Abstract:

1. The aim of the experiment is: to find the density of a liquid.
2. The method used is: the U-tube method.
3. The main result is : $\rho(liquid) = 0.83 \pm 0.07 gm / cm^3$

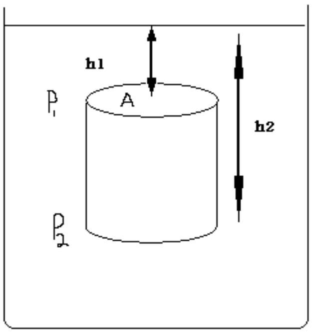
Theory:

Fluids exert forces on the walls of the containers they are in or any other surface they touch. When the liquid is at rest, it makes (exerts) perpendicular forces on the walls it touches.

The pressure of fluid on a certain surface is the force exerted by the fluid per unit area.

$$\text{Pr}essure = \frac{force(perpendicular)}{area} \Rightarrow P = \frac{F}{A}$$

Pressure maybe different at different points below the liquids surface, the pressure is larger at points farther below the surface.

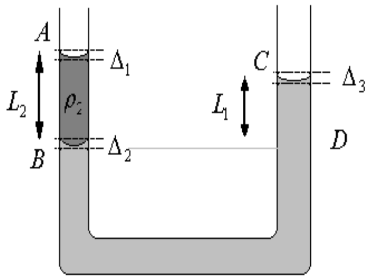


We take a portion of the liquid at a shape of a cylinder. The pressure at the top of the cylinder = P_1 and it is P_2 at the bottom of it. The liquid above pushes the down with force P_1A, the liquid below pushes with a force P_{2a}, and the weight of the cylinder acts down with force $= mg$.

The cylindrical portion is static equilibrium, so that the net force acting on it is zero.

$$P_a - mg - P_1A = 0$$
$$m = \rho V = \rho A(h_2 - h_1)$$
$$P_2A - \rho Ag(h_2 - h_1) - P_1A = 0$$
$$P_2A - P_1A = \rho Ag(h_2 - h_1)$$
$$P_2 - P_1 = \rho g(h_2 - h_1)$$

And so the difference in pressure depends only on the difference in the vertical height.



We use the liquids with densities ρ_1, ρ_2 where $\rho_1 > \rho_2$ then :

$$P_B - P_A = \rho_2 g L_2$$
$$P_D - P_C = \rho_1 g L_1$$

but the points B, D are at the same vertical height in liquid so $P_B = P_D$ and $P_A = P_C = P_a$ (atmospheric pressure on both the open sides of the tube)

Also liquid 1 will be water with density of $\rho_1 = 1gm / cm^3$.

We notice that we add coloring pouder but because the quantity we added was so little with comparison with the quantity of water we have. So its effect will be neglected ,even if the coloring material was Hg , we also neglect the effect of the atmospheric pressure in the place we have done the experiment which was different from the standard one because water as all liquids can't be affected by pressure. We also neglect the effect of salts which were contained in the water we used in our experiment , since it is not pure , because the quantity of those salts is very little with comparison with the water's quantity , the water is suitable for drinking.

$$\text{Then} \quad \rho_1 L_1 = \rho_2 L_2$$

$$L_1 = \rho_2 L_2$$

$$\rho_2 = \frac{L_1}{L_2}$$

To find the error for (ρ) :

$$\rho = \frac{L_1}{L_2}$$

$$\Delta\rho = \frac{\Delta L_1}{L_1} + \frac{\Delta L_2}{L_2}$$

where $\Delta L_1 \approx \Delta_2 + \Delta_3, \Delta L_2 \approx \Delta_1 + \Delta_2$

Procedure:

First we added suitable quantity of water to the tube and made it equilibrium on the table to make the two surfaces of water on the same height on the meter fixed on the tube.

After that we started to add the unknown liquid on one side of the tube (a quantity of about 3 centimeters cube) and then we waited for about a minute to make the liquid equilibrium to take the right measure . We repeated those measurements five times and put the data taken in the table shown .

We tried to measure $\Delta_2, \Delta_3, \Delta_1$ by fixing a ruler and taking the measurements with it .

Data:

No.						**Average**
$L_1(cm)$	4.10	9.10	11.5	13.5	15.3	10.7
$L_2(cm)$	4.90	11.0	13.9	16.3	18.5	12.9

Calculations:

$$\Delta L_1 \approx \Delta_2 + \Delta_3 = 1.5 + 2.5 = 4mm$$
$$\Delta L_2 \approx \Delta_1 + \Delta_2 = 1.5 + 2.5 = 4mm$$
$$\overline{L_1} = 10.70cm$$
$$\overline{L_2} = 12.92cm$$

from the graph slope $= \dfrac{\Delta L_1}{\Delta L_2} = \dfrac{(L_1)_2 - (L_1)_1}{(L_2)_2 - (L_2)_1} = \dfrac{15.3 - 4.10}{18.5 - 4.90} = 0.824$

$$\rho = \frac{\overline{L_1}}{\overline{L_2}} = \frac{10.70}{12.92} = 0.8282 gm/cm^3$$
$$\Delta\rho = \frac{\Delta L_1}{\overline{L}_1} + \frac{\Delta L_2}{\overline{L}_2} = \frac{0.4}{10.7} + \frac{0.4}{12.92} = 0.07 gm/cm^3$$

$$\rho = 0.83 \pm 0.07 gm/cm^3$$

Results and Conclusion:

$$\rho = 0.83 \pm 0.07 gm/cm^3$$

We find that the density calculated as shown in the report corresponds with the density of the oil of Paraffin (the density is shown in the table of densities in Appendix E page 113 at the laboratory manual) with the range of error calculated.

We should mention that the tube we used was clean inside and need not to be cleaned again, if it wasn't clean and have some dirt inside of it (because of remaining liquids inside) and this causes the density of the liquid which would be added to change and not to give correct ratio at the end to give the wanted density. We could solve this problem by adding a few cm of acetone in the tube and shake it well then to pour the acetone out of the tube.

Another point we must mention is that we wait for about a minute after adding the amount of liquid each time before taking measurements because some of the liquid could be stuck at the edges of the tube inside and those stuck amounts would come down by taking some time to become apart of the liquid we added and would make a difference of the measurement.