Density, Displacement, and Weight in fluids - PHY100's

Apparatus: Digital balance, dual pan balance, table clamp, metal rod to fit mounting hole on dual pan balance, lab jack, 50 ml graduated cylinder, tri-pour beaker, lead sinker, steel bolt, and rubber cork (all three of which fit easily in graduated cylinder), paper clips, string, eye dropper, golf ball.

Density is defined as the mass divided by the volume of a material, mass being the amount of matter present and volume being the amount of space the matter takes up. Standard SI measurement units of mass are kilograms (kg) while SI units of volume are cubic meters (m^3), so density has SI units of kg/ m^3. Densities reported in units of g/cm^3 are not SI, but are common because the relatively small samples used in experiments are more easily measured with tools calibrated for smaller units. Still, for most given physics equations, it is necessary to convert all quantities to standard SI units for your calculations to yield the correct answers.

Any kind of substance can be found in most any quantity, so knowing just the mass or just the volume doesn't say anything about the type of material. For example, a 1000 kg mass could be a large pile of cotton or a small pile of lead, a 0.5 m^3 volume could be a rather light load of Styrofoam while it would be a tremendous amount of steel. On the other hand, the ratio of mass to volume tells exactly how much stuff exists per unit volume and for pure substances will be characteristic only to very specific materials based on the type of atoms, the spacing between them, and the environmental conditions affecting them. These principles apply to matter in solid, liquid, and gaseous states alike.

Be aware: No units are given on this sheet, so you will need to include those when filling in the blanks!! Make sure that all measured data is recorded precisely with units exactly as taken from the measurement tool (including your visual estimate of the last decimal place), and then also recorded separately in standard S.I. units.

When asked, be sure to explain your methods clearly:

1. Find the mass of the golf ball, lead sinker, rubber cork, and steel bolt both on the mechanical dual pan balance and on the electronic digital pan balance. Which measurement device do you believe is more precise? Why?

Mass of golf ball: _____ _____

Mass of lead sinker: _____ _____

Mass of rubber cork: _____ _____

Mass of steel bolt: _____ _____

2. Find the weight of each item. How is this different from the mass?

Weight of golf ball: _____

Weight of lead sinker: _____

Weight of rubber cork: _____

Weight of steel bolt: _____

3. Use the equipment at your disposal to find an experimental volume for each object. Explain how it was done. Be concise!

Volume of golf ball: _____ _____

Volume of lead sinker: _____ _____

Volume of rubber cork: _____ _____

Volume of steel bolt: _____ _____

4. For the golf ball only, also approximate the volume theoretically using the standard formula for the volume of a sphere. $V_{sphere} = 4*pi*r^3/3$, where r is the radius of the sphere. (This is only an approximation because the golf ball isn't truly a smooth sphere, right?) Then find the combined volume of fluid that can be held by all of the dimples in the surface of the ball.

Calculation of ball volume:

Combined volume of all dimples in ball:

5. Find the weight of each object when completely submerged in water. Measure out the volume of the water it displaces and find its weight too. How does the volume of the displaced water compare to the volume of the object?

(Mount the mechanical dual pan balance on the rod so that it is up off the bench's surface. Hang the object from the underneath of the left balance pan so it's apparent mass can be measured while submerged in water below.)

<u>When under water</u>

Mass sinker: _____ Weight: _____ Water Weight: _____

Mass cork: _____ Weight: _____ Water Weight: _____

Mass bolt: _____ Weight: _____ Water Weight: _____

6. How does the weight of each object in air found in step 2 differ from the weight of each object when under water? Compare these differences to the respective weights of the displaced water. How could you compare quantitatively?

7. Calculate the density of each object and the water from your experimental data.

Sinker_____	Standard Textbook Values:	lead: 11300 kg/cubic meter
Cork_____		rubber: 1350 kg/cubic meter
Bolt_____		steel: 7860 kg/cubic meter
Water_____		water: 1000 kg/cubic meter

Densities of Various Substances

Grams per Cubic Centimeter (g/cm^3)	Material	Kilograms per Cubic Meter (kg/m^3)
	Typical Solids:	
22.570	Osmium	22,570
21.450	Platinum	21,450
19.950	Uranium	19,950
19.320	Gold	19,320
11.344	Lead	11,344
10.500	Silver	10,500
8.960	Copper	8,960
8.560	Brass	8,560
7.874	Iron	7,874
7.310	Tin	7,310
2.699	Aluminum	2,699
0.917	Ice	917
	Typical Liquids:	
13.600	Mercury	13,600
1.260	Glycerin	1,260
1.025	Seawater	1,025
1.000	Water (4^oC)	1,000
0.810	Benzene	810
0.791	Ethyl Alcohol	791