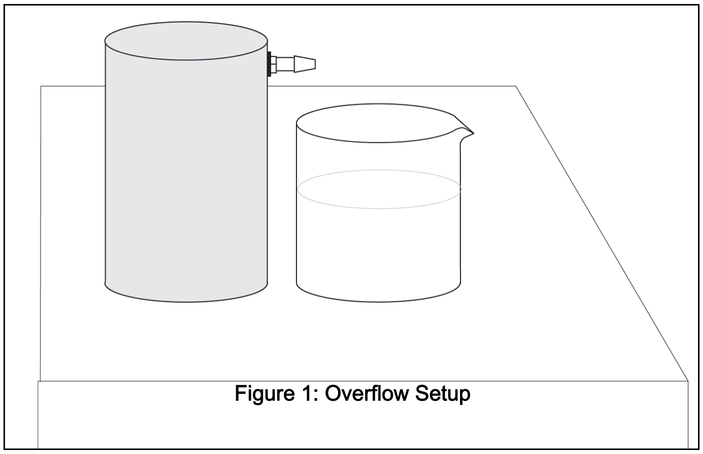


Figure 1: Overflow Setup

5. Measure the volume of water that was displaced by reading the water level in the graduated cylinder in milliliters (1 ml = 1 cm^3). Record this volume in Table 1.1.

6. Repeat this procedure for the other objects. Note that the plastic object will float in water so it cannot be used in this part of the experiment.

Analysis

For each of the regular objects, calculate the percent difference between the two values found for the volume.

Questions

1. Which objects have nearly the same volume?

2. Which objects have nearly the same length?

3. Which objects have nearly the same cross-sectional area?

4. Did any two objects have the same volume but did not have the same length or the same area?

Table 1.1: Length, Area, and Volume

Object	Length	Area	Volume	Displaced Volume	% Diff.
Aluminum cylinder					
Aluminum block					
Brass cylinder					
Plastic cylinder					
Aluminum irregular shape					
Brass block					

Experiment 2: Density

Equipment Needed	
Density Set: Brass Cylinder	Calipers
Density Set: Brass Block	Mass Balance
String	Overflow Can
Graduated Cylinder, 50 mL	Beaker

See the PASCO catalog or web site at www.pasco.com for more information about equipment.

Purpose

This experiment finds the densities of different-shaped objects made of the same material.

Procedure

Using the mass balance, find the mass of the brass cylinder and the brass block. Record the results in Table 2.1.

I. Calculated Volume

A. Cylinder

Using the calipers, measure the length, L, of the brass cylinder. Record the results in Table 2.1. Measure the diameter of the cylinder. Divide the diameter by two to get the radius, r. Calculate the volume of the cylinder using:

$$V = \pi r^2 L.$$

Record the results in Table 2.1.

B. Block

Using the calipers, measure the length (L), width (W), and height (H) of the brass block. Calculate the volume of the block using:

$$V = L \times W \times H$$

Record the results in Table 2.1.

II. Displaced Volume

For each of the two brass objects, find the volume by finding the volume of water that each one displaces:

1. Put the beaker under the overflow can spout as shown in Figure 1 (from Experiment 1).
2. Pour water into the overflow can until it overflows into the beaker. Allow the water to stop overflowing on its own and empty the beaker into the sink and return it to its position under the overflow can spout without jarring the overflow can.
3. Tie a string to each of the objects.
4. Gently lower the first object into the overflow can until it is completely submerged. Allow the water to stop overflowing and then pour the water from the beaker into the graduated cylinder.
5. Measure the volume of water that was displaced by reading the water level in the graduated cylinder in milliliters (1 ml = 1 cm^3). Record this volume in Table 2.1.
6. Repeat this procedure for the other object.

Analysis

For each method of finding the volume, calculate the density, d, of each object using:

$$d = \frac{\text{mass}}{\text{volume}}$$

Obtain the accepted value for the density of brass from your instructor or from a reference book.

For each experimental value of the density, calculate the percent difference from the accepted value and record the results in Table 2.2.

