Name: _____ Section: _____ Date: _____

# Worksheet - Exp 11: Archimedes' Principle

***Objective:*** The objective of this lab is to investigate the buoyant force acting on a variety of objects, the density of the objects, and the density of our tap water.

***Procedure:***

***Flip to pages 3 and 4 and quickly check parts 4 and 5, this will clarify the worksheet. You may choose to do each cylinder for each part before moving on, or you may perform everything with the brass cylinder before moving on to the aluminum and wood. Take special note of the changes mentioned for the wood cylinder in part 5. If you perform all calculations in g/cm$^3$ you will have the same units as the density chart. Recall that 1 cm$^3$ = 1 ml***

***Part 1: Overflow Method***

1. Measure the mass of the brass cylinder; you will need to use the triple beam balance. Determine its **weight**, $F_g$.

   $m_{brass}$:_____**g** (1 pt) $m_{Al}$:_____**g** (1 pt) $m_{wood}$:_____**g** (1 pt)

   $F_{g_{brass}}$:_____**N** (1 pt) $F_{g_{Al}}$:_____**N** (1 pt) $F_{g_{wood}}$:_____**N** (1 pt)

2. Position the spouted can so that its spigot pours into the overflow container. Fill it with water just until it begins to overflow.

3. Place the overflow container on the digital balance, and set the zero point to the mass of the container and the little water it may hold.

4. Replace the overflow container under the spigot. Submerge the brass cylinder in the water, allowing displaced water to collect in the overflow container.

5. Measure the mass of the displaced water; ***calculate its weight***. This is the buoyant force, $F_B$.

   $F_{B_{brass}}$:_____ (2 pts) $F_{B_{Al}}$:_____ (2 pts) $F_{B_{wood}}$:_____ (2 pts)

6. Calculate $\rho_{obj}$ (density of the object). Use the density chart on the lab physicists webpage to calculate percent error.

   $\rho_{obj} = \frac{\rho_W F_g}{F_B}$

   $\rho_{brass}$:_____ (3 pts) $\rho_{Al}$:_____ (3 pts)

   % Error:_____ (3 pts) % Error:_____ (3 pts)

***Part 2: Direct Measurement - Mass***

7. Calibrate the triple beam balance.

8. Suspend the object (brass cylinder) from a string attached to the balance.

9. Partially fill the overflow container with water, then submerge the object. Do not allow the object to touch the container. Measure the apparent mass of the object in water, $m'$. Calculate $F'_g$.

$m'_{brass}$:_____ (2 pts) $m'_{Al}$:_____ (2 pts) $m'_{wood}$:_____ (2 pts)

$F'_{g_{brass}}$:_____ (2 pts) $F'_{g_{Al}}$:_____ (2 pts) $F'_{g_{wood}}$:_____ (2 pts)

10. Determine $F_B$ for the object. How much less does it weigh in water than in air? $F_B = F_g - F'_g$

$F_{B_{brass}}$:_____ (2 pts) $F_{B_{Al}}$:_____ (2 pts) $F_{B_{wood}}$:_____ (2 pts)

11. Calculate $\rho_{obj}$:

$\rho_{obj} = \frac{\rho_W F_g}{F_B}$

$\rho_{brass}$:_____ (3 pts) $\rho_{Al}$:_____ (3 pts)

% Error:_____ (3 pts) % Error:_____ (3 pts)

***Part 3: Displacement Method - Volume***

12. Partially fill the graduated cylinder with water; take note of the water level. Use the pipette to fine-tune the meniscus.
13. Carefully submerge the object in water and determine the volume of water displaced by the object.

    $V_{brass}$:_____ (2 pts) $V_{Al}$:_____ (2 pts) $V_{wood}$:_____ (2 pts)

14. Remove and dry the object, then empty the graduated cylinder and invert it on a paper towel to dry.
15. Determine $F_B$ on the object:

    $F_B = \rho_W g V$

    $F_{B_{brass}}$:_____ (2 pts) $F_{B_{Al}}$:_____ (2 pts) $F_{B_{wood}}$:_____ (2 pts)

16. Calculate $\rho_{obj}$:

    $\rho_{obj} = \frac{m}{V}$

    Use the volume determined from the displacement method and $m$, not $m'$.

    $\rho_{brass}$:_____ (3 pts) $\rho_{Al}$:_____ (3 pts)

    % Error:_____ (3 pts) % Error:_____ (3 pts)

***Part 4: Aluminum Cylinder***

17. Repeat *Part 1* through *Part 3* for the next object (aluminum cylinder).
18. Draw a free-body diagram for this object submerged in water. (5 pts)

***Part 5: Buoyant Force - Floating Object***

19. Although you need to modify or omit certain steps, repeat *Part 1* through *Part 3* for the wood cylinder:
    - *Omit Step 6*, *Step 11*, and *Step 16*.
    - *Modify Step 9* and *Step 13* Allow the wood object to float.
20. Draw a free-body-diagram for the wood object floating in water. (5 pts)

***Part 6: Density of Tap Water***

21. For each metal object: Use the following equation and the graduated cylinder volume from *Part 3* to determine the density of our tap water.
    $\frac{m-m'}{V} = \rho_W$

    Using brass cylinder $\rho_W$:_____ (3 pts)  % Error:_____ (3 pts)

    Using aluminum cylinder $\rho_W$:_____ (3 pts)  % Error:_____ (3 pts)