MND Physics

Archimedes' Principle

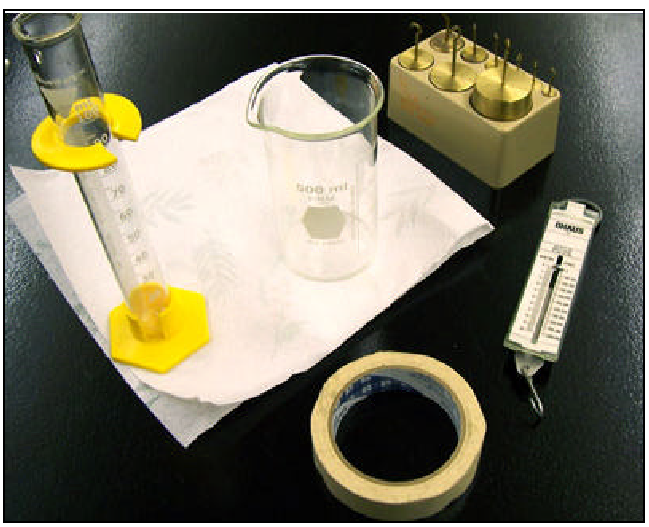
An upward buoyant force acts upon objects in fluids (liquids or gases). If the buoyant force is greater than or equal to the object's weight, the object will float. If the object's weight is greater than the buoyant force, the object will sink. Further, the weight of the displaced fluid is equal to the buoyant force: this is known as Archimedes' Principle.

$$F_{BUOYANT} = F_{WEIGHT\ OF\ OBJECT\ IN\ AIR} - F_{WEIGHT\ OF\ OBJECT\ IN\ FLUID}$$

$$F_{BUOYANT} = \rho_{FLUID}\, V_{FLUID}\ g$$

EQUIPMENT:

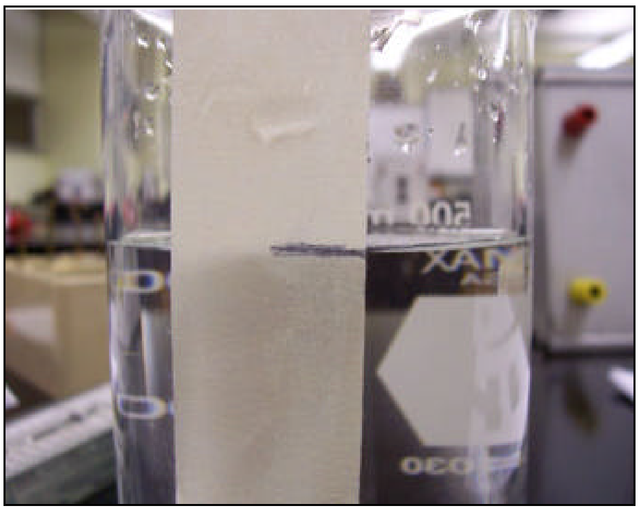
500 ml beaker, masking tape, fine point pen or pencil, cool tap-water, graduated cylinder, hanging spring scale, mass set, paper towels.



PROCEDURE: Trial 1- Buoyant force on a 500 g mass in water.

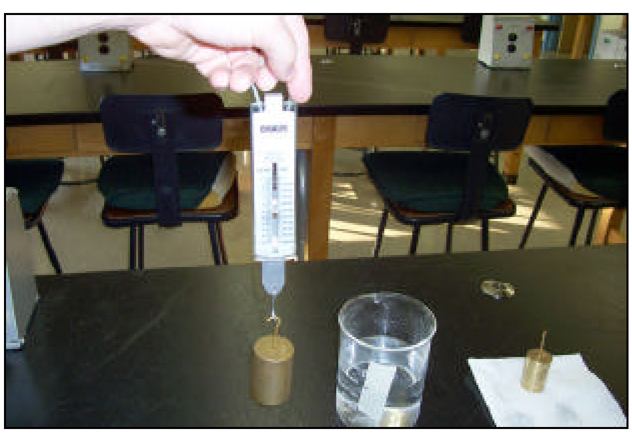
Preparing the beaker:

1. Place a piece of masking tape on a 500 ml beaker on the outside of the beaker wall as shown. Pour cool tap water into a 500 ml beaker somewhere between the 300 and 400 ml mark (the initial beaker volume is NOT critical… only the line on the masking tape is critical). With a fine point pencil or pen, carefully mark the top of the water line on the masking tape as shown.

