Abstract :

1. The aim of the experiment is : to find the density of a metal and then to find the spaces between atoms in the metal given.

2. The method used is : measuring the length , width , thickness and mass of the metal with vernier caliber , micrometer and a balance scale .

3. The main result is :

$$\rho = 6.8 \pm 0.03 gm/cm^3$$

spacing between atoms (a) = 2.302 A^o

Theory :

We find the density of the metal with the equation :

$$\rho = \frac{Mass}{Volume} = \frac{M}{V}$$

and with our rectangular shaped metal of thickness T, length L and width W , then Volume V = L×W×T .

To find the error in the density , we calculate the uncertainty in ρ .

$$\frac{\Delta\rho}{\rho} = \frac{\Delta M}{M} + \frac{\Delta V}{V}$$

but V = L × W × T
so that the uncertainty in V will be :

$$\frac{\Delta V}{V} = \frac{\Delta L}{L} + \frac{\Delta T}{T} + \frac{\Delta W}{W}$$

Then we ca find the approximate expression for the distance between atoms in the metal given.

The total number of atoms (N) in the material = $nN_A = \frac{M}{A_W} N_A$

Where (n) is the number of moles , N_A is Avogadro’s number = 6.02 × 10^{23} and A_W is the atomic mass of the material .

We assume that each atom is contained inside a box of volume a^3. Then the volume V is : $V = N \times a^3$.

$$a^3 = \frac{V}{N} = \frac{V}{\frac{M}{A_W} N_A} = \frac{VA_W}{MN_A} = \frac{A_W}{\frac{M}{V} N_A} = \frac{A_W}{\rho \times N_A}$$

so $a = \sqrt[3]{\frac{A_W}{\rho \times N_A}}$

Procedure :

a) We obtained a metal block , caliper , micrometer and balance scale .
b) We measured the length L and the width W with the use of vernier caliper . We repeated the measurement five times each time from a different place .
c) We measured the thickness with the use of the micrometer and also we repeated the measurement five times from different places .
d) Finally we used a balance scale to measure the mass of the block .

Data :

Table of the data in the exp.

M = 30.06 ± 0.05 g						**average**
Length L (cm)	5.220	5.240	5.225	5.235	5.230	5.230
Width W (cm)	1.925	1.920	1.925	1.925	1.915	1.922
Thickness T (cm)	0.442	0.438	0.441	0.411	0.411	0.4406

Calculations :

$\overline{L} =$ 5.230 cm $\quad \overline{T} =$ 0.4406 cm $\quad \overline{W} = 1.922$ cm

σ_s (L) = 7.9 × 10^{-3} cm $\quad \sigma_s$ (T) = 1.51× 10^{-3} cm $\quad \sigma_s$ (W) = 4.47 × 10^{-3} cm

ΔL = 0.004 cm $\quad$ ΔT = 0.0007 cm $\quad$ ΔW = 0.002 cm

V = 4.43 cm^3

$$\rho = \frac{M}{V} = \frac{30.06}{4.43} = 6.80 gm/cm^3$$

$$\frac{\Delta V}{V} = \frac{\Delta L}{L} + \frac{\Delta W}{W} + \frac{\Delta T}{T} = \frac{0.004}{5.23} + \frac{0.002}{1.922} + \frac{0.0007}{0.4406} = 3.39 \times 10^{-3}$$

$$\frac{\Delta M}{M} = \frac{0.05}{30.06} = 1.66 \times 10^{-3}$$

$$\frac{\Delta \rho}{\rho} = \frac{\Delta M}{M} + \frac{\Delta V}{V} = 5.06 \times 10^{-3}$$

$$\Delta \rho = 0.03 gm/cm^3$$

$$\rho = 6.80 \pm 0.03 gm/cm^3$$

Returning to appendix e we assume the metal to be cast iron

$$a = \sqrt[3]{\frac{A_W}{\rho \times N_A}} = \sqrt[3]{\frac{55.84}{7.6 \times 6.02 \times 10^{23}}} = 2.302 \times 10^{-8} \text{ cm} = 2.302 \ A^o$$

Results and Conclusion:

$\rho = 6.8 \pm 0.03 gm / cm^3$

a (spacing) = 2.302 A^o

The result of density here is different from the number shown in the appendix e and that result is related to a problem with the balance scale , and that for after we had calibrated the balance scale and after that it was used by other students and was moved from its place without enogh careful. For the the time wasn’t enough we couldn’t check the balance scale carefully so we used it with this situation and this caused the error that happened . And another reason is that also for the time wasn’t enough we couldn’t redo our measurement . And for that our measure was 30.06 .

If we revised that result and made a simple change we would put the mass to be 33.66 gm to make the denity be the right measure as is it in appendix e .
So that we could correct this systematic error by adding 3.1 gm for mass and continue the calculation .

Abstract:

1. The aim of the experiment is : to find the ratio R between the linear momentum before a collision between two balls and the linear momentum after so as to test the law of conservation of linear momentum which says that "the linear momentum of an isolated system is conserved ".
2. The method used is : measuring the horizontal distances after the balls fall and measuring the masses of them .
3. The main result is : $R = 1.06 \pm 0.02$

Theory:

First we use two balls with the same diameter so that the direction of the force that happens with the collision between the two balls would be straight so as to make the direction of the velocity after the collision for the pushed ball horizontal (by making the diameters equal we make the centers on a straight horizontal line) , so that we would make sure that there is no vertical velocity toward the ground would affect the motion of the ball .

We also make the heavier ball push the other ball so that the two balls would continue their way after collision horizontally to fall on sand wit different velocities . We don't choose the balls with the same weight because when the collision happens one of the balls will stop (the pushing ball) and the other will continue with the same speed of the pushing ball before it stops. We also don't choose the heavier ball to be the pushed one because the other ball would return back and push the heavier ball with a little force and make move softly .

We assume that the mass of the moving object = m , the velocity of it = v and the momentum of the object is (P) . Then :

$$P = mV$$

We consider an isolated system consisting of N objects , when the object no. i is moving with a velocity with mass of m_i , then the total momentum of the system is:

$$P = \sum_{i=1}^{N} m_i V_i$$

Assuming that the mass of the ball 1 is m_1, the mass of the ball 2 is m_2 , the speed of ball 1 before the collision is V_{1b}, the speed of ball 2 is zero ($V_{2b} = 0$) , the speed of ball 1 is V_{1a} and the speed of ball 2 is V_{2a} . We define the ratio R as :

$$R = \frac{P_a}{P_b}$$

$$P_a = m_1V_{1a} + m_2V_{2a} \qquad \text{and} \qquad P_b = m_1V_{1b} + m_2V_{2b} = m_1V_{1b}$$

Then by substitution: $R = \dfrac{m_1V_{1a} + m_2V_{2a}}{m_1V_{1b}}$

The ball falls in a parabolic trajectory inside the tray of sand .The vertical distance from the point of collision to the sand is $y = \frac{1}{2}gt^2$ where g is the acceleration of gravity and t is the time of flight for ball 1 which also equals the time of flight for the two balls after collision because both of them are falling freely under the acceleration of gravity and with the same initial velocity which equals zero .

Then we find $t = \sqrt{\dfrac{2y}{g}}$.

We assume that X_{1b} is the horizontal distance for ball 1 when it falls on the sand (before collision) , X_{1a} is the horizontal distance for ball 1 when it falls (after collision) , and X_{2a} is the horizontal distance for ball 2 when it falls (after collision) . As shown in figure 1 & figure 2 .

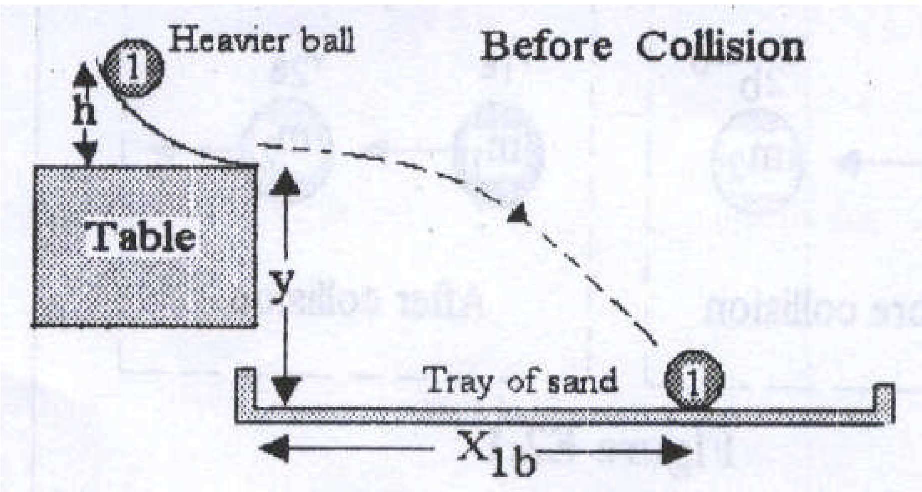


figure .1.

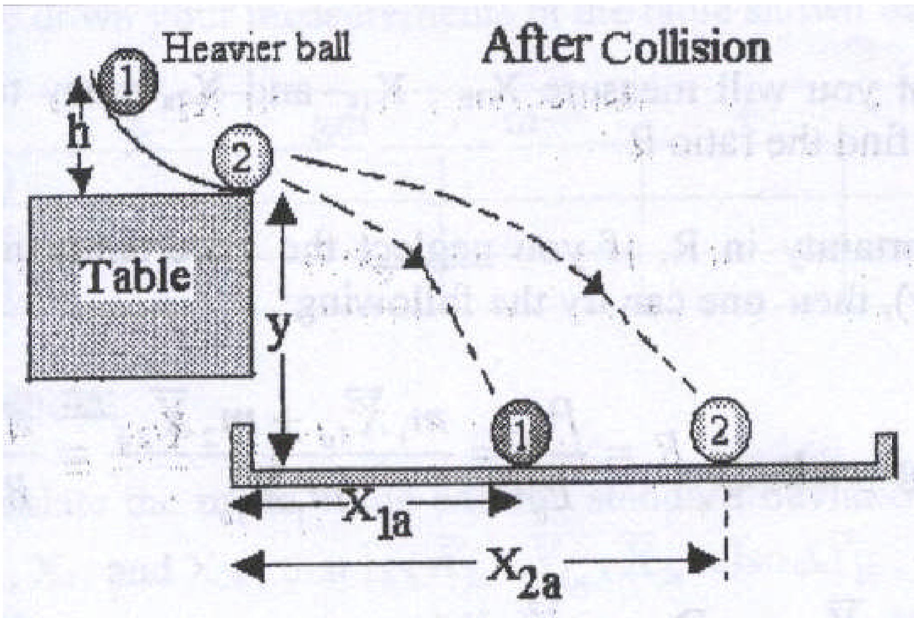


figure .2.

