

Archimedes' Principle states that the upward buoyant force which acts on an object is equal to the weight of the fluid which it displaces. Use this principle and your knowledge of physics to solve the following problems.

Other useful information:

$\rho_{\text{water}} = 1.0 \text{ g/cm}^3$	$\rho_{\text{ethanol}} = 0.76 \text{ g/cm}^3$	$\rho_{\text{mercury}} = 13.6 \text{ g/cm}^3$
$\rho_{\text{air}} = 1.20 \text{ kg/m}^3$	$\rho_{\text{He}} = 0.18 \text{ kg/m}^3$	
Volume of a block: $V=lwh$	Density: $\rho=m/V$	
Volume of a sphere: $V=(4/3)\pi r^3$	Weight (Newtons): $F_g = \text{mass} \times (10)$	
	Net force: $\Sigma F = \text{mass} \times \text{acceleration}$	

PART I

1. If a block of aluminum measures 4.0 cm x 5.0 cm x 2.0 cm is completely submerged in a tank of water, what volume of water does it displace?
2. What is the mass of the displaced water (1 gram of water=1ml of water)?
3. What is the weight of the displaced water?
4. How large of a buoyant force acts on the block?
5. The mass of the aluminum block is 108 g. Determine its density.
6. If you release the metal block, will it sink, or will it float to the surface? Explain your reasoning.
7. If you suspend the completely submerged the aluminum block from a string what will be the tension in the string? (Hint: The net force on the block is zero. Draw a force diagram!)
8. If the block was submerged in ethyl alcohol instead, would the tension in the string be bigger or smaller? Explain your answer.
9. What would happen to the aluminum block if you dropped it into a large container of liquid mercury? Explain your answer.

PART II

10. A block of wood has dimensions 4.0 cm x 5.0 cm x 2.0 cm. Its mass is 20.0 g. How much does it weigh?
11. What is the density of the block of wood?

12. If the block of wood is completely submerged in water, how large of a buoyant force will act on it. (Hint: you should not need to do any additional calculations!)
13. If you let go of the wooden block when it is completely submerged will it start to sink or will it rise to the surface? What will be its initial acceleration?
14. Once the wood is floating on the surface, what is the net force acting on it?
15. How large of a buoyant force acts on the block as it floats on the surface?
16. What volume of water is being displaced by the wood block?
17. What percentage of the wood block is above the surface of the water?
18. How much mass could you add to the block before it's top surface was level with the water?

PART III

19. Imagine a person with a mass of 85 kg (188 lbs). If their density is 940 kg/m^3 , what is their volume in cubic meters?
20. What is the weight of the air that is displaced by the person?
21. Do people experience an upward buoyant force? If so, why don't we notice it much?
22. Imagine a spherical helium balloon with a radius of 2.0 meters. (No seriously, imagine it...can you picture how large it would be? What is the volume of the balloon?)
23. Determine both the mass and the weight of the helium in the balloon.
24. Determine both the mass and the weight of the air that would be displaced by the balloon.
25. If the balloon was tethered to the ground by a string, what would be the tension in the string? You can ignore the weight of the balloon material (Draw a force diagram!)
26. If the person un-tethered the balloon and held onto the string would he float away? Why or why not?
27. BONUS: What radius would the helium balloon have to lift the person off the ground?
28. BONUS: In the previous question we ignored the material of a balloon. If a helium balloon is made from mylar which has an AREA density of 0.01 g/cm^2 , what is the minimum radius a helium balloon can have and still float (without supporting any other weight). Remember, the surface area of a sphere is $A=4\pi r^2$.