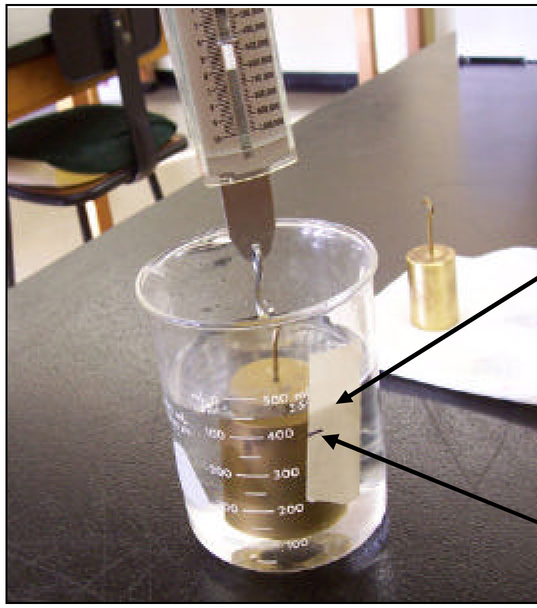


Weighing the mass in air and in water:

2. IMPORTANT: Zero the spring scale!
3. Hang a 500 g mass from the spring scale. Measure the weight of the mass in air. Record the value.



4. Fully immerse the mass in the water, suspended by the spring scale. Do not allow the mass to touch the sides or bottom of the beaker. Carefully place another mark at the top of the new water line. Measure the weight of the submerged mass and record the value.



5. Remove the mass and dry it off.

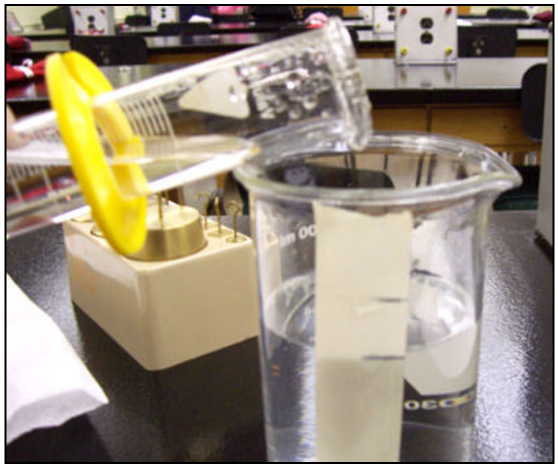
Measuring the volume of displaced water:

IMPORTANT: The volume markings in milliliters <u>on the beaker</u> are NOT SIGNIFICANT and are not accurate enough to use in this experiment. Displaced water volume can only be calculated using a graduated cylinder.

6. Replace any water in the 500 ml beaker that may have been carried off by the submerged mass and bring the water level exactly back up to the <u>initial mark</u> (the lower of the two marks).

7. Fill a <u>graduated cylinder</u> with tap water and record the initial water level in your data table.

8. Using the water in the graduated cylinder, carefully fill the 500 ml beaker to the second mark (the higher of the two marks).



9. Record the amount of water poured into the 500 ml beaker from the graduated cylinder: this represents the amount of water volume your mass displaced. Record the final level in your data table.

PROCEDURE: Trial 2 - Buoyant force on a 1000 g mass in water.

1. Remove the tape from the beaker. Thoroughly dry all equipment. Repeat the above 9-step procedure from trial 1 using a 1000 g mass.

DATA:

Trial 1	
Weight of 500 g mass in air (actual weight)	N
Weight of 500 g mass submerged (apparent weight)	N
Initial water level in the <u>graduated cylinder</u> (not the beaker)	ml
Final water level in the <u>graduated cylinder</u> (not the beaker)	ml
Volume of displaced water in ml's (initial level – final level)	ml
Volume of displaced water in m^3 (convert ml's to cubic meters)	m^3

Trial 2	
Weight of 1000 g mass in air (actual weight)	N
Weight of 1000 g mass submerged (apparent weight)	N
Initial water level in the <u>graduated cylinder</u> (not the beaker)	ml
Final water level in the <u>graduated cylinder</u> (not the beaker)	ml
Volume of displaced water in ml's (initial level – final level)	ml
Volume of displaced water in m^3 (convert ml's to cubic meters)	m^3

CALCULATE THE BUOYANT FORCE:

Method 1:

Calculate the buoyant force (for each trial separately) by subtracting the weight of the mass submersed in the water from the weight of the mass in air:

$F_{BUOYANT} = F_{WEIGHT\ OF\ OBJECT\ IN\ AIR} - F_{WEIGHT\ OF\ OBJECT\ IN\ FLUID}$

Method 2:

Calculate the buoyant force (for each trial separately) using the density of water (in kg/m^3), the volume of water displaced (in cubic meters), and gravity (in m/s^2):

$F_{BUOYANT} = \rho_{FLUID} V_{FLUID}\ g$

Error:

Calculate the percent error (for each trial separately) using method 1 as the accepted value and method 2 as the calculated value.

QUESTIONS:

1. What was the most limiting accuracy factor in this experiment (i.e. what thing or process caused the greatest amount of error)?

2. Since both masses in this experiment sink, is the buoyant force the same for both masses? Explain.

3. Tim and Sally are floating on a raft in a swimming pool. What happens to the water level in the entire pool if they both fall off the raft into the water?

4. Icebergs are huge floating masses of ice from glaciers or polar ice sheets. Only the tip is visible. If the density of the ice is 0.92 g/cm3 and the density of seawater is 1.03 g/cm3, what percentage of the iceberg will be above the water?