Then we find the horizontal speed of each ball to be :

$$V_{1b} = \frac{X_{1b}}{t} = \frac{X_{1b}}{\sqrt{2y/g}} \Rightarrow P_{1b} = \frac{m_1 X_{1b}}{\sqrt{2y/g}}$$

$$V_{1a} = \frac{X_{1a}}{t} = \frac{X_{1a}}{\sqrt{2y/g}} \Rightarrow P_{1a} = \frac{m_1 X_{1a}}{\sqrt{2y/g}}$$

$$V_{2a} = \frac{X_{2a}}{t} = \frac{X_{2a}}{\sqrt{2y/g}} \Rightarrow P_{2a} = \frac{m_2 X_{2a}}{\sqrt{2y/g}}$$

Substituting the equations in the equation of R we find that :

$$R = \frac{P_a}{P_B} = \frac{m_1 \overline{X}_{1a} + m_2 \overline{X}_{2a}}{m_1 \overline{X_{1b}}} = \frac{A}{B}$$

Where:

$$A = m_1 \overline{X}_{1a} + m_2 \overline{X}_{2a} \qquad B = m_1 \overline{X_{1b}}$$

$$\frac{\Delta R}{R} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$$

where $\Delta A = m_1 \Delta \overline{X}_{1a} + \overline{X}_{1a} \Delta m_1 + m_2 \Delta \overline{X}_{2a} + \overline{X}_{2a} \Delta m_2$

and $\Delta B = m_1 \Delta \overline{X}_{1b} + \overline{X}_{1b} \Delta m_1$

Procedure:

First we fixed the curved track on a table and fixed the tray of sand certainly under the edge of the table . Then we chose two balls which have almost the same diameters to be used in the experiment. After that we rolled the ball no. 1 on the track and measured the distance $\overline{X}_{1b}$ on the sand , and then we made the surface of the sand flat as it was before the ball fell over it. We repeated this operation five times.

After that we stopped ball 2 on the edge of the track and then we rolled the ball no.1 toward ball 2 to make a collision between the two balls . Then we measured the distances $\overline{X}_{1a}$ and $\overline{X}_{2a}$ on the sand after each time we made the surface of the sand flat again. We repeated this five times.

Then we measured the masses of the two balls with the balance scale and repeated the measurement for each ball two times for checking.

The data we got is shown in the table.

Data:

$m_1 = 16.71$ g , $m_2 = 4.96$ g , $\Delta m_1 = 0.05$ g , $\Delta m_2 = 0.05$ g

No.						**Average**
$X_{1b}(cm)$	42.7	42.8	42.5	42.6	42.8	42.68
$X_{1a}(cm)$	25.8	25.4	26	26.7	26	25.98
$X_{2a}(cm)$	64.1	64.8	66	65.7	66	65.32

Calculations:

$$R = \frac{m_1 \overline{X}_{1a} + m_2 \overline{X}_{2a}}{m_1 \overline{X}_{1b}} = \frac{16.71 \times 25.98 + 4.96 \times 65.32}{16.71 \times 42.68} = \frac{758.113}{713.1828} = 1.062999 = 1.06$$

$$\Delta X_{1a} = \sigma_m = \frac{\sigma_s}{\sqrt{5}} = \frac{0.471168759}{2.236067978} = 0.210713075 = 0.2cm$$

$$\Delta X_{2a} = \sigma_m = \frac{\sigma_s}{\sqrt{5}} = \frac{0.84083292}{2.236067978} = 0.376031913 = 0.4cm$$

$$\Delta X_{1b} = \sigma_m = \frac{\sigma_s}{\sqrt{5}} = \frac{0.130384048}{2.236067978} = 0.058309518 = 0.06cm$$

$$A = m_1 \overline{X}_{1a} + m_2 \overline{X}_{2a} = 758.113 g.cm$$
$$B = m_1 \overline{X_{1b}} = 713.1828 g.cm$$

$$\Delta A = m_1 \Delta \overline{X}_{1a} + \overline{X}_{1a} \Delta m_1 + m_2 \Delta \overline{X}_{2a} + \overline{X}_{2a} \Delta m_2$$
$$= 16.71 \times 0.21071 + 25.98 \times 0.05 + 4.96 \times 0.376031 + 65.32 \times 0.05 = 9.951133772 g.cm$$

$$\Delta B = m_1 \Delta \overline{X}_{1b} + \overline{X}_{1b} \Delta m_1 = 16.71 \times 0.058309518 + 42.68 \times 0.05 = 3.108352046 g.cm$$

$$\frac{\Delta R}{R} = \frac{\Delta A}{A} + \frac{\Delta B}{B} = \frac{9.951133772}{758.113} + \frac{3.108352046}{713.1828} = 0.017484316$$
$$\Delta R = 0.017484316 \times 1.062999 = 0.018585811 = 0.02$$

$$R = 1.06 \pm 0.02$$

Results and Conclusion:

$$R = 1.06 \pm 0.02$$

I think that the result here is different a little from the real value (the result here ranges between 1.04 – 1.08 while the real value is 1.00) and this is related for some expected systematic errors during the experiment .

First if the lower of the track is not horizontal this would make the ball 1 before collision has a vertical with the horizontal one which we assumed that the vertical speed is zero and this would decrease our measurement for the horizontal distance on the sand. And like this would happen when the collision happens that the ball 1 would push the other ball with a force which is not horizontal so that it would affect on the angle of flying for each ball and make the horizontal distances measured on the sand less than the wanted one.

On the other hand the two balls we have chosen could be not the same diameters which we assumed at the beginning and this would affect that the force from the pushing ball won't be horizontal because the centers of the two balls won't be on a straight line as we assumed to make the velocities of the two balls horizontal and this would affect the measure of the horizontal distances just as when the track is not horizontal.

In another way the measurements taken with every instrument can't be very accurate because we always take the middle of the hole the ball would make when it falls on the sand and this estimation for the center of the hole can't be always very accurate because it depends on the sight which not accurate.

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 : $\rho(liquid) = 0.83 \pm 0.07 gm/cm^3$

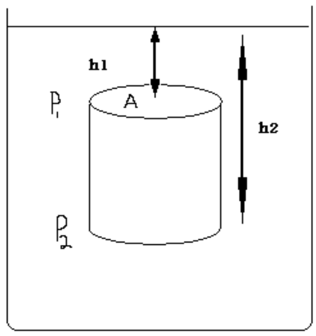
Theory:

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.



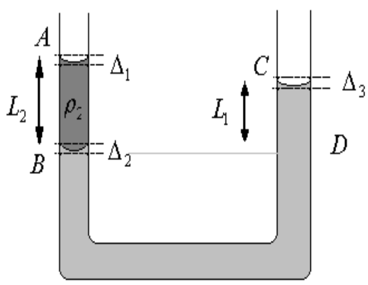
We take a portion of the liquid at a shape of a cylinder. The pressure at the top of the cylinder = P_1 and it is P_2 at the bottom of it. The liquid above pushes the down with force P_1A, the liquid below pushes with a force P_{2a}, and the weight of the cylinder acts down with force $= mg$.

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.

Abstract:

1. The aim of the experiment is: to test if the material is Ohmic or non-Ohmic material by the plot and then finding the resistance from it.
2. The method used is: Voltmeter – Ammeter method.
3. The main result is : $R =$

Theory:

The resistance R of a metallic conductor is defined by:

$$R = \frac{voltage}{current} = \frac{V}{I}$$

where I is the current flowing through the conductor and V is the potential difference applied between the endpoints of the conductor.

Materials are divided into two parts according to Ohms' law : Ohmic and Non-Ohmic materials.

For a metallic conductor the resistance is constant provided that the temperature of the wire stays essentially constant because the resistance R doesn't depend on either V or I but on the temperature of the material.

Figure 1.0

We can test if the material is Ohmic or not by plotting a graph of the potential difference V across the material against the current I through it keeping the temperature of the material constant. If the graph is not a line the material is Non-Ohmic.

If two resistors are connected in parallel then we can substitute our resistor equivalent to both of them of magnitude R_p where:

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow R_p = \frac{R_1 R_2}{R_1 + R_2}$$

If two resistors are connected in series then the resistors could be replaced by a single equivalent resistor R_s :

$$R_s = R_1 + R_2$$

The uncertainty in R (ΔR) is calculated by:

$$\frac{\Delta R}{R} = \frac{\Delta V}{V} + \frac{\Delta I}{I}$$

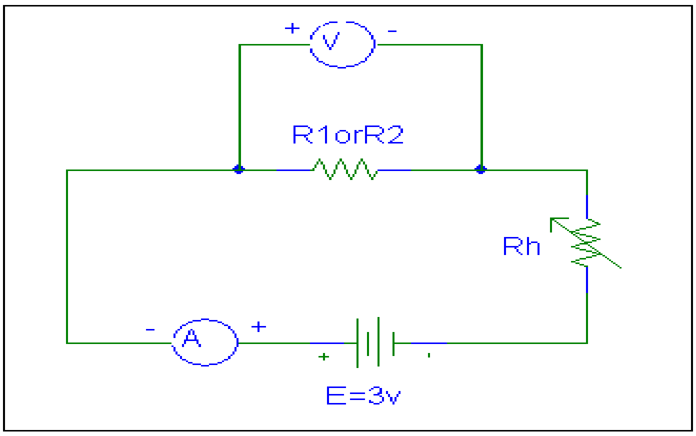
Procedure:

A. <u>One Resistance:</u>

We connected the following circuit using only one resistance which was R1. We are provided with a power supply of 3 or 4 volts.

Figure 2.0

A circuit with one resistance.



We estimated the uncertainty in our measurements in the current and voltage from the scale of the voltmeter and the ammeter we used ($\Delta I, \Delta V$). As we used the scale of 3 volts in the voltmeter where every volt is divided into tenths our estimation of ΔV was $\Delta V = 0.1 volts$, also we used the scale of 50mA in the ammeter so we estimated $\Delta I = 2.0 mA$.

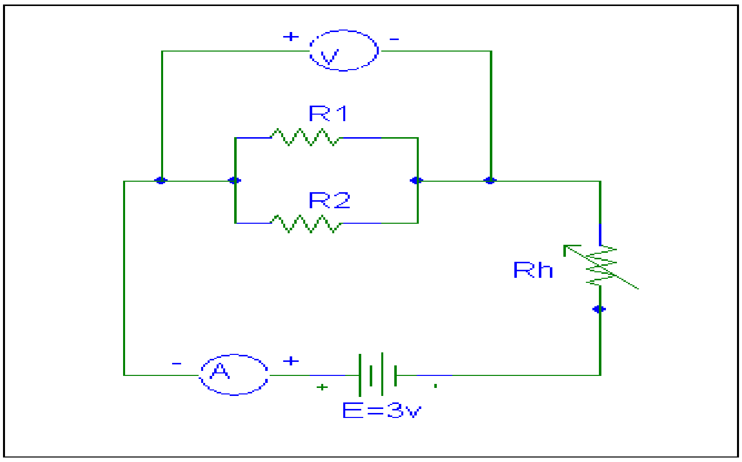
Then we measured the current I in the resistor and the potential difference V across the resistance. After that we changed the current by adjusting the variable resistor Rh and again measured I and V. We repeated the changing for 6 times and wrote down our measurements . We tried to take as large range as possible (a difference of 0.5 volt each time).

B. Two Resistors in Parallel:

We connected the following circuit with the resistors R1 and R2 in parallel as in the following circuit.

Figure 3.0

A circuit with two resistances connected in parallel.



