CONCEPTUAL PHYSICS	Tech Lab

Liquids: Buoyancy   **Buoyancy and Flotation Simulation**

Pool Cubes: Buoyancy

Purpose
To investigate the nature of the buoyant force and to see the role it plays in determining whether or not an object floats

Apparatus
__computer   __PhET sim, "Buoyancy" (available at http:://phet.colorado.edu)

Discussion
When objects are immersed in a fluid, the fluid exerts a force on them. This is the buoyant force.

Procedure
INITIAL SETUP
Turn the computer on and let it complete its startup cycle. Locate and open the PhET sim, "Buoyancy," and note that it opens in its "Intro" tab. Do not change the settings in the on-screen Blocks, Fluids, or Show Forces panels.

PART A: WOOD
Step 1: Measure (in the sim) and record the weight (W) of the 5.00-kg wood block.

Step 2: a. Place the wood block in the water and notice that it floats.

b. When the wood block rests on the ground, the downward gravitational force is balanced by an upward normal ("contact") force. When floating, the gravitational force is still there, but the normal ("contact") force is not. The force exerted by the fluid is the buoyant force (B). When floating, which force is greater: the gravitational force or the buoyant force? Defend your answer.

c. Record the value of the buoyant force acting on the wood block.

Step 3: a. What volume of water does the wood block displace when it floats in the water?

b. What is the mass of that displaced water? (Note that the density of water is 1.00 kg/L.)

_____

_____

c. What is the weight of the displaced water?

_____

_____

PART B: BRICK
Step 1: Measure and record the weight (W) of the 5.00-kg block of brick (in air).

_____

Step 2: a. Measure and record the **_apparent weight_** (N) of the brick when submerged in water.

_____

b. Does the brick appear to be ___heavier or ___lighter when submerged in water?

c. When submerged in water, the brick appears to have an additional force pushing it ___upward

___downward. This additional force is the **_buoyant force_** (B).

Step 3: a. In the space to the right, draw and label a diagram of the
brick block at rest on the bottom of the pool to show how the forces
of weight, apparent weight, and buoyant force act on the block.

b. Calculate the size of the buoyant force. Show your work.

Step 4: What is the volume of the brick block? (Observe; do not calculate!)

_____

Step 5: What is the volume, mass, and weight of the displaced water?

Summing Up

1. How does the buoyant force acting on an object compare to the weight of the water displaced by that object?

_____

_____

2. The wood floated; the brick did not. What condition—in terms of forces—is required for an object to float?

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3. What is the condition for floating in terms of object and fluid densities?

_____

_____

Going Further

1. **Fluid Density.** Replace the water with oil (using the on-screen Fluids panel). Describe and execute a method to determine the density of the oil.

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2. **Latent Bloomer.** Switch the sim to the Buoyancy Playground tab. Select My Block from the on-screen control panel.

   a. What is the density of the densest block you can create?

   _____

   b. i. Place that block in the water. It __floats __sinks __is neutrally buoyant.

      ii. Now maximize its volume. It __floats __sinks __is neutrally buoyant.

      iii. While at maximum volume, minimize its mass. It __floats __sinks __is neutrally buoyant.

   c. Without dragging the low-density block or changing its mass or volume, how can you bring it to rest at the **bottom** of the pool?

   _____

   _____

3. **Sim Surfing.** Click the on-screen Reset All button. Select Two from the on-screen Blocks panel. Set Block A to be an 8-L block of Styrofoam; set Block B to be a 2-L block of brick. Place the Styrofoam block in the water. Place the brick block on top of the Styrofoam block. The arrangement floats.

   a. What is the mass of the stack?

   _____

   b. What is the volume of the water displaced?

   _____

   c. What is the mass of the water displaced?

   _____

   d. Change the volume of the Styrofoam block to 6 L, 4 L and 2 L. What do you observe during this process?

   _____

   _____

   e. Adjust the volume of the Styrofoam block until the stack has neutral buoyancy. Record the volume of the block.

   _____

   f. **"Above and Beyond" Challenge!** An object with a high density ρ_H can be floated on an object with a low density ρ_L in a fluid with a density ρ if the volumes of the objects (V_H and V_L) are right.

      i. The condition for such a stack having neutral buoyancy, in terms of masses (m_H and m_L) and volumes (V_H and V_L) of the blocks and the density ρ of the water is expressed mathematically

      $$\rho = (m_H + m_L) / (V_H + V_L)$$

      ii. What is mass m in terms of density ρ and volume V?

      iii. Eliminate m_H and m_L from the initial expression in f.i. above. Solve to find the volume of the Styrofoam block V_L required so that if a brick block (whose volume V_H is known) is stacked on top of it, the stack will be neutrally buoyant in a fluid whose density is ρ. This is an algebraic solution to the puzzle you solved in the sim in 3.d. above. Your solution may include ρ_H, V_H, ρ_L, V_L, ρ, and constants.

iv. Given $V_H = 2.0$ L, $\rho_H = 2.0$ kg/L, $\rho_L = 0.15$ kg/L, and $\rho = 1.0$ kg/L, what is V_L?

v. If the calculated value does not match the value found in the sim, ask your instructor for assistance.

g. i. Calculate the largest volume of aluminum that can be supported by a 10.0-L block of wood floating in gasoline. The density of aluminum is 2.70 kg/L, the density of wood is 0.40 kg/L, and the density of gasoline is 0.70 kg/L.

ii. Can you verify your solution using the sim?