Phys 170 Homework Chapter 15

No need to submit this problem set. These are questions that may appear in the Final Exam.
I reserve the right to ask additional questions that are not on this list, however.

Constants: $g = 9.8m/s^2$, $G = 6.67 \times 10^{-11} Nm^2 kg^{-2}$.
Density of water: $\rho_w = 10^3 kg/m^3$, Density of mercury: $\rho_m = 13.6 \times 10^3 kg/m^3$, Density of gold: $\rho_g = 19.3 \times 10^3 kg/m^3$
Atmospheric pressure: $1atm = 10^5 Pa$.

1. Give the definition of (using equations or in words) (i) pressure; (ii) density.

   (i) $P = \frac{F}{A}$
   (ii) $\rho = \frac{m}{V}$

2. What is the density of a object with a mass of $500g$ and a volume of $40cm^3$? Write your answer in SI unit.

$$
\begin{aligned}
V = 40cm^3 &= 40 \times (10^{-2}m)^3 = 40 \times 10^{-6}m^3 \\
\Rightarrow \rho &= \frac{0.5kg}{40 \times 10^{-6}m^3} = 12500kg/m^3
\end{aligned}
$$

3. An object with density $\rho = 2000kg/m^3$ is found to have a volume $V = 3cm^3$. What is the mass of the object? Be careful with the unit.

$$\text{Recall: } 1cm^3 = 10^{-6}m^3$$
$$m = \rho V = (2000kg/m^3)(3 \times 10^{-6}m^3) = 6 \times 10^{-3}kg = 6g$$

4. A constant pressure of $P = 2Pa$ is exerted on a plane of area $A = 4m^2$, what is the total force on the plane due to the pressure?

$$P = \frac{F}{A} \Rightarrow F = PA = (2N/m^2)(4m^2) = 8N$$

5. What is the Archimedes' Principle? Give three examples of its real life application.

   Archimedes' Principle: Buoyant force equals to the weight of the water displaced.

   (a) Hot air ballon

   (b) Ship floating on the sea

   (c) The high buoyancy of the Dead Sea

(d) Submarine

(e) Determining the density of an object (e.g. gold crown) by dipping it in a fluid

6. According to the Bernoulli's Principle of fluid dynamics, does the pressure increase or decrease in a region of high fluid velocity?

   High velocity means low pressure.

7. Give two examples of the application of the Bernoulli's Principle.

   (a) Air multiplier (Dyson fan)

   (b) Curve ball

   (c) Bunsen burner

   (d) Airplane

8. Explain why planes could fly.

   The shape of the wings makes the air flows above the wings faster than the air below. According to the Bernoulli's Principle, the pressure above the wings become lower and generate an upward force to lift up the plane.

9. Explain why a heavy ship made of metal can float on the ocean.

   According to the Archimedes' Principle: Buoyant force equals to the weight of the water displaced. If the ship can displace an amount of water that equals to its weight, there would be enough buoyant force to keep it afloat.

10. Explain why it is easier to float on salt water (such as the Dead Sea) compared with fresh water.

    According to the Archimedes' Principle: Buoyant force equals to the weight of the water displaced. Since salt water is heavier than fresh water, it generates a stronger buoyant force for the same volume of water displaced.

11. Explain why hot air balloons can fly.

    The hot air inside the balloon displaced an equal volume of cold air. The weight of the cold air equals to the buoyant force according to the Archimedes' Principle. Since cold air is more dense, it weighs more than hot air, so the buoyant force is stronger than the weight due to the hot air inside the balloon. As a result there is a net upward force allowing a hot air ballon to fly.

    Mathematically:

    $$F_{up} = B - m_{hot}g = m_{cold}g - m_{hot}g = (m_{cold} - m_{hot})g > 0$$