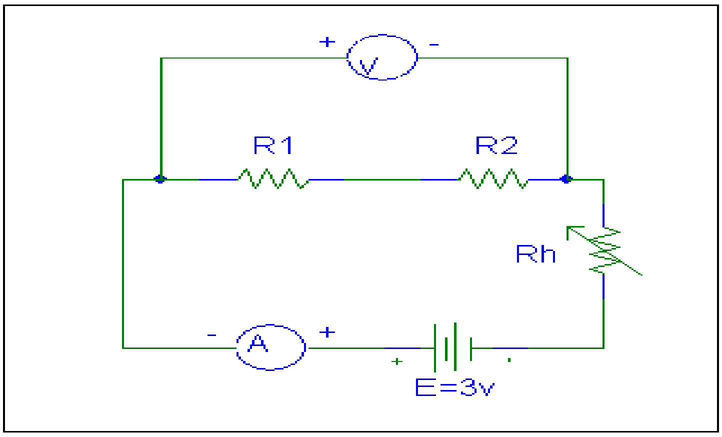
We estimated the error in our readings of I and V as we did before because we used the same scales in each of the ammeter and the voltmeter. After that we wrote down the reading (only one time) .

C. Two Resistors in Series:

We connected the following circuit with resistors R1 and R2 in series as the following circuit:

Figure 4.0

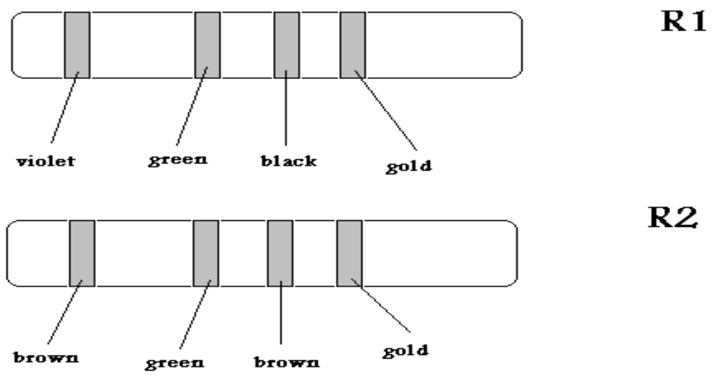
A circuit with two resistors connected in series.



We estimated the error in reading our values as we did before because we used the same scale in each of the voltmeter and the ammeter. We wrote down the readings of the ammeter and the voltmeter (only one time).

D. *The Values of the two resistors using the color code:*

The two resistors were as shown in the following sketches:



Data:

No.	1	2	3	4	5	6	7	Average
I (mA)	46	38	30	22	14	10	4.0	23
V(volts)	3.0	2.5	2.0	1.5	1.0	0.7	0.3	1.6

Calculations:

Results and Conclusion:

$$R_s = R_1 + R_2$$
$$R_s = R_1 + R_2$$
$$R_s = R_1 + R_2$$

The calculation of each resistor includes a part of the other's period of error range. Also the results calculated were corresponding (with its range of error) with the values read with the color code. We assume that our calculations were somehow precized.

Abstract:

1. The aim of the experiment is : to find the ratio R between the linear momentum before a collision between two balls and the linear momentum after so as to test the law of conservation of linear momentum which says that "the linear momentum of an isolated system is conserved ".
2. The method used is : measuring the horizontal distances after the balls fall and measuring the masses of them .
3. The main result is : $R = 1.06 \pm 0.02$

Theory:

First we use two balls with the same diameter so that the direction of the force that happens with the collision between the two balls would be straight so as to make the direction of the velocity after the collision for the pushed ball horizontal (by making the diameters equal we make the centers on a straight horizontal line) , so that we would make sure that there is no vertical velocity toward the ground would affect the motion of the ball .

We also make the heavier ball push the other ball so that the two balls would continue their way after collision horizontally to fall on sand wit different velocities . We don't choose the balls with the same weight because when the collision happens one of the balls will stop (the pushing ball) and the other will continue with the same speed of the pushing ball before it stops. We also don't choose the heavier ball to be the pushed one because the other ball would return back and push the heavier ball with a little force and make move softly .

We assume that the mass of the moving object = m , the velocity of it = v and the momentum of the object is (P) . Then :

$$P = mV$$

We consider an isolated system consisting of N objects , when the object no. i is moving with a velocity with mass of m_i , then the total momentum of the system is:

$$P = \sum_{i=1}^{N} m_i V_i$$

Assuming that the mass of the ball 1 is m_1, the mass of the ball 2 is m_2 , the speed of ball 1 before the collision is V_{1b}, the speed of ball 2 is zero ($V_{2b} = 0$) , the speed of ball 1 is V_{1a} and the speed of ball 2 is V_{2a} . We define the ratio R as :

$$R = \frac{P_a}{P_b}$$

$$P_a = m_1V_{1a} + m_2V_{2a} \qquad \text{and} \qquad P_b = m_1V_{1b} + m_2V_{2b} = m_1V_{1b}$$

Then by substitution: $$R = \frac{m_1V_{1a} + m_2V_{2a}}{m_1V_{1b}}$$

The ball falls in a parabolic trajectory inside the tray of sand .The vertical distance from the point of collision to the sand is $y = \frac{1}{2}gt^2$ where g is the acceleration of gravity and t is the time of flight for ball 1 which also equals the time of flight for the two balls after collision because both of them are falling freely under the acceleration of gravity and with the same initial velocity which equals zero .

Then we find $t = \sqrt{\frac{2y}{g}}$.

We assume that X_{1b} is the horizontal distance for ball 1 when it falls on the sand (before collision) , X_{1a} is the horizontal distance for ball 1 when it falls (after collision) , and X_{2a} is the horizontal distance for ball 2 when it falls (after collision) . As shown in figure 1 & figure 2 .

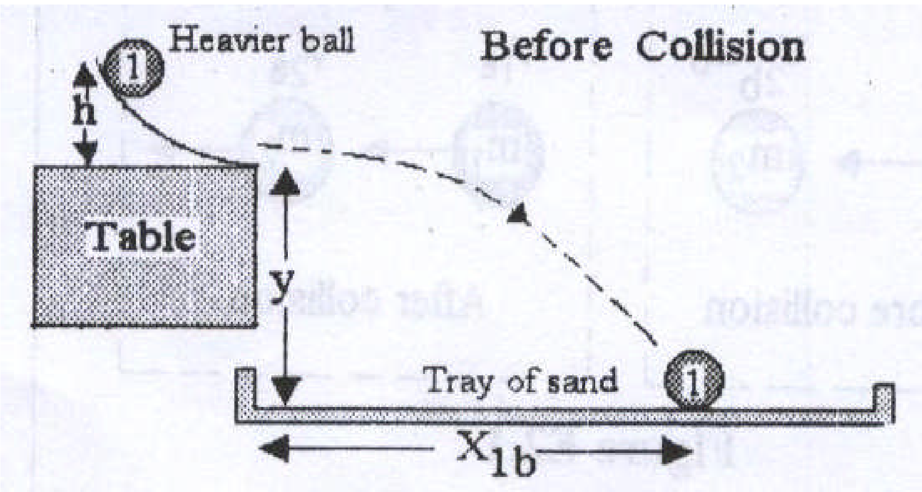


figure .1.

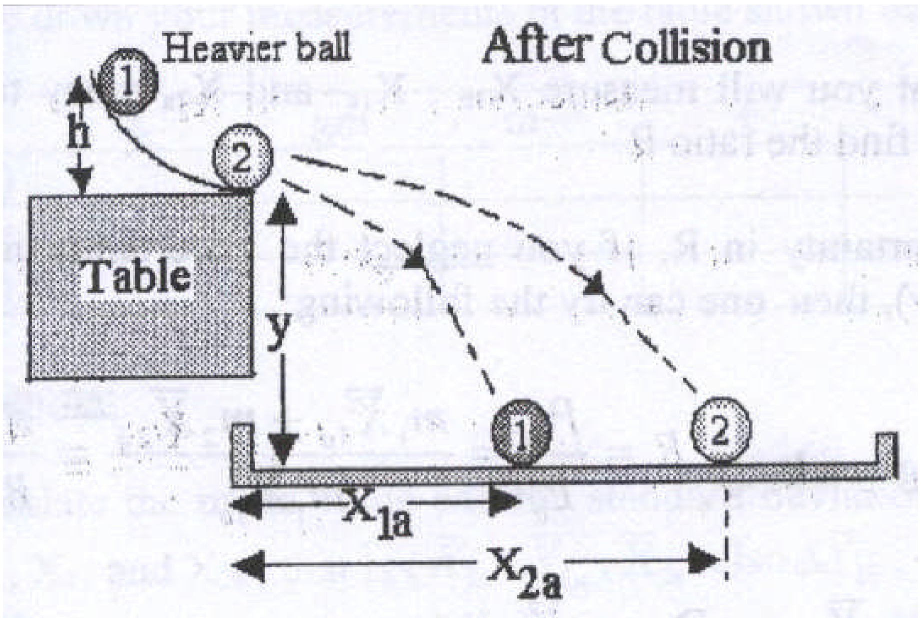


figure .2.

Then we find the horizontal speed of each ball to be :

$$V_{1b} = \frac{X_{1b}}{t} = \frac{X_{1b}}{\sqrt{2y/g}} \Rightarrow P_{1b} = \frac{m_1 X_{1b}}{\sqrt{2y/g}}$$

$$V_{1a} = \frac{X_{1a}}{t} = \frac{X_{1a}}{\sqrt{2y/g}} \Rightarrow P_{1a} = \frac{m_1 X_{1a}}{\sqrt{2y/g}}$$

$$V_{2a} = \frac{X_{2a}}{t} = \frac{X_{2a}}{\sqrt{2y/g}} \Rightarrow P_{2a} = \frac{m_2 X_{2a}}{\sqrt{2y/g}}$$

Substituting the equations in the equation of R we find that :

$$R = \frac{P_a}{P_B} = \frac{m_1 \overline{X}_{1a} + m_2 \overline{X}_{2a}}{m_1 \overline{X_{1b}}} = \frac{A}{B}$$

Where:

$$A = m_1 \overline{X}_{1a} + m_2 \overline{X}_{2a} \qquad B = m_1 \overline{X_{1b}}$$

$$\frac{\Delta R}{R} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$$

where $\Delta A = m_1 \Delta \overline{X}_{1a} + \overline{X}_{1a} \Delta m_1 + m_2 \Delta \overline{X}_{2a} + \overline{X}_{2a} \Delta m_2$

and $\Delta B = m_1 \Delta \overline{X}_{1b} + \overline{X}_{1b} \Delta m_1$

Procedure:

First we fixed the curved track on a table and fixed the tray of sand certainly under the edge of the table . Then we chose two balls which have almost the same diameters to be used in the experiment. After that we rolled the ball no. 1 on the track and measured the distance $\overline{X}_{1b}$ on the sand , and then we made the surface of the sand flat as it was before the ball fell over it. We repeated this operation five times.

After that we stopped ball 2 on the edge of the track and then we rolled the ball no.1 toward ball 2 to make a collision between the two balls . Then we measured the distances $\overline{X}_{1a}$ and $\overline{X}_{2a}$ on the sand after each time we made the surface of the sand flat again. We repeated this five times.

Then we measured the masses of the two balls with the balance scale and repeated the measurement for each ball two times for checking.

The data we got is shown in the table.