Questions

1. Which object took up more space?
2. Which object weighed more?
3. Which object was more dense?

Table 2.1: Measurement

Object	Mass	Dimensions	Volume	Displaced Volume
Cylinder				
Block				

Table 2.2: Results

Object	Calculated Density	Density by Displacement	% Difference from Accepted
Cylinder			
Block			

Experiment 3: Buoyant Force

Equipment Needed	
Density Set	Triple-beam Balance
String	Overflow Can
Graduated Cylinder, 50 mL	Beaker

See the PASCO catalog or web site at www.pasco.com for more information about equipment.

Purpose

This experiment measures the buoyant force on an object in water by using Archimedes' Principle and by finding the upward force on the object while it is submerged.

Procedure

I. Archimedes' Principle

Archimedes' Principle states that the buoyant force exerted on an object partially or fully submerged in a fluid will be equal to the weight of the fluid displaced by the object. To use this principle to find the buoyant force exerted on each object, follow these steps:

1. Find the mass of the empty beaker in kilograms and record this at the top of Table 3.1. Put the beaker under the overflow can spout as shown in Figure 1.

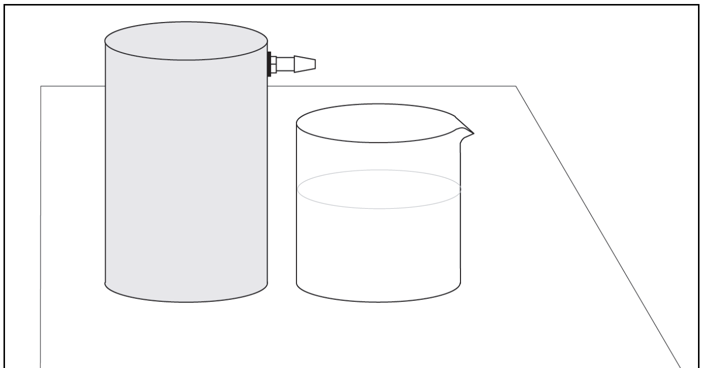


Figure 1: Overflow Setup

2. Pour water into the overflow can until it overflows into the beaker. Allow the water to stop overflowing on its own and empty the beaker into the sink and return it to its position under the overflow can spout without jarring the overflow can.

3. Tie a string to each of the objects.

4. Gently lower the first object into the overflow can until it is completely submerged. Allow the water to stop overflowing and then find the mass of the beaker with the water in it (in kilograms). Record this mass in Table 3.1.

5. Calculate the mass of the water by subtracting the mass of the beaker. Then calculate the weight of the displaced water by multiplying the mass in kilograms by the acceleration due to gravity (9.8 m/s^2). Record the result in Table 3.1 and Table 3.2.

6. Repeat this procedure for the other objects. Note that the plastic object will float in water but it can still be used in this part of the experiment. Also, repeat the procedure for the brass cylinder with only half the cylinder submerged.

II. Upward Force

When an object is submerged in a fluid, the apparent weight of the object is less than the weight in air because of the buoyant force (See Figure 2).

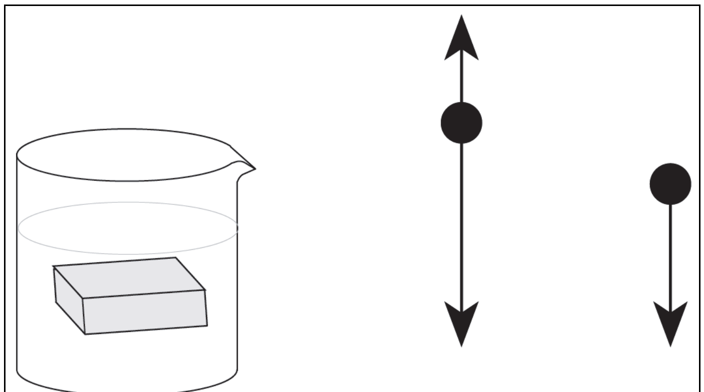


Figure 2: Free Body Diagram

Thus the buoyant force can be calculated by finding the difference between the weight of the object in air and the apparent weight of the object when it is submerged in water.

