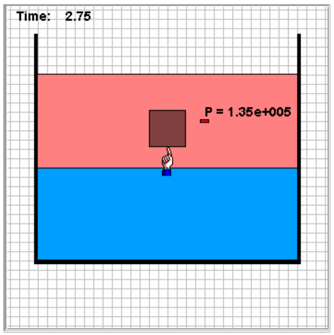
Worksheet for Exploration 14.3: Buoyancy and Oil on Water



This Exploration will address the buoyant force in more depth (pun intended). Specifically, what happens if we put an object in two "layers" of fluids? Assume the brown block is a *cube* **(position is given in meters and pressure is given in pascals)**. Restart.

Note: The format of the pressure is written in short hand. For example atmospheric pressure, 1.01×10^5 Pa, is written as 1.01e+005.

Move the pressure indicator and measure the pressure at the bottom of the wooden block and at the top of the block.

a. If the block is a cube, what is the force on the block due to the water (buoyant force)?

   i. First sketch a free body force diagram for forces acting on the reshaped box. (One of these is the buoyant force).

$F_{buoyant}$=________

b. What, then, is the weight of the block? What is the density of the block? (*Use the symbol F_g as the force due to gravity, ie., weight*).

F_g=________

density=________

c. Another method: How much (what percentage) of the block is submerged? Check that the density of the block is that same percentage of the density of water (1000 kg/m^3).
   i. When you determine density use the mass of the block from part b.

%Submerged=_______

density=_________

Now consider what would happen if we put the **block in an oil** with a different density.

d. Predict what you expect will happen if we put the block in an oil with a density of 700 kg/m^3.

e. Try it. Was your prediction correct? Explain.

f. What is the pressure at the bottom of the block and at the top of the block? What is the buoyant force on the block in the oil?

P_{bottom}=_________

P_{top}=_________

   i. To determine the buoyant force you can use the mass of the block from above, and the density of the oil.

$F_{buoyant}$=_________

ii. OR you can use the pressure measurements at the top and bottom to help you determine the buoyant force on the block. The two results should agree.

$F_{buoyant}$=_________

iii. How does the buoyant force compare to the weight of the object?

Now, suppose the wood block is put in a **mixture of water on the bottom with oil on the top** (the oil floats on the water and doesn't mix with the water).

g. What do you expect will happen? Why?

h. Try it. Is more or less of the block submerged in water in this case compared with the block simply floating in water (without oil)? Why?

i. One way to look at what happened is to measure the pressures. Find the pressure at the bottom of the block and at the top of the block.

P_{bottom}=_________

P_{top}=_________

j. What is the pressure difference and thus the *TOTAL BUOYANT FORCE* on the block?

$\Delta P =$ ________

$F_{buoyant} =$ _________

k. In order for a block to float only in water (with air on top), to get the same pressure difference to support the block, why does the block need to be lower in the water? (Think about the density of air compared with the density of oil and, therefore, the change in pressure with depth in air and the oil.)

Another way to look at this is to compare the buoyant forces.

l. In comparison with the block floating in water only, has the buoyant force increased, decreased or stayed the same?

m. What is the volume of water that the block displaces?
   i. When in water/air.

   $V_{water\ displaced} =$ _________

   ii. When in water/oil

   $V_{water\ displaced} =$ _________

n. What is the weight of that water?
   i. When in water/air.

$F_{g \text{ diplaced water (i)}}$=__________

   ii. When in water/oil.

$F_{g \text{ displaced water (ii)}}$=__________

o. What is the volume of oil that the block displaces?

$V_{\text{oil displaced}}$=__________

p. What is the weight of the displaced oil?

$F_{g \text{ displaced oil}}$ =__________

q. How do those two compare with the weight of the block?
   i. That is, compare the total weight of displaced material for each case.