Data:

$m_1 = 16.71$ g , $m_2 = 4.96$ g , $\Delta m_1 = 0.05$ g , $\Delta m_2 = 0.05$ g

No.						**Average**
$X_{1b}(cm)$	42.7	42.8	42.5	42.6	42.8	42.68
$X_{1a}(cm)$	25.8	25.4	26	26.7	26	25.98
$X_{2a}(cm)$	64.1	64.8	66	65.7	66	65.32

Calculations:

$$R = \frac{m_1 \overline{X}_{1a} + m_2 \overline{X}_{2a}}{m_1 \overline{X}_{1b}} = \frac{16.71 \times 25.98 + 4.96 \times 65.32}{16.71 \times 42.68} = \frac{758.113}{713.1828} = 1.062999 = 1.06$$

$$\Delta X_{1a} = \sigma_m = \frac{\sigma_s}{\sqrt{5}} = \frac{0.471168759}{2.236067978} = 0.210713075 = 0.2cm$$

$$\Delta X_{2a} = \sigma_m = \frac{\sigma_s}{\sqrt{5}} = \frac{0.84083292}{2.236067978} = 0.376031913 = 0.4cm$$

$$\Delta X_{1b} = \sigma_m = \frac{\sigma_s}{\sqrt{5}} = \frac{0.130384048}{2.236067978} = 0.058309518 = 0.06cm$$

$$A = m_1 \overline{X}_{1a} + m_2 \overline{X}_{2a} = 758.113 g.cm$$
$$B = m_1 \overline{X_{1b}} = 713.1828 g.cm$$

$$\Delta A = m_1 \Delta \overline{X}_{1a} + \overline{X}_{1a} \Delta m_1 + m_2 \Delta \overline{X}_{2a} + \overline{X}_{2a} \Delta m_2$$
$$= 16.71 \times 0.21071 + 25.98 \times 0.05 + 4.96 \times 0.376031 + 65.32 \times 0.05 = 9.951133772 g.cm$$

$$\Delta B = m_1 \Delta \overline{X}_{1b} + \overline{X}_{1b} \Delta m_1 = 16.71 \times 0.058309518 + 42.68 \times 0.05 = 3.108352046 g.cm$$

$$\frac{\Delta R}{R} = \frac{\Delta A}{A} + \frac{\Delta B}{B} = \frac{9.951133772}{758.113} + \frac{3.108352046}{713.1828} = 0.017484316$$
$$\Delta R = 0.017484316 \times 1.062999 = 0.018585811 = 0.02$$

$$R = 1.06 \pm 0.02$$

Results and Conclusion:

$$R = 1.06 \pm 0.02$$

I think that the result here is different a little from the real value (the result here ranges between 1.04 – 1.08 while the real value is 1.00) and this is related for some expected systematic errors during the experiment .

First if the lower of the track is not horizontal this would make the ball 1 before collision has a vertical with the horizontal one which we assumed that the vertical speed is zero and this would decrease our measurement for the horizontal distance on the sand. And like this would happen when the collision happens that the ball 1 would push the other ball with a force which is not horizontal so that it would affect on the angle of flying for each ball and make the horizontal distances measured on the sand less than the wanted one.

On the other hand the two balls we have chosen could be not the same diameters which we assumed at the beginning and this would affect that the force from the pushing ball won’t be horizontal because the centers of the two balls won’t be on a straight line as we assumed to make the velocities of the two balls horizontal and this would affect the measure of the horizontal distances just as when the track is not horizontal.

In another way the measurements taken with every instrument can’t be very accurate because we always take the middle of the hole the ball would make when it falls on the sand and this estimation for the center of the hole can’t be always very accurate because it depends on the sight which not accurate.

BIRZEIT UNIVERSITY
Physics Department

Physics 111

Experiment No. 6

Index of Refraction

Student's Name: **Ahmad Bader**- Student's No. **: 1071477**

Partner's Name: **Tha'er Majdoba** - Partners' No. **: 1070925**

Instructor: **Dr. Yakoob Anini** Section No.: **3**

Date: 6-4-2008

– **Abstract:**

1)The aim of the experiment:

is to measure the index of refraction of transport for a kind material (Glass or Plastic) , and to use least square fit method .

2) The method used:

is by measuring the angles of the reflection of the light when it falls throw a medium like glass by placing a block of glass on a piece of white paper .

3) The main results are:

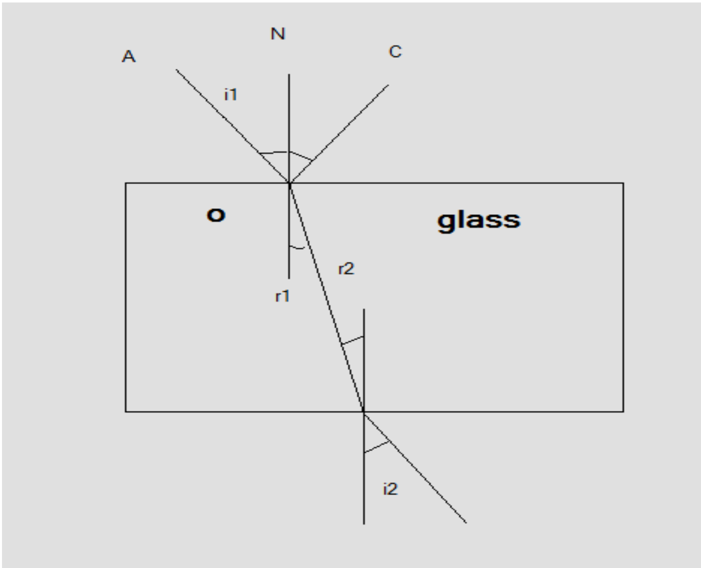
$\mu = 1.46 \pm 0.03$

– **Theory:**

When light passes from one medium to another, the path of the light bends, Examples of media are glass , plastic, water and air different colors bend by different amounts at the boundary between the two media that bending is called " refraction " and each medium has it's own refraction index N due that not all media bend a given light by the same amount (index of refraction = speed of light in vacuum / speed of light in the medium)

$$n = \frac{c}{v}$$

The refraction index is a measure of how much bending will occur for the light when it falls on a medium in the figure below:



When light falls on a block of glass from air AO represent a rag of light traveling in air incident on the surface of the block , OC represent the reflected ray, OB represents the refracted ray while ON represent the normal to the block surface "I" is the angle of incidence while "r" is the angle of refraction applying Snell's law which is :

$$\mu_a \sin(i) = \mu_g \sin(r)$$

μ_a is the index of refraction of air which is near that of the vacuum ($\mu_a \approx 1$). μ_g is the index of refraction of the glass.

Then:

$$\sin(i) = \mu_g \sin(r) = \mu \sin(r)$$

$$\sin(i) = \mu \sin(r)$$

Then we can find μ from the plot of sin(i) vs. sin(r). The error in μ is founded by:

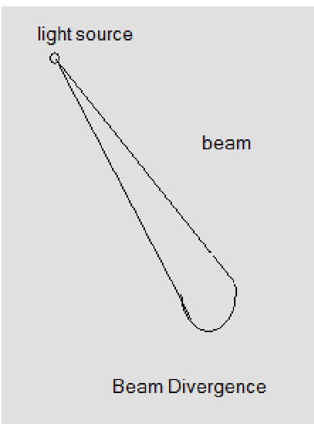
$$\mu = \frac{\sin(i)}{\sin(r)}$$

$$\Delta\mu = \left|\frac{\cos(i)\Delta i}{\sin(r)}\right| + \left|\frac{-\sin(r)\cos(i)\Delta r}{\sin^2(r)}\right|$$

$$\Rightarrow \frac{\Delta\mu}{\mu} = \frac{\cos(\mathrm{i})}{\sin(\mathrm{i})}\Delta i + \frac{\cos(\mathrm{r})}{\sin(\mathrm{r})}\Delta r$$

Procedure:

The block was placed on a piece of white paper the borders of block were drown in the paper . The angle of incidence were marked as shown on the figure on the previous page the first angle was choosed near 10 , the second angle near 20 , and so a narrow bean of light was shone exactly on path 1, then the path was marked and labeled this procedure was repeated for five more times for other angle from 20 to 60 , the block was removed and for eash outgoing bean , a perpendicular line was drown to the block boundary at each exit point, the exist point and the incident point were connected for each incident and out going $i_1 = i_2)$,$(\mathrm{r}_1 = r_2)$ for each incident and outgoing beam were measured and written down in the table below after all Δr & $\Delta \mathrm{i}$ were estimated in radians .



– **Data:**

NO.	Angle (i) degree		i average	Sin ($\bar{i}$)	Angle (r) degree		r average	Sin ($\bar{r}$)
	i_1	i_2			r_1	r_2		
1	10	9	9.5	0.17	7	6	6.5	0.11
2	20	20	20	0.34	13	12	12.5	0.22
3	30	27	28.5	0.48	20	18	19	0.33
4	40	36	38	0.62	26	25	25.5	0.43
5	50	48	49	0.76	32	31	31.5	0.52
6	60	60	60	0.87	36	35	35.5	0.58

– **Calculations: (Using Least Square Fit method**)

Let x= Sin ($\bar{r}$), y= Sin ($\bar{i}$)

x_i	y_i	$x_i y_i$	x_i^2	$y_i - mx_i - b$	$(y_i - mx_i - b)^2$
0.11	0.17	0.019	0.0121	0.075	5.625*10
0.22	0.34	0.075	0.0484	0.079	6.241*10
0.33	0.48	0.16	0.1089	0.053	2.81*10
0.43	0.62	0.27	0.1849	0.042	1.764*10
0.52	0.76	0.4	0.2704	0.046	2.116*10
0.58	0.87	0.5	0.3364	0.066	4.356*10
$\sum x_i$= 2.19	$\sum y_i$= 3.24	$\sum x_i y_i$= 1.424	$\sum x_i^2$= 0.96		$\sum(y_i - mx_i - b)^2$= 0.022912 = 0.023

$$D = N\sum x_i^{\ 2} - (\sum x_i)^2$$ = 0.96

$$m = (N\sum x_i y_i - \sum x_i \sum y_i)/D$$ = 1.46

$$b = (\sum x_i^{\ 2} \sum y_i - \sum x_i \sum x_i y_i)/D =$$ = 0.008127

<u>Calculation of errors:</u>

$$\sigma_y^{\ 2} = \frac{1}{N-2}\sum (y_i - mx_i - b)^2 =$$ = 1.44*10

$$\Delta\mu = \sigma_m = \sqrt{\frac{N\sigma_y^{\ 2}}{D}} =$$ = 0.033843 = 0.034=0.03

$$\Delta b = \sigma_b = \sigma_y\sqrt{\frac{\sum x_i^{\ 2}}{D}} =$$ = 0.013611 = 0.014=0.01

– **<u>Results and conclusion:</u>**

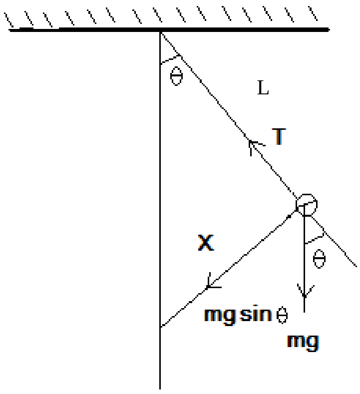
μ = 1.46 ± 0.03

According to the range test , our range in this experiment is 1.43< μ <1.49 and the theoretical value of M of glass is 1.52 , so our experimental value is not included in the range , so the range test failed … so our experiment failed systematic errors exist due to use a glass block which have not equally borders and they were inaccurate , and there were systematic errors due to, that we had estimated the middle of the light bean each time so in conclusion we were able to find the index of refraction of glass and learn how to use the least square fit method ,

ABSTRACT:

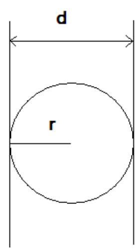
1. The aim of the experiment is: to measure the acceleration of gravity (g) at BZU.
2. The method used is: simple pendulum method.
3. The main result is : $g = 960 \pm 30$ cm/s^2

THEORY:



First of all we have to make a few assumptions which are needed for making the experiment to be successful. Those assumptions are: the string is weightless, the ball is completely spherical, and the angle between the string and the normal is too small so that $q = \sin(q) = \tan(q)$ where q is the angle between the string and the normal measured with radian measure which is without a unit.

