BIRZEIT UNIVERSITY
Physics Department

Physics 111

Experiment No. 3

Density of a Liquid

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– Abstract:

1) The aim of the experiment:

To calculate the density of an unknown liquid and then identify the liquid using the result.

2) The method used :

Is the U-tube Method .(By adding colored water into the U-tube and then add an unknown liquid to one of its sides six times and then take the measurements (L1, L2) after waiting few moments).

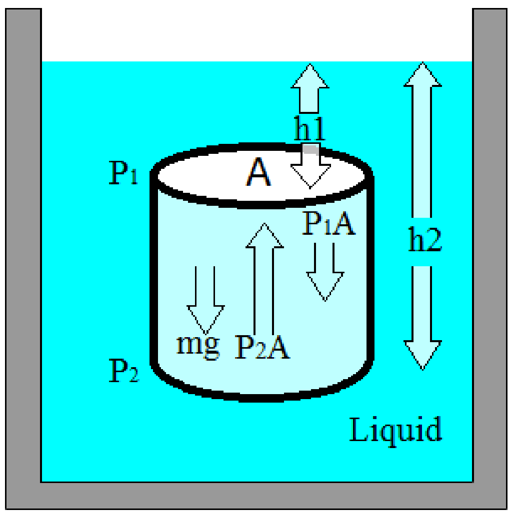
3) The main results are:

$\rho = 0.86 \pm 0.04\ gm/cm^3$

– Theory:

It's known that the pressure of the fluid on a surface is the force exerted by the fluid per unit area :

Pressure $(P) = \frac{force}{area} = \frac{F}{A}$ As figure shows :

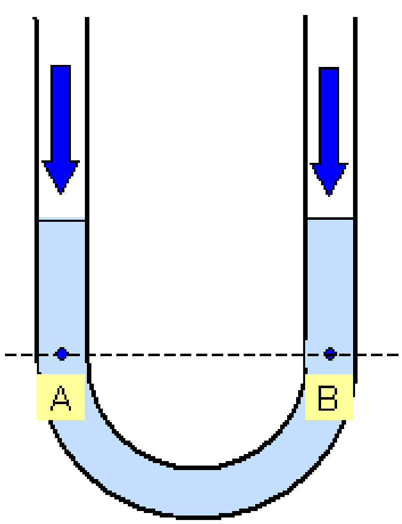


A part of liquid in shape of a cylinder was considered with area (A) and height (h_2-h_1). P1, P2 pressures as the liquid is in static equilibrium and the net force acting on it is zero.

➔ $+P_2A - mg - P_1A = 0$.
Since $m = \text{density} \times \text{Volume} = \rho V$.
Since $V = A(h_2 - h_1)$. ➔ $P_2 - P_1 = \rho A(h_2 - h_1)$.
And this will be used in the experiment to identify the unknown liquid. And for finding the error in ρ we use $\rho = \frac{L_1}{L_2}$

$$\Rightarrow \Delta\rho = \frac{\Delta L_1}{L_1} + \frac{L_1 \Delta L_2}{L^2{}_2} \Rightarrow \frac{\Delta\rho}{\rho} = \frac{\Delta L_1}{L_1} + \frac{\Delta L_2}{L_2}.$$

In the experiment there was two liquids with different densities ρ_1, ρ_2. Where $\rho_1 > \rho_2$ ➔ $P_B - P_A = \rho_2 g L_2$ and $P_D - P_C = \rho_1 g L_1$.
PB = PD as the two points are on the same level (same vertical height).
$P_A = P_C = P_a$ affected only by the atmospheric pressure (P_a = atmospheric pressure). And by solving the two equations ➔ $\rho_1 L_1 = \rho_2 L_2$. And because in this experiment Liquid1 is water and the density of water = 1 gm\cm^3.Thus $L_1 = \rho_2 L_2$.
L_1 vs. L_2 is a straight line with a slope equal to ρ.



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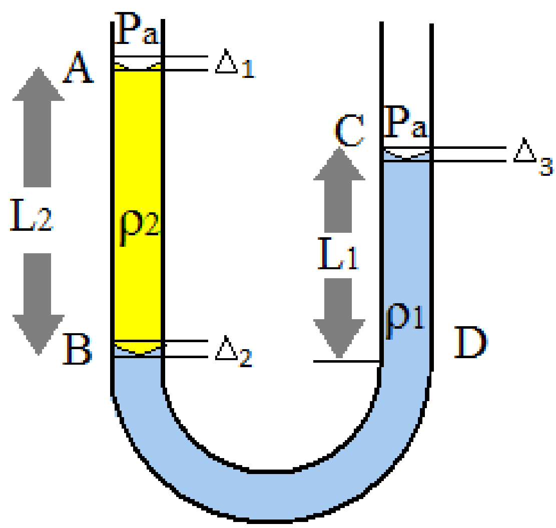

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Before adding the unknown liquid

after adding the liquid

– Procedure:

At first we cleaned the U-tube using acetone by shaking it and pouring it away. Then we added colored water until it reached the height of 20 cm nearly 1/3 of the U-tube. Then we started adding the unknown liquid to one of the tube sides nearly 3 cm each time, and before the measurements were taken we waited for few moments until the liquid settled down. After that we estimated Δ_1, Δ_2 and Δ_3. And at the end measurements were taken six times and written down.

– Data:

No	1	2	3	4	5	6	Average
L_1(cm)	**2.6**	**5.4**	**7.6**	**10.7**	**13.4**	**16.5**	**9.4**
L_2(cm)	**3.4**	**6.4**	**9.2**	**13.1**	**15.9**	**19.6**	**11.3**

ΔL_1= $\Delta_3 + \Delta_2 = 0.1 + 0.1 = 0.2$cm **(By estimation, see Manual)**

ΔL_2=$\Delta_1 + \Delta_2$ **=0.2+0.1=0.3cm**

– Calculations:

Centroid $(\overline{L_1}, \overline{L_2}) = (\ 9.4\ ,\quad 11.3\ )$

From the graph:

$$\text{slope} = = \frac{\Delta L1}{\Delta L2} = \frac{9.4-2.6}{11.3-3.4} = \frac{6.8}{7.9} = 0.86 gm \backslash cm^3$$

$$\frac{\Delta\rho}{\rho} = \frac{\Delta L_1}{\overline{L_1}} + \frac{\Delta L_2}{\overline{L_2}} = \frac{0.2}{9.4} + \frac{0.3}{11.3} = 0.05$$

$$\Delta\rho = 0.05 \times 0.86 = 0.04$$

—Results and Conclusion:

$\rho = 0.86 \pm 0.04\ gm/cm^3$

- **Discrepancy :** | true value – result| = | 0.82 – 0.86 | = 0.04
  $0.04 < 2 \times 0.04$.
- My result is accepted because $D < 2\times \Delta\rho$.

- **Systematic errors:**
  At first there were some dirt in the tube ,we have tried to use acetone to clean the tube but there still little dirt in it which affects the result ,Also the two meters which were fixed in the two side of the tube were not exactly on the same level so the data wasn't accurate as it should be the right side was higher than the lift side by 0.2 cm and this also affect the estimation of $\Delta 1$, $\Delta 2$, $\Delta 3$.

- **Questions:**

Q1 : The unknown liquid is Paraffin

Q2 : the measurements will be wrong because (L1,L2) will be higher so we will get wrong result for the density of the unknown liquid and the unknown liquid won't be identified . The equation $\rho_1 L_1 = \rho_2 L_2$ won't give us an accurate result.

Q3 : So that all the added liquid settles down to get correct measurements.