Table 3.1: Measurement

Object	Mass of Beaker + Water	Mass of Water	Weight of Displaced Water
Aluminum Cylinder			
Aluminum Block			
Brass Cylinder			
Brass Block			
Plastic Cylinder			
Irregular Shape			
Brass Cylinder 1/2 Submerged			

1. Put the triple-beam balance on top of a stand as shown in Figure 3. Tie a string to the bottom of the pan.

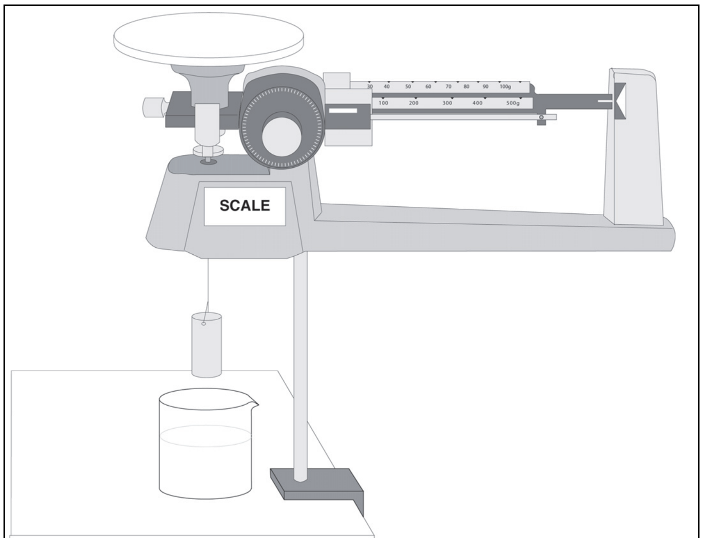


Figure 3: Scale Setup

2. Hang the first object from the string. The balance will read the same as when the object is placed on top of the pan. Multiply the mass by the acceleration due to gravity (9.8 m/s^2) and record the object's weight in Table 3.2.

3. While the object is still hanging from the balance, submerge the object in a beaker of water so that the entire object is under water but it is not touching the sides or bottom of the beaker. Record the reading on the scale and multiply by gravity to get the apparent weight. Record in Table 3.2.

4. Calculate the buoyant force by taking the difference between the weight in air and the weight in water. Record in Table 3.2.

5. Repeat these steps for all the objects. Note that the plastic cylinder will float so don't try to completely submerge it in the water. Also, for the half-submerged brass cylinder, find the apparent weight in the water when only half the cylinder is submerged.

Table 3.2: Measurements

Object	Weight in Air	Weight in Water	Buoyant Force (W_{air} - W_{water})	Weight of Displaced Water
Aluminum Cylinder				
Aluminum Block				
Brass Cylinder				
Brass Block				
Plastic Cylinder				
Irregular Shape				
Brass Cylinder 1/2 Submerged				

Questions

1. In each case, is the buoyant force found using the difference between weights equal to the weight of the water displaced?
2. Which objects had the same buoyant force when submerged? Why?
3. For the plastic cylinder, what was the weight in water?
4. How was the buoyant force for the totally submerged brass cylinder related to the buoyant force for the half-submerged brass cylinder?

NOTES

Experiment 4: Specific Heat

Equipment Needed	
Density Set: Aluminum Cylinder and Block	Density Set: Brass Cylinder and Block
String	Overflow Can
Graduated Cylinder, 50 mL	Beaker
Styrofoam Cup	Cold Water
Triple-beam Balance	Bunsen Burner
Heating Stand	Thermometer

See the PASCO catalog or web site at www.pasco.com for more information about equipment.

Purpose

This experiment shows that the specific heat of a material depends on the type of material but not on the amount of material.

Procedure

The specific heat, c, of a material is defined to be the amount of heat needed to raise the temperature of one gram of the material one degree Celsius. To measure this heat, the method of mixtures will be used. The following procedure will be repeated for four objects (aluminum cylinder, aluminum block, brass cylinder, and brass block):

1. Heat a beaker of water to boiling. While the water continues to boil, hang the object by a string so that the object is completely submerged in the boiling water but it is not touching the bottom of the beaker. Allow the object to come to equilibrium with the boiling water (wait about 5 minutes). See Figure 4.1.