Where L is the length of the string taking in our accounts the radius of the ball where we take the radius and add it to the length of the string to have the right measurement we want to have to be accurate in the other measurements after it , surely , we took the radius of the ball because we considered the ball as spherical body 100%.



$$L = S + d / 2$$

We take :

$$mg \cos(q) = T$$

By Newton's second law:

$$F=ma$$

By substitution :

$$-mg\ \sin(q) = m\frac{d^2x}{dt^2}$$

While $$\frac{d^2x}{dt^2} = -g\sin(q) @ -g\tan(q) = -g\frac{X}{L}$$

$$\frac{d^2x}{dt^2} = \frac{-g}{L}X$$

So that the equation is a straight line equation :

$$X = A\sin(wt)$$

$$\frac{dx}{dt} = wA\cos(wt)$$

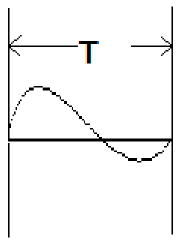
$$\frac{d^2x}{dt^2} = -w^2A\sin(wt)$$

$$= -w^2X$$

$$-w^2X = -\frac{g}{L}X$$

$$w = \sqrt{g/L}$$

$$T = \frac{2p}{w} = 2p\sqrt{L/g}$$



To find the best estimation for the angle could be found for it to as small as we want by measuring the values of the sin & tan for a number of angles as shown in the table below(table2).

To find the wanted quantity which is (g) we make a graph of T^2 vs. L we find the slope $\frac{4p^2}{g}$ and so we find (g).

The error could be found by the following :

$$g = \frac{4p^2}{m}$$ Where

Then $\quad Dg = \frac{4p^2}{m^2} Dm \text{ Þ } \frac{Dg}{g} = \frac{Dm}{m}$

For the graph which we are going to draw :
After we draw the points on the graph we start to find the best equation of the straight line for the points, of course we find this equation by finding the best slope , and the best Y-intercept for the equation.

The best estimation for the best line is that line that intersects the larger number of the data points, and also is the line that the points on each side of it have the same sum of distances, between it and the line, and those on the other side.

Simply we make a calculation for the estimated distances for the points from the line and then we make the real and best equation for the line.
Those equations are shown in the calculations below.

First we draw the points and then we draw the line from the equation get from the calculations, so that we consider if our work is good or there is some errors in it.

PROCEDURE:

First of all we took the measurement of the radius of the ball with a caliper by taking the measurement of diameter and dividing it by 2.

Radius = diameter/2

Then we fixed the pendulum on the table after fixing the string and the ball strongly on the stand.

Then we measured the length of the string to the edge of the ball and added it to our measurement of the radius which we took before and wrote it in the table below.

After that we fixed the angle of the string (between it and the normal) to be at most 15 degrees. At that moment we let the bal to oscillate freely ,after starting the timer with it , for ten times and then stopped the timer and measured that period and wrote it down in the table. We repeated the measurement of time for the same situation each time for three times and at the end we took the average of them to have the right time.

We increased the length of the string each time of about 20-30 cm and repeated our measurements ,but , keeping the angle to be almost the same.

DATA:

No.	S	L				**t**	One	t^2

	(string length-cm)	(Whole length-cm)	t1	t2	t3	**average**	period	sec^2
1	47.40	48.420	13.77	13.77	13.86	13.80	1.380	1.904
2	78.30	79.320	17.87	17.72	17.80	17.80	1.780	3.167
3	106.5	107.52	20.87	20.63	20.59	20.70	2.070	4.284
4	142.6	143.62	23.33	23.91	23.86	23.70	2.370	5.618
5	156.7	157.72	25.52	25.69	25.63	25.61	2.561	6.560
6	182.2	183.22	27.20	27.36	27.33	27.30	2.730	7.451

Diameter = 2.04 cm
Radius = diameter/2 = 2.04/2 = 1.02 cm
We add the radius to the string length (S) to get the whole length wanted (L).

q degrees	q *radian*	$\sin(q)$	$\tan(q)$	$\frac{\tan(q) - \sin(q)}{\tan(q)} \times 100\%$
5	0.0873	0.0872	0.0875	0.38%
10	0.175	0.174	0.176	1.52%
15	0.262	0.259	0.268	3.41%
20	0.349	0.342	0.364	6.03%
30	0.524	0.500	0.577	13.4%
45	0.785	0.707	1.00	29.3%
60	1.05	0.866	1.73	50.0%
75	1.31	0.966	3.73	74.1%

From the table above we see that the angle in radian equals its sin and also its cos during the range of 0 – 20 degrees but not above that range so that we used the angle to be small enogh which is almost 15 degrees to fit with the differenciated formula which depends on the tan of the angle which equals it.

CALCULATIONS:

$A=\sum_{i=1}^{6} L_i =$ 719.82 cm $H=\sum_{i=1}^{6} T_i^2 =$ 28.98354211 s^2

$F=\sum_{i=1}^{6} L_i T_i^2 =$ 4010.595351 $cm.s^2$ $Z=\sum_{i=1}^{6} L_i^2 =$ 99268.5804 cm^2

$\overline{T^2} =$ 4.830590352 s^2 $\overline{L}$ = 119.97 cm

For demonstration here are the values for LT^2 from which we calculated the sum of them:

The values of LT^2

92.211048	**251.223370**	**460.5640823**	**806.699178**	**1034.710774**	**1365.186898**

$$D = N\left(\sum_{i=1}^{6} L_i^2\right) - \left(\sum_{i=1}^{6} L_i\right)^2 = 6(99268.5804) - (518140.832) = 77470.65$$

$$\textit{Best slope},\ m = \frac{N \times F - A \times H}{D} = \frac{6(4010.595351) - (719.82)(28.98354)}{77470.65} = 0.041314$$

$$\approx 0.04 s^2/cm$$

$$\textit{Best y-intercept},\ b = \frac{Z \times H - A \times F}{D} =$$

$$= \frac{(99268.5804)(28.98354211) - (719.82)(4010.595351)}{77470.65} = -0.125875608$$

So that we see that the equation of the best line is :

$$y = 0.041314\text{ x} - 0.125875608$$

For calculating the error :

$k_i = T_i^2 - mL_i - b$	0.029841	0.016056	-0.032708	-0.19077	0.17023	0.0073659
k_i^2	0.00089051	0.00025747	0.0010698	0.036394	0.028977	0.000054256

$\sum_{i=1}^{6} k_i^2 = 0.0676429$

$\sigma_y^2 = \frac{1}{N-2}\sum_{i=1}^{6} k_i^2 = 0.016910729$

$\sigma_m^2 = \frac{N\sigma_y^2}{D} = 2.455932013$

$\Delta m = 1.56714135$

$\sigma_b^2 = \frac{\sigma_y^2}{D} Z = 40632.814$

$\Delta b = 201.57583$

$$g = \frac{4\pi^2}{m} = 955.5672614 = 960\ cm/s^2$$

For calculating the error in g :

$$\frac{\Delta g}{g} = \frac{\Delta m}{m} \Rightarrow \Delta g = g\frac{\Delta m}{m}$$

$$\Delta g = 955.5672614 \times \frac{1.56714135}{0.041314} = 26.469 \approx 30 cm/s^2$$

Then:

$$g = 960 \pm 30\ \text{cm/s}^2$$

RESULTS AND CONCLUSION:

$g = 960 \pm 30$ cm/s^2

First we say that the real known (g) nationally is to equal (9.81 m/s2), but in our case here we see that it differs, but , that is normal because as we know that the place we tried to measure it from is higher than the sea level from which the national value for the known (g) were measured. As a result for the high level we expect that the value for (g) will be smaller, and this results from the general law of gravitation were the center of earth will be farther than the sea level and so the radius of earth at that point which affects the result to be less than known. So that we see that the result is within the expected new value for the location of Birzeit university where we made the experiment.

About the experimental errors, we always expect some systematic errors and also random errors (which always occur) to be found as there is no perfect results could be obtained in any experiment in the real world as always we return our measurements to our senses and also our tools which are also inaccurate or not accurate as we hope to make perfect results.

One expected error is caused from the measurement of time lasted for the oscillating of the pendulum and that error is a result of the delay of our natural response between the two operations of seeing the moment of the stop or the starting of the pendulum and the moment when the brain responds and sends the signal to make the timer tool stops or starts and that affects the measurement of time intervals and that would of course affect also our later calculations. (It is as we know some mental operation which lasts of about 0.1 of a second).

A second expected error is that we supposed the cord to be weightless and that the ball is completely spherical and also our neglection of the air friction with our ball. These all are factors which would affect the measurement but we neglect them all because , of course , of the simple ways we use, the simple tools we have, and because the aim of the experiment is only to learn simple method for measuring things which looks so complicated, but not to find the real exact value for the wanted variable.

There is another point which we must consider always which is that the line we draw on the plot sheet is not always accurate and that returns for some reasons which depends on the scale we use and other factors. But one of the important things which makes a difference, of course after the scale we take according to the paper we have, is the thickness of the pencil we use to draw the line and that always makes a difference from what we want.

جامعة بيرزيت

BIRZEIT UNIVERSITY
Physics Department

Physics 111

Experiment No. 8

Half-Life of a Draining Water Column

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Partner's Name: Ahmad Qamhiya Partners' No. : 1081923

Instructor: Dr. Ya'kob Anini Section No.: 5

Date:17/11/2008

– **Abstract:**

1) The aim of the experiment: to measure the decay constant and the half-life of a draining column of water.

2) The method used: - the Burette method.

3) The main results are:

$t_{½}$= 67 ± 5 sec (h vs. t graph)

$t_{½}$= 69 sec (Ln (h) vs. t graph)

-Theory:- We consider a tube having water in it of a height (h_0) at time (t_0). When we open the valve water drains from it at some rate.

