Laboratory 2 Sample Protocol

Contents

Objective

To investigate fluid statics by measuring buoyancy forces and hydrostatic thrust, and to validate theoretical principles using experimental data.

Materials and Equipment

1. Quadrant balance apparatus
2. Graduated cylinder (500 mL or larger)
3. Thermometer
4. Objects for buoyancy testing (rocks, composites, wood samples)
5. Weighing scale (±0.01 g precision)
6. Water (at ambient temperature)
7. Ruler or measuring tape
8. Transfer pipette
9. Weight hangers and standard masses

Procedure

Part 1: Displacement Volumes and Buoyancy

1. **Prepare the Setup:**
   - Measure and record the temperature of the water.
   - Fill the graduated cylinder with a sufficient amount of water. Record the initial volume level, (V_{\text{initial}}).
2. **Measure Object Data:**
   - Weigh the first object (e.g., Rock-1) and record its mass.
   - Gently submerge the object in the water and record the new volume level, (V_{\text{final}}).
   - Calculate the displaced volume, (\Delta V = V_{\text{final}} - V_{\text{initial}}).
   - Repeat the procedure three times for each object (Rock-2, Composite-1, etc.).
3. **Repeat Measurements:**
   - Repeat the displacement experiment for all six objects.
   - Ensure all measurements are consistent and record the data in a table.

Part 2: Hydrostatic Forces and Center of Pressure

1. **Prepare the Apparatus:**
   - Measure and record the water temperature.
   - Verify both tanks in the quadrant balance are empty. Trim the assembly to ensure the submerged plane is vertical.
2. **Partial Submersion:**
   - Add water into the trim tank to bring the balance to the 0 position. Add weights as needed to stabilize the apparatus.
   - Gradually add water to the quadrant tank until the apparatus is level again. Record the water depth ((h)) and the free surface width ((b)).
   - Repeat the procedure for at least three trials with varying weights.
3. **Full Submersion:**

- Fully submerge the plane surface by incrementally increasing weights and adding water to balance the apparatus.
- Record (h), (b), and the applied masses for at least three trials.

Data Analysis

1. **Displacement Volumes and Buoyancy:**
   - Calculate the buoyancy force for each object using: [F_B = \rho_{\text{water}} \cdot \Delta V \cdot g]
   - Compare calculated object volumes with measurements from the displacement method.
2. **Hydrostatic Forces:**
   - Calculate moments, (M), using the formula: [M = W \cdot \left(\frac{3b}{8} \right) \cdot h]
   - Plot (M) vs. (h) for fully submerged data. Fit a straight line and compute (R^2).
   - Use the slope of the line to calculate the specific weight of water and compare it to literature values.
3. **Partially Submerged Data:**
   - Plot: [M + \frac{\gamma_w W R_2^2 h}{2} \quad \text{vs.} \quad h^3]
   - Evaluate the fit using (R^2).

Deliverables

1. Completed data tables for Part 1 and Part 2.
2. Plots and calculations demonstrating experimental results.
3. A step-by-step experimental protocol with annotations for improvements.
4. Discussion addressing:
   - Archimedes' principle and its application.
   - Comparison of measured and theoretical buoyancy forces.
   - Analysis of hydrostatic forces and center of pressure.