# ARCHIMEDES' PRINCIPLE

**Objective**

To determine the densities of irregularly shaped objects using Archimedes' Principle.

**Equipment:** 600 mL beaker, balance on a ring stand, string, a set of objects (1 known cube, and 2 unknown irregular), distilled water, 1 – known cube, 2 – unknown irregular cube.

**Procedure**

1. Measure and record the weight of the objects provided. Fill the beaker one-half to two-thirds full of distilled water. Place the balance on the ring stand (ask your instructor if you are confused). There is a small clip directly under the balance pan. Tie the string to this clip.

2. Suspend the cube from the string and measure the weight on the balance. Place the cube in the water so that it is totally submerged but not touching the side or bottom of the container. Balance the system and record this new weight.

3. Determine the density of the cube using the following formula:

$$\rho_{object} = \rho_{fluid} \frac{m_{air}}{m_{air} - m_{fluid}},$$

where the ρ's represent the densities of the object and fluid, $m_{air}$ is the weight of the object in air, and $m_{water}$ is the weight of the object in water.

4. Determine the density of the cube using the definition of mass density (weight/volume).

5. Repeat steps 2 and 3 for the irregular object. You must be careful that no air is trapped in any voids in the objects as this will affect the results.

**Error Analysis**

6. Compute the percent difference between the measured densities of the cube (one using Archimedes' Principle and one using the definition of density). Use this value as your uncertainty in the measured densities of the irregular objects. The formula for percent difference is given below.

$$\% \text{ difference} = \left| \frac{\rho_1 - \rho_2}{\frac{1}{2}(\rho_1 + \rho_2)} \right| \times 100\%$$

## Graphs and Diagrams

1. Make two free body diagrams showing all the forces acting on an object (a) when it is hanging from the string *not* in the water and (b) when it is hanging from the string and submerged in the water.

## Questions and Calculations

1. What is Archimedes' Principle? How is it related to the concept of hydrostatic pressure?

2. Identify the composition of the unknown objects based on their densities. If there are several possibilities (due to the percent uncertainty) state which possibility you feel is most likely and explain why you claim this.

3. If there was a bubble of air trapped in one of your objects, how would it affect the density measurements? Would the density go up, down or not change at all? Explain.

4. Suppose you are finding the weight of a beaker of water, and you have it on the balance and are ready to record the weight. Your partner dips the tip of his or her pen in the water but does not touch the beaker or the balance. Does the presence of the pen affect the reading on the balance? If so, how? If not, why not?

5. **211 Students** Based on your free body diagrams and the definition of density, derive the formula used to calculate the density of the irregular objects.