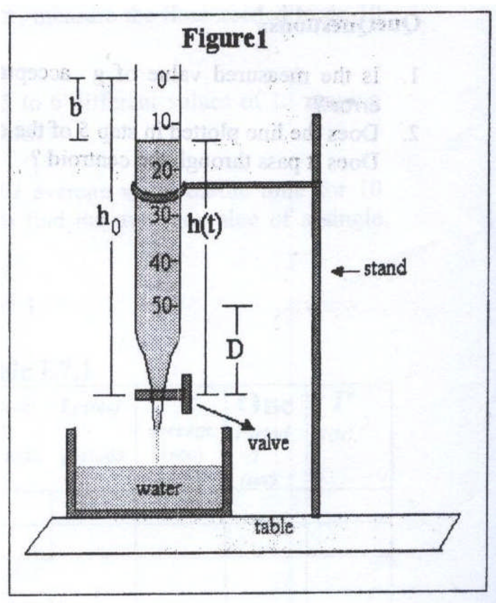


Figure1

The rate of the decay of the water column is proportional to its height (h) that is:

$$\frac{-dh}{dt} \propto h(t$$

λ is a constant:

$$\frac{-dh}{dt} = \lambda\, h(t)$$

Multiplying the last equation by
dt and dividing by h(t) we get

$$\frac{dh}{h} = -\lambda\, dt$$

$$\int_{h0}^{h(t)} \frac{dh}{h} = \int_{0}^{t} \lambda\, dt$$

$$Ln\, h(t) - Ln\, h_0 = -\lambda\, t$$
$$h(t) = h_0 e^{-\lambda t}$$

So that λ is the decay constant.

When h(t) = $\frac{h_0}{2}$ then:

$$\frac{h_0}{2} = h_0 \;\; e^{-\lambda t_{1/}}$$

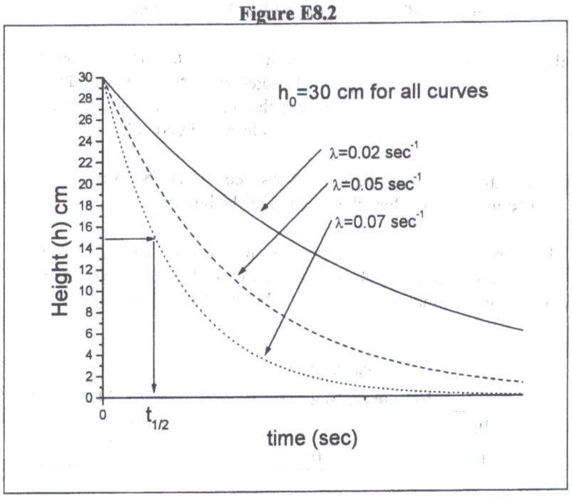
$$\frac{1}{2} = e^{-\lambda t}$$

$$-\lambda\, t_{\frac{1}{2}} = -Ln2$$

$$t_{\frac{1}{2}} = \frac{Ln2}{\lambda}$$

When λ is greater then $t_{1/2}$ is smaller:

Figure E8.2



- **<u>Procedure:</u>**

– The total burette length h0 was measured in burette units which is (h0= 50 units + D {in burette units} , D was measured in cm's then was converted into burette units , then the burette was filled with water using the funnel , the valve was adjusted such the water will drain in about 3 minutes during the experiment the valve setting wasn't changed and the burette was clean and vertical , the reading of the burette (b) was measured every 10 second , the opening of the burette was closed using my finger then the burette was filled again with water to same initial height without changing the setting of the valve and taking measurements were repeated for two more times and written down in the table that is shown in the next page .

Data:

Total burette length h_0 = 58 u in burette units (u)

Time (sec.)	Burette reading (u)			$\bar{b}$	$h = h_0 - \bar{b}$	Ln (h)
	b_1	b_2	b_3			
0	0	0	0	0	58.0	4.1
10	4.5	3.7	3.7	4.0	54.0	4.0
20	8	7.5	7.5	7.7	50.3	3.9
30	11.5	11.0	10.9	11.1	46.9	3.8
40	15.3	14.5	14.5	14.8	43.2	3.8
50	18.5	17.7	17.8	18.0	40.0	3.7
60	21.5	20.9	20.7	21.0	37.0	3.6
70	25.0	26.1	23.7	24.2	33.8	3.5
80	28.0	26.8	26.6	27.1	30.9	3.4
90	30.5	29.7	29.6	29.9	28.1	3.3
100	33.3	32.2	32.4	32.6	25.4	3.2
110	35.7	34.8	35.1	35.2	22.8	3.1
120	38.5	37.4	37.5	37.6	20.4	3.0
130	40.5	39.6	40.0	40.0	18.0	2.9
140	4307	41.8	42.0	42.	15.7	2.8
160	46.8	46.0	46.0	46.3	11.7	2.5
170	48.6	48.0	47.7	48.1	9.9	2.3

– **Calculations:**

1) From h vs. t graph paper (Obtain 6 values for $t_{½}$ **)**

$t_{½}$ (sec)	**82**	**73**	**60**	**65**	**56**	**66**

The average value of $t_{½}$ is:

$t_{½}$= **67 sec.**

$\Delta t_{½} = \sigma_m(t_{½}) = 3.8$ sec

2) From ln (h) vs. t graph:

Slope = $-\lambda$ = - 0.01006 sec^{-1}

$t_{½} = Ln(2) / \lambda = 69$ sec

– **Results and conclusion:**

$t_{½}$=	67 ± 5 sec	(h vs. t graph)
$t_{½}$=	69 sec	(Ln (h) vs. t graph)

According to Range test the practical value of the half life of a draining water column equals 69 sec , according to the graph of (Ln) vs. t but our Range of experiment 62<t<72 so it's included in our range and our result is accepted and our experiment succeeded ,so it succeeded too and the systematic errors were due to period reaction time and how to deal with the stop watch and how to estimate the length of the burette before the experiment .

Birzeit University
Physics Department
Physics 111

Experiment No.9

RC circuit

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Section: 8

Date : 1/12/2004

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Abstract:

1)The aim of the experiment is to find the time constant τ of an RC circuit and the value of its capacitor.
2)The method used is by measuring the voltage on the capacitor at certain moments in a charging and a discharging circuits.
3)**The main result is**:

$C = 21 \pm 1 \mu F$

Theory:

Lets consider the series RC circuit shown in figure 1, consisting of a capacitor C and a resistance R connected in series to a voltage source ε , at t=0 the capacitor is uncharged that is, $Q_0 = 0$, when the circuit is closed then the capacitor will start charging.

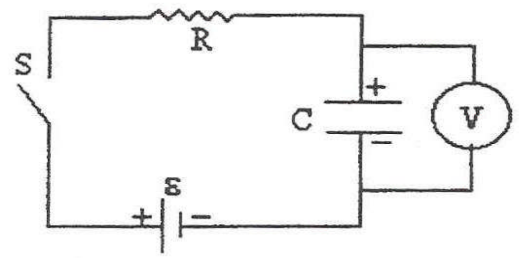


Figure 1

Here are the two states , charging and discharging , we will treat at this experiment:

A. Charging:

From Kirchhoff's second rule , which implies that the sum of all voltage drops over a closed group is zero ($\sum_{i=1}^{n} V_i = Zero$) we find that ,in our circuit, :

$$\varepsilon - IR - \frac{Q}{C} = 0 \Rightarrow I = \frac{\varepsilon}{R} - \frac{Q}{RC} \Rightarrow \frac{\partial Q}{\partial t} = \frac{\varepsilon}{R} - \frac{Q}{RC}$$

$$\Rightarrow \frac{\partial Q}{\frac{\varepsilon}{R} - \frac{Q}{RC}} = \partial t \qquad ;(\text{as } I = \frac{\partial Q}{\partial t})$$

Integrating both sides:

$$\int_{Q=0}^{Q(t)} \frac{1}{\frac{\varepsilon}{R} - \frac{Q}{RC}} \partial Q = \int_{0}^{t} \partial t \Rightarrow -RCLn\left(\frac{(\varepsilon/R) - (Q/RC)}{\varepsilon/R}\right) = t$$

$$Ln\left(\frac{(\varepsilon/R) - (Q/RC)}{\varepsilon/R}\right) = \frac{-t}{RC}$$

Exponentiating both sides , we get :

$$\frac{(\varepsilon / R) - (Q / RC)}{\varepsilon / R} = e^{\frac{-t}{RC}} \Rightarrow 1 - \frac{Q}{\varepsilon C} = e^{\frac{-t}{RC}}$$

$$\Rightarrow Q(t) = \varepsilon C(1 - e^{\frac{-t}{RC}})$$

and as the voltage on the capacitor has the relation (V=Q/C) with the charge on it , thus:

$$V(t) = \varepsilon(1 - e^{\frac{-1}{RC}})$$

At the time t=RC ,which is known as the time constant τ of the circuit the voltage on the capacitor is:

$$V(t = RC) = \varepsilon(1 - e^{-1}) = \varepsilon(1 - \frac{1}{e}) = 0.63\varepsilon \qquad \text{E1}$$

We see from equation E1 that the time constant τ is the time needed for the potential difference on the capacitor V(t) to reach 0.63 of the maximum voltage ε .

Note : τ can be found from the graph of the charging curve as that of figure 3 by drawing a parallel line to the t-axis passes through 0.63 ε volts on the v-axis , then by drawing a parallel line to the v-axis , from the point where the first line cuts the curve of V vs. t , and the point where it cuts the t-axis is τ as shown in figure 2.

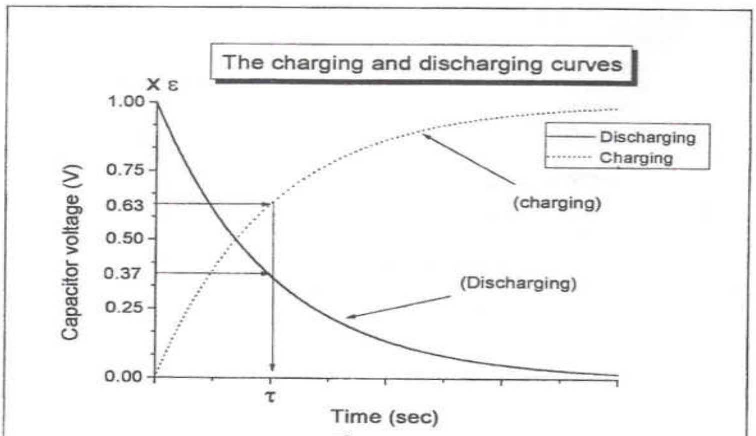


Figure 2

B. Dicharging:

After the capacitor has been charged, and if we removed the power supply, and a resistance R is connected ,by series, to this circuit as shown in figure 3 , the capacitor has an initial potential difference of ε and an initial charge of $Q_0 = C\varepsilon$ .Then the capacitor will start discharging through the resistance . Back again to Kirchhoff's second rule ;

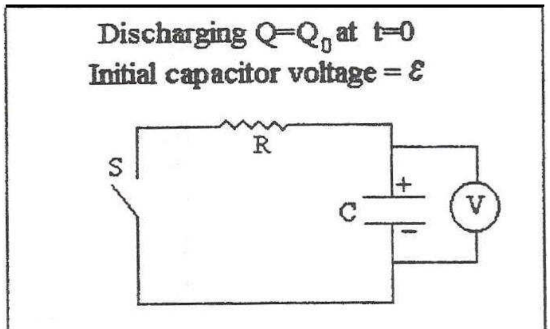


Figure 3

$$-IR - \frac{Q}{C} = 0 \Rightarrow -\frac{\partial Q}{\partial t}R - \frac{Q}{C} = 0 \Rightarrow R\frac{\partial Q}{\partial t} = -\frac{Q}{C}$$

Dividing both sides by RQ;

$$\frac{\partial Q}{Q} = -\frac{1}{RC}\partial t$$

Integrating both sides;

$$\int_{Q=0}^{Q(t)} \frac{\partial Q}{Q} = -\frac{1}{RC}\int_0^t \partial t \Rightarrow LnQ(t) - LnQ_0 = -\frac{1}{RC}t$$

$$\Rightarrow Ln(\frac{Q(t)}{Q_0}) = -\frac{1}{RC}t$$

Exponentiating both sides , we get ;

$$\frac{Q(t)}{Q_0} = e^{-\frac{1}{RC}t} \Rightarrow Q(t) = Q_0 e^{-\frac{1}{RC}t} \Rightarrow Q(t) = \varepsilon C e^{-\frac{1}{RC}t}$$

And as the voltage on the capacitor V =Q/C ;

$$V(t) = \frac{Q(t)}{C} = \varepsilon e^{-\frac{t}{RC}}$$

And at time t=τ ;

$$V(t = RC) = \varepsilon e^{-1} = \frac{\varepsilon}{e} = 0.37\varepsilon$$

E2

From the discharging curve as that shown in figure 2 we can find τ , but this time the first line cuts the v-axis at v=0.37ε volts (see figure 2).