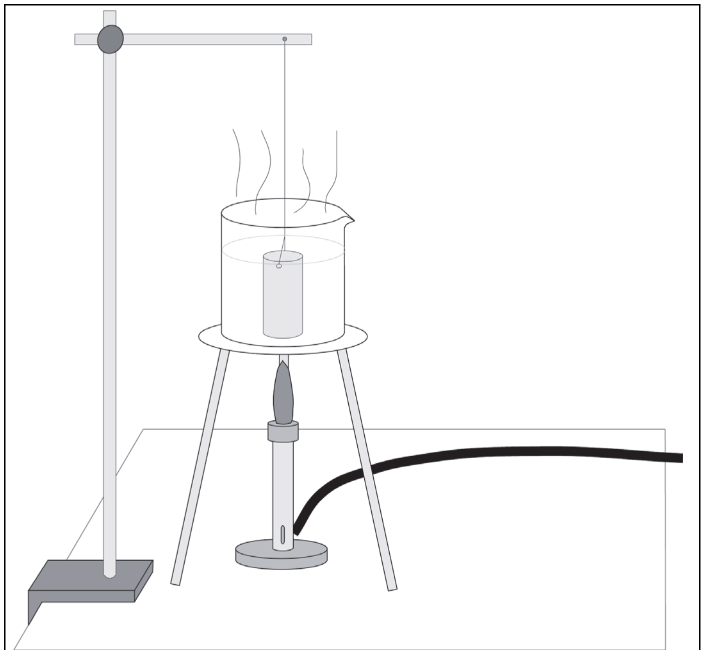


Figure 4.1: Heating Setup

2. While waiting, find the mass of a dry styrofoam cup and then prepare a styrofoam cup of cold water (about 3°C below room temperature) into which the heated object can be completely submerged. When the object has finished heating, record the temperature of the cold water to the nearest tenth of a degree, then record the temperature of the boiling water, and quickly transfer the heated object from the hot water to the cold water (See Figure 2). Record in Table 4.1.

3. Watch the temperature of the cold water rise, stirring the water gently. After several minutes, the temperature will peak out (above room temperature) and began to fall. Record this equilibrium (peak) temperature to the nearest tenth of a degree in Table 4.1.

4. After the equilibrium temperature has been reached remove the object from the water and weigh the water with the cup. Subtract the mass of the cup from the mass of the water with the cup and record the mass of the water in Table 4.1.

Table 4.1: Measurements

Object	Hot Temperature	Cold Temperature	Equilibrium Temperature	Mass of Water
Aluminum Cylinder				
Aluminum Block				
Brass Cylinder				
Brass Block				

5. Calculate the change in temperature for the object:

$$\Delta T = \text{HOT TEMP} - \text{EQUILIBRIUM TEMP}.$$

Record this in Table 4.2.

6. Calculate the change in temperature for the water in the styrofoam cup:

$$\Delta T = \text{EQUILIBRIUM TEMP} - \text{COLD TEMP}.$$

Record this in Table 4.2.

7. When the object is cooled in the water, the heat lost by the object is equal to the heat gained by the water because energy is conserved (neglecting any losses to the environment):

$$\Delta Q_{OBJECT} = \Delta Q_{WATER}$$

$$(mc\Delta T)_{OBJECT} = (mc\Delta T)_{WATER}$$

Solving for the specific heat of the object gives:

$$c = \frac{m_{WATER} c_{WATER} (\Delta T)_{WATER}}{m_{OBJECT} (\Delta T)_{OBJECT}}$$

where c_{WATER} is 1 cal/g °C. Calculate the specific heat for the object and record the results in Table 4.2.

8. Look up the accepted value for the specific heat for the material used and record in Table 4.2. Calculate the percent difference between the experimental value and the accepted value.

9. Repeat this procedure for the other objects.

Questions

1. Do the two aluminum objects have the same specific heat?

2. Do the two brass objects have the same specific heat?

3. How does starting the cold water below room temperature minimize the effect of the losses to the environment?

Table 4.2: Calculations

Object	Object ΔT	Water ΔT	Specific Heat	Accepted Value	% Difference
Aluminum Cylinder					
Aluminum Block					
Brass Cylinder					
Brass Block					