Physical Science 303 - Activity

1 Archimedes' principle

1.1 Review

Fluid is a state of matter which has no fixed shape (thus it can *flow*), for instance, liquid or gas. We will be mostly dealing with the liquids. Thus, we first review some notions used widely with liquids (or more generally with matter)

1. **Density**, ρ, is defined as the mass of the fluid (or matter) per unit volume. Thus

$$\rho = \frac{m}{V}. \tag{1}$$

   The units for density are kg/m^3. Here we note that if the density ρ and the volume V are given we can compute the *mass* by using the following equation

$$m = \rho V \tag{2}$$

2. **Weight** of the matter can be computed if density and volume are given

$$\begin{aligned} W &= mg \\ &= (\rho V)g \end{aligned} \tag{3}$$

   where g is the acceleration due to gravity (9.8 m/s^2) and W is the weight of the given matter. Recall that weight is a *force*.

1.2 Activity

1. **Required Box**: Box 1

2. **Required Items**: Overflow can, acrylic beaker, graduated cylinder, tap water, wooden box

1. Fill up the overflow can with the tap water. Google™ up the density of tap water with proper units ρ_w : _____

2. Place the acrylic beaker under the nozzle of the overflow can as shown.
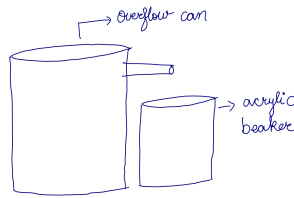

Figure 1: Overflow can

3. Now immerse the wodden box in the overflow can. You will observe some *volume* of water flowing out from the nozzle into the beaker. Write the reason for this process

4. Transfer the water from beaker to the graduated cylinder and measure the volume
   V_{over} : _____

5. Using the equation 3 and density of water ρ_w, compute the weight of this displaced water

   W_{disp} : _____

6. Using pull spring or triple beam balance, measure the weight of the wodden block
   W_{wood} : _____

1.3   Theoretical analysis

In this section we aim to conduct the theoretical study based on the experiment.

1. Draw the free body diagram of the wodden box *floating* in the water. It should be useful to draw an analogy with the wodden box *kept* on the table (we studied this situation earlier in the class).

Here the force exerted by the water (fluid) on the wodden box is know as *bouyant force*. From the activity we conclude that the bouyant force exerted by the fluid, in the vertically upward direction, is equal to the weight

of the fluid displaced by the object! This is know as the Archimedes' principle. I would highly encourage
you to read the story[1] of this discovery.

2   Answer the following questions

1. A 5 kg object is released from the rest while fully submerged in a liquid. The liquid displaced by the
   submerged object has a mass of 3 kg. How far and in what direction does the object move in 0.2
   seconds, assuming that it moves freely in the liquid?
   Hint: As usual, first draw the free body diagram. Now compute the bouyant force from the data given
   in the question. Then apply Newton's II law of motion to compute acceleration of the mass. Finally
   use the kinematical equation of motion to compute the displacement.

2. Assuming that the object of volume V is completely submerged in the water, does the bouyant force
   exerted by the water depend on the nature of the object (steel, brass, aluminium . . .)? Give reason
   for your answer.

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[1]http://www.longlongtimeago.com/once-upon-a-time/great-discoveries/eureka-the-story-of-archimedes-and-the-golden-crown