A third way for finding τ is from the linear equation we get from taking the natural logarithm of both sides of equation E2 ;

$$Ln\{v(t)\} = Ln\,\varepsilon e^{-\frac{t}{RC}} \rightarrow Ln\{v(t)\} = Ln\,\varepsilon - \frac{t}{RC} \qquad \text{E3}$$

Equation E3 gives a linear equation with the y-intercept Ln(ε) and with a slope $m = -1/RC = -1/\tau$.
So $\tau = -1/m$
The value of the unknown capacitor can be found using this equation :

$$C = \frac{\bar{\tau}}{R}$$

The uncertainty in C ΔC is found by taking the partial derivative of the later equation , thus;

$$\Delta C = \left|\frac{\Delta\bar{\tau}}{R}\right| + \left|-\frac{\bar{\tau}\Delta R}{R^2}\right| \rightarrow \Delta C = C\left(\frac{\Delta\bar{\tau}}{\bar{\tau}} + \frac{\Delta R}{R}\right)$$

The uncertainty in $\bar{\tau}$, $\Delta\bar{\tau} = \sigma_m(\tau)$,the standard deviation of the mean value of the measurements of τ .The resistance R is measured either by the ohmmeter or using the color code on it, and ΔR , the uncertainty in R, is to be estimated from the multi-meter (switched to as an ohmmeter) or from the color code.

Procedure:

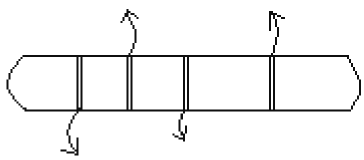
1.We connected the resistance and the capacitor in series and connected the multi-meter in parallel to the capacitor (the anode to the anode and the cathode to the cathode), and the wire which was connected to the positive part of the resistance was connected to the anode of the power supply, and the cathode of the capacitor was connected to the cathode of the power supply.

2.We connected the two terminals of the capacitor to each other by a wire so as to discharge it from any charge , and we kept the them connected .
3.We switched the multi-meter on and switched it to work as a voltmeter and we chose the suitable scale that included the minimum and maximum voltage which was about 5 Volts.
4.My partner removed the mentioned wire at the same time he started the stop watch.
5.My partner counted to five (a number per second was counted) and when he said “five” I read the voltmeter and wrote the measured value down.
6.We repeated step five until I had 3 same successive measured values.
7.We removed the wire connected to the cathode and connected it with that connected to the anode so as to take the power supply away from the circuit. At this moment my partner started the stop watch again (after it was calibrated).
8.We repeated step 5 until the time equaled that of the charging one.
9.We measured the value of the resistance twice : from the color code and using the multi-meter which was switched to work as an ohmmeter.
10.We took the value of the capacitor which was written on it.

Data:

$C = 22\mu F$

(From the color code)



$R = (100 \pm 5) \times 10^4\ \Omega$

(From the multi-meter)[1]

$R = 994 \pm 3\ \Omega$

Time (sec)	Charging $V_{Capacitor}$ (volts)	Discharging $V_{Capacitor}$ (volts)
0	0.00	4.83
5	1.04	3.75
10	1.84	2.96
15	2.47	2.37
20	2.99	1.88

[1] In this measurement the multi-meter was switched to work as an ohmmeter.

25	3.34	1.49
30	3.63	1.18
35	3.90	0.93
40	4.09	0.75
45	4.25	0.60
50	4.37	0.47
55	4.47	0.37
60	4.54	0.30
65	4.60	0.24
70	4.65	0.19
75	4.69	0.15
80	4.72	0.12
85	4.75	0.09
90	4.77	0.08
95	4.78	0.06
100	4.79	0.05
105	4.80	0.04
110	4.81	0.03
115	4.82	0.02
120	4.83	0.02
125	4.83	0.01
130	4.83	0.01

Calculations:

1)From the linear graph paper:

*a) The time constant from the charging curve (τ_c) :

$\tau_c = 20.56$ Sec

*b) The time constant from the discharging curve (τ_d) :

$\tau_d = 21.48$ Sec

2)From the semi-log graph ;

$$Slope = \frac{Ln0.23 - Ln2.96}{65-10} = -0.0462\ Sec^{-1}$$

$\tau_s = 21.60$ Sec (the time constant from the semi-log graph)

$\bar{\tau} = 21.2125$ Sec

$$\Delta\tau = \frac{\sigma_s}{\sqrt{N}} = \frac{0.5721}{\sqrt{3}} = 0.33 Sec$$

Resistance

$R = (100 \pm 5) \times 10^4\ \Omega$

$$C = \frac{\tau}{R} = \frac{21.2}{10^6} = 21.2\times10^{-6} F$$

$$\Delta C = C(\frac{\Delta\bar{\tau}}{\bar{\tau}} + \frac{\Delta R}{R})$$

$$\Delta C = C(\frac{\Delta\bar{\tau}}{\bar{\tau}} + \frac{\Delta R}{R}) = 21.2\times10^{-6}(\frac{0.33}{21.2} + \frac{5\times10^4}{100\times10^4})$$

$$= 21.2\times10^{-6}(0.016 + 0.05) = 1.39\times10^{-6} F$$

$$C = 21 \pm 1\mu F$$

Results & conclusion:

$$C = 21 \pm 1\mu F$$

1.The range of measured value of C is from 20 to 22 μF and so the manufacturer's stated value of C written on the capacitor lies within the range.
2.Increasing the resistance R affects both the charging and discharging processes by increasing the time needed for charging and discharging. Notice that $\tau = RC$
3.The unit of $\tau = RC$ is seconds :

$$[\tau] = [RC] = \Omega\times F = \frac{Votls}{A}\times\frac{colom}{Volts} = \frac{colom}{colom/\sec} = \sec$$

Notice that:

* $R = \frac{V}{I}$
* $C = \frac{Q}{V}$
* $I = \frac{\partial Q}{\partial t}$

4.A systematic error I expect in this experiment is that when my partner finished his periodic counting and I read the value of the voltage it was not the certain value , as sometimes the value changed after its ,relatively, long steady just after he began a new counting. Much more digits are to be taken for the voltage.

Abstract:

1. The aim of the experiment is: to test if the material is Ohmic or non-Ohmic material by the plot and then finding the resistance from it.
2. The method used is: Voltmeter – Ammeter method.
3. The main result is : $R =$

Theory:

The resistance R of a metallic conductor is defined by:

$$R = \frac{voltage}{current} = \frac{V}{I}$$

where I is the current flowing through the conductor and V is the potential difference applied between the endpoints of the conductor.

Materials are divided into two parts according to Ohms' law : Ohmic and Non-Ohmic materials.

For a metallic conductor the resistance is constant provided that the temperature of the wire stays essentially constant because the resistance R doesn't depend on either V or I but on the temperature of the material.

Figure 1.0

We can test if the material is Ohmic or not by plotting a graph of the potential difference V across the material against the current I through it keeping the temperature of the material constant. If the graph is not a line the material is Non-Ohmic.

If two resistors are connected in parallel then we can substitute our resistor equivalent to both of them of magnitude R_p where:

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow R_p = \frac{R_1 R_2}{R_1 + R_2}$$

If two resistors are connected in series then the resistors could be replaced by a single equivalent resistor R_s :

$$R_s = R_1 + R_2$$

The uncertainty in R (ΔR) is calculated by:

$$\frac{\Delta R}{R} = \frac{\Delta V}{V} + \frac{\Delta I}{I}$$

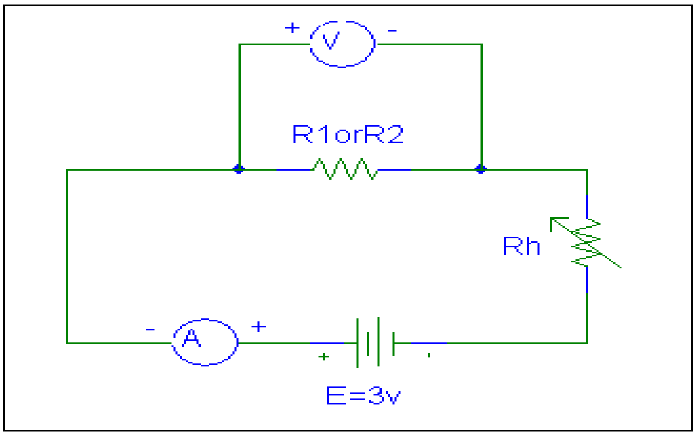
Procedure:

A. One Resistance:

We connected the following circuit using only one resistance which was R1.
We are provided with a power supply of 3 or 4 volts.

Figure 2.0

A circuit with one resistance.



We estimated the uncertainty in our measurements in the current and voltage from the scale of the voltmeter and the ammeter we used ($\Delta I, \Delta V$). As we used the scale of 3 volts in the voltmeter where every volt is divided into tenths our estimation of ΔV was $\Delta V = 0.1 volts$, also we used the scale of 50mA in the ammeter so we estimated $\Delta I = 2.0 mA$.

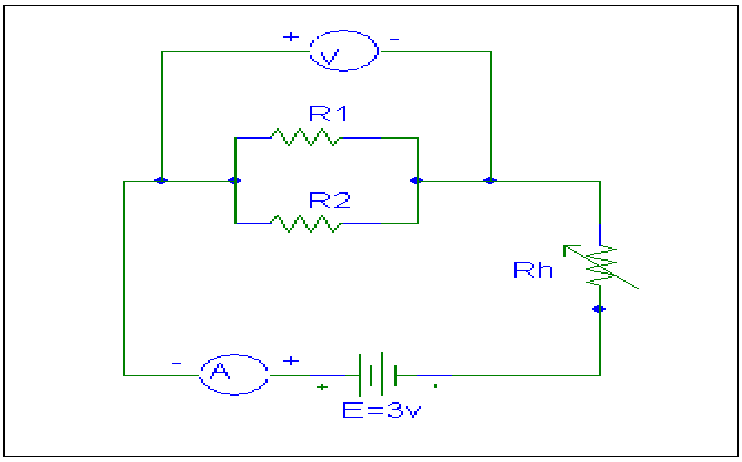
Then we measured the current I in the resistor and the potential difference V across the resistance. After that we changed the current by adjusting the variable resistor Rh and again measured I and V. We repeated the changing for 6 times and wrote down our measurements . We tried to take as large range as possible (a difference of 0.5 volt each time).

