Course and Section_______ Names ____________________________

Date____________ ____________________________________

ARCHIMEDES' PRINCIPLE EXPERIMENT

Introduction

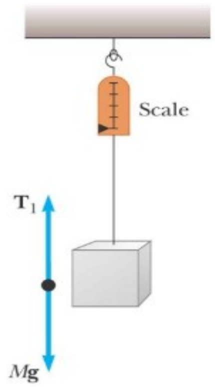
Archimedes' principle states that an object submerged in a fluid is buoyed by a force that is equal to the weight of the displaced fluid. In this lab, you will do two experiments involving Archimedes' principle.

Equipment: Vertical long rod, clamp, smart cart, irregular shape mass + string, plastic beaker, digital scale, plastic cup, water.

PART I – Force Sensor

Preliminary questions

Case (a). A metal object is suspended by a string from a spring scale.



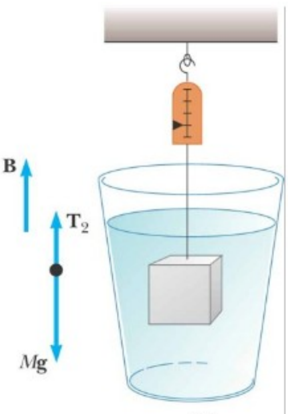
(a)

1. Which force does the spring scale measure?

__ T_1 __ Mg

2. How is the weight of the object related tension T_1 ?

Case (b). The same the metal object is suspended by the spring scale, but now it is also immersed into a beaker full of water.



(b)

3. Which force does the spring scale measure?

__ T_2 __ Mg __ B

4. How does T_1 compare to T_2 ?

5. Write the equation which relates the buoyant force B with T_1 and T_2.

6. Remember the distinction between weight and mass, how does a scale work?

__ it measures the weight and it displays the weight of an object.
__ it measures the weight and it displays the mass of an object.
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Procedure

Step 1. Open the capstone file "**F-t.cap**" located in the T:/Capstone on your computer. Capstone will display a force vs time graph. If the digital scale is under the beaker remove it since it not used in this part of the experiment.

Step 2. Pair the smart cart, which is used as a force sensor (the spring scale). Take a reading of the force with no mass attached, you should read zero force. If not go to '*Hardware Setup*' on left panel. Click on circle next to '*Smart Cart Force Sensor*'. Then click on '*zero sensor now*'. Then click 'ok'. You want the cart to read a zero force value if no forces are applied.

Step 3. Hang the metal (either aluminum or copper) from the force sensor as shown in case (a). Record the value of the force for a few seconds, then take the average.

Step 4. Next, place the metal into the cup of water until it's submerged as shown in case (b). You might have to adjust the height of the force sensor, so the block doesn't touch the bottom of the beaker. Record the value of the force for a few seconds, then take the average.

Analysis

7. Search online for the exact value of the density of your metal block (copper or aluminum)

ρ_{metal} = ______ (kg/m^3) (exact value)

The two forces measured in case (a) and case (b) are usually referred as *weight in air* and *weight in water* respectively. Input their values in the table below.

(a) weight in air	(b) weight in water

8. Use the weight in air to find the mass of the metal block.

$mass_{metal}$ = ______ (kg)

9. Calculate the buoyant force using the values of the two forces in the table above.

B = ______ (N)

Now that you know *B* you can find the density of the metal block by knowing its weight and the density of water ρ_{water} = 1,000 kg/m^3 without the need to know its volume.

10. Show the calculations to obtain the formula of the density of the metal block ρ_{metal} expressed as function of B, W_{metal} and ρ_{water}. Hint: volume of displaced water = volume of the metal block.

11. Calculate the density using the formula obtained above.

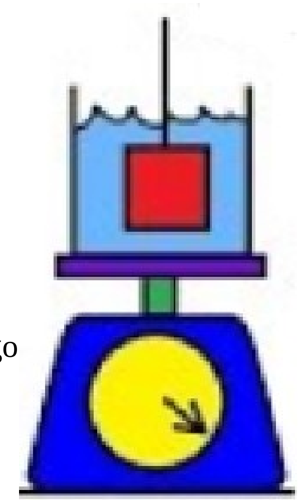
ρ_{metal} = _______ (kg/m^3) (measured value)

12. Calculate the percentage error for the density.

13. Calculate the the volume of the metal block.

V_{metal} = ______ (cm^3)

PART 2 - Digital Scale



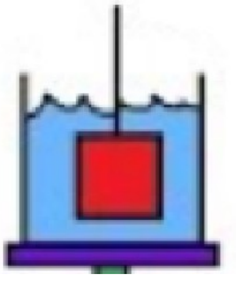
A beaker partly filled with water sits on a digital scale. Next, a metal block is lowered into the water by a string. The block does not touch the bottom of the beaker and no water overflows.

Preliminary questions

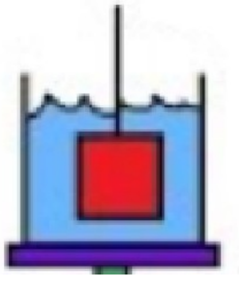
14. After you submerge the block, does the reading measured by the digital scale go up, go down, or stay the same?

15. Does the tension in the string go up, go down, or stays the same?

16. Below there are two pictures for the free body diagrams of the block (on the left), and the free body diagram of the water (on the right). To simplify the physics ignore the beaker as if the water, without its container, simply stays on top of the scale. Use the notation: m_W = mass of the water, m_M = mass of the metal block, W_W = weight of the water. W_M = weight of the metal block. B = buoyant force. B' = reaction of B. T = tension. N = normal. Draw the two free body diagrams below:



(all forces acting on the metal block)



(all forces acting on the water)

17. What is the expression of the total weight measured by digital scale before the metal block is submerged? Use the notation above.

weight 1 =

18. What is the expression of the total weight measured by the digital scale with the metal block submerged in the water? Use the notation above.

weight 2 =

19. How is the buoyant force related to weigh 1 and weight 2?

Procedure

Step 1. Use the digital scale to find the weight 1 of the beaker with water in it.

Step 2. Next, suspend the metal block using the hook on the force sensor, then submerge the metal block into the beaker sitting on the digital scale. Use the digital scale to find the weight 2.

Analysis

Input in the table below the values of the weight in *step 1* and 2 and calculate the buoyant force

weight 1	weight 2

20. Calculate the magnitude of the buoyant force from the values of the two weights.

B = ______ (N)

21. Calculate the density of the metal block ρ_{metal} from B, W_M and ρ_{water}

ρ_{metal} =_______ (kg/m^3)

22. How does your measured density compare with the accepted value? Calculate the percentage error.

23. Calculate the percentage difference of the two densities of the metal block obtained from Part 1 and Part 2.