B. Two Resistors in Parallel:

We connected the following circuit with the resistors R1 and R2 in parallel as in the following circuit.

Figure 3.0

A circuit with two resistances connected in parallel.



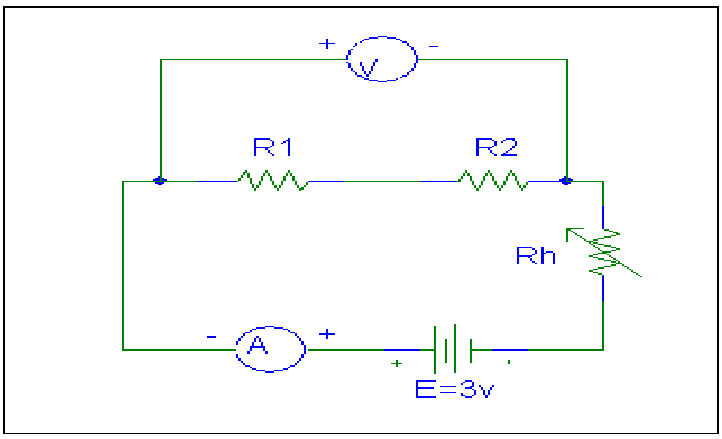
We estimated the error in our readings of I and V as we did before because we used the same scales in each of the ammeter and the voltmeter. After that we wrote down the reading (only one time) .

C. Two Resistors in Series:

We connected the following circuit with resistors R1 and R2 in series as the following circuit:

Figure 4.0

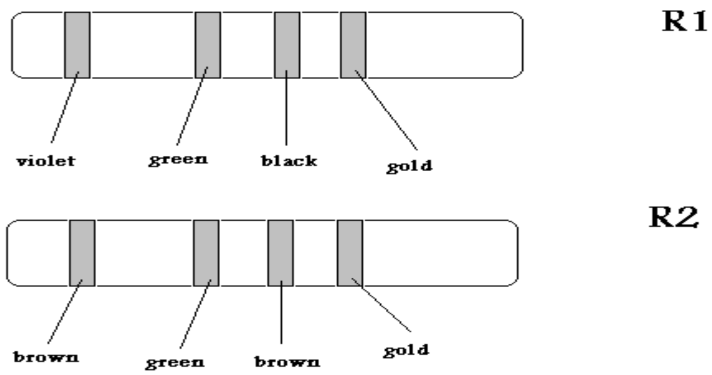
A circuit with two resistors connected in series.



We estimated the error in reading our values as we did before because we used the same scale in each of the voltmeter and the ammeter. We wrote down the readings of the ammeter and the voltmeter (only one time).

D. The Values of the two resistors using the color code:

The two resistors were as shown in the following sketches:



Data:

No.	1	2	3	4	5	6	7	Average
I (mA)	46	38	30	22	14	10	4.0	23
V(volts)	3.0	2.5	2.0	1.5	1.0	0.7	0.3	1.6

Calculations:

Results and Conclusion:

$R_s = R_1 + R_2$

$R_s = R_1 + R_2$

$R_s = R_1 + R_2$

The calculation of each resistor includes a part of the other's period of error range. Also the results calculated were corresponding (with its range of error) with the values read with the color code. We assume that our calculations were somehow precized.

BIRZEIT UNIVERSITY
Physics Department

Physics 111

Experiment No. 6

Index of Refraction

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Instructor: **Dr. Yakoob Anini**   Section No.: **3**

Date: 6-4-2008

– **Abstract:**

1)The aim of the experiment:

is to measure the index of refraction of transport for a kind material (Glass or Plastic) , and to use least square fit method .

2) The method used:

is by measuring the angles of the reflection of the light when it falls throw a medium like glass by placing a block of glass on a piece of white paper .

3) The main results are:

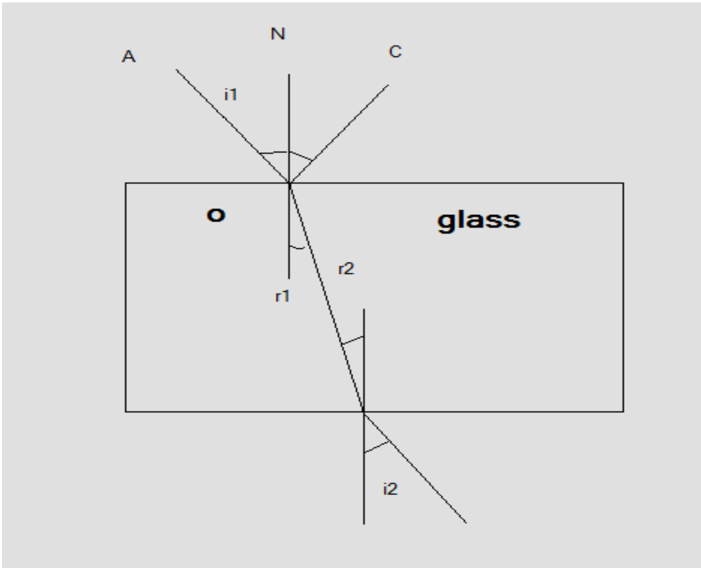
$$\mu = 1.46 \pm 0.03$$

– **Theory:**

When light passes from one medium to another, the path of the light bends, Examples of media are glass , plastic, water and air different colors bend by different amounts at the boundary between the two media that bending is called " refraction " and each medium has it's own refraction index N due that not all media bend a given light by the same amount (index of refraction = speed of light in vacuum / speed of light in the medium)

$$n = \frac{c}{v}$$

The refraction index is a measure of how much bending will occur for the light when it falls on a medium in the figure below:



When light falls on a block of glass from air AO represent a rag of light traveling in air incident on the surface of the block , OC represent the reflected ray, OB represents the refracted ray while ON represent the normal to the block surface "I" is the angle of incidence while "r" is the angle of refraction applying Snell’s law which is :

$$\mu_a \sin(i) = \mu_g \sin(r)$$

μ_a is the index of refraction of air which is near that of the vacuum ($\mu_a \approx 1$). μ_g is the index of refraction of the glass.

Then:

$$\sin(i) = \mu_g \sin(r) = \mu \sin(r)$$

$$\sin(i) = \mu \sin(r)$$

Then we can find μ from the plot of sin(i) vs. sin(r). The error in μ is founded by:

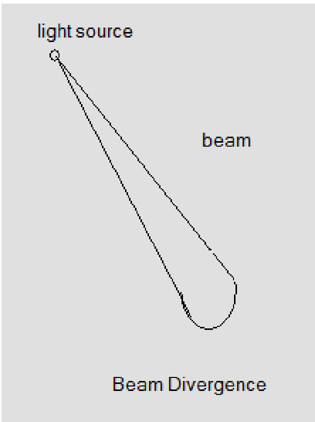
$$\mu = \frac{\sin(i)}{\sin(r)}$$

$$\Delta\mu = \left|\frac{\cos(i)\Delta i}{\sin(r)}\right| + \left|\frac{-\sin(r)\cos(i)\Delta r}{\sin^2(r)}\right|$$

$$\Rightarrow \frac{\Delta\mu}{\mu} = \frac{\cos(\mathrm{i})}{\sin(\mathrm{i})}\Delta i + \frac{\cos(\mathrm{r})}{\sin(\mathrm{r})}\Delta r$$

Procedure:

The block was placed on a piece of white paper the borders of block were drown in the paper . The angle of incidence were marked as shown on the figure on the previous page the first angle was choosed near 10 , the second angle near 20 , and so a narrow bean of light was shone exactly on path 1, then the path was marked and labeled this procedure was repeated for five more times for other angle from 20 to 60 , the block was removed and for eash outgoing bean , a perpendicular line was drown to the block boundary at each exit point, the exist point and the incident point were connected for each incident and out going $i_1 = i_2)$,$(\mathrm{r}_1 = r_2)$ for each incident and outgoing beam were measured and written down in the table below after all Δr & $\Delta \mathrm{i}$ were estimated in radians .



– **Data:**

NO.	Angle (i) degree		i average	Sin ($\bar{i}$)	Angle (r) degree		r average	Sin ($\bar{r}$)
	i_1	i_2			r_1	r_2		
1	10	9	9.5	0.17	7	6	6.5	0.11
2	20	20	20	0.34	13	12	12.5	0.22
3	30	27	28.5	0.48	20	18	19	0.33
4	40	36	38	0.62	26	25	25.5	0.43
5	50	48	49	0.76	32	31	31.5	0.52
6	60	60	60	0.87	36	35	35.5	0.58

– **Calculations: (Using Least Square Fit method**)

Let x= Sin ($\bar{r}$), y= Sin ($\bar{i}$)

x_i	y_i	$x_i y_i$	x_i^2	y_i-mx_i-b	$(y_i-mx_i-b)^2$
0.11	0.17	0.019	0.0121	0.075	5.625*10
0.22	0.34	0.075	0.0484	0.079	6.241*10
0.33	0.48	0.16	0.1089	0.053	2.81*10
0.43	0.62	0.27	0.1849	0.042	1.764*10
0.52	0.76	0.4	0.2704	0.046	2.116*10
0.58	0.87	0.5	0.3364	0.066	4.356*10
$\sum x_i=$ 2.19	$\sum y_i=$ 3.24	$\sum x_i y_i=$ 1.424	$\sum x_i^2=$ 0.96		$\sum(y_i-mx_i-b)^2=$ 0.022912 = 0.023

$$D = N\sum x_i^{\ 2} - (\sum x_i)^2$$ = 0.96

$$m = (N\sum x_i y_i - \sum x_i \sum y_i)/D$$ = 1.46

$$b = (\sum x_i^{\ 2} \sum y_i - \sum x_i \sum x_i y_i)/D =$$ = 0.008127

Calculation of errors:

$$\sigma_y^{\ 2} = \frac{1}{N-2}\sum (y_i - mx_i - b)^2 =$$ = 1.44*10

$$\Delta\mu = \sigma_m = \sqrt{\frac{N\sigma_y^{\ 2}}{D}} =$$ = 0.033843 = 0.034=0.03

$$\Delta b = \sigma_b = \sigma_y \sqrt{\frac{\sum x_i^{\ 2}}{D}} =$$ = 0.013611 = 0.014=0.01

– **Results and conclusion:**

μ = 1.46 ± 0.03

According to the range test , our range in this experiment is 1.43< μ <1.49 and the theoretical value of M of glass is 1.52 , so our experimental value is not included in the range , so the range test failed … so our experiment failed systematic errors exist due to use a glass block which have not equally borders and they were inaccurate , and there were systematic errors due to, that we had estimated the middle of the light bean each time so in conclusion we were able to find the index of refraction of glass and learn how to use the least square fit method ,