LAB REPORT

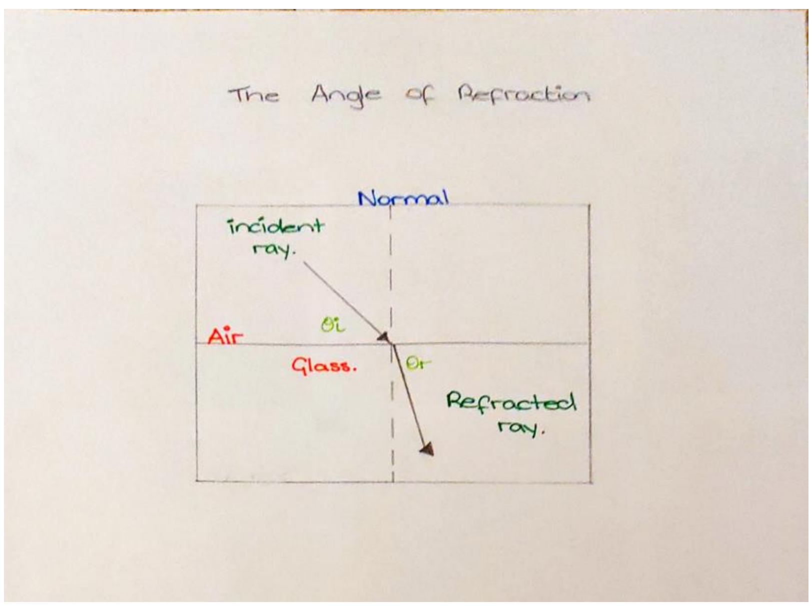
Name:

Date: 13th of March 2021

Title of the Experiment: Snell's Law

Aim of the Experiment: To investigate the relationship between the angle of incidence and the angle of refraction for a regular transparent block a hence calculate its refractive index.

Theory: When a ray of light passes across a boundary of two media, it bends either towards the normal or away from the normal due to change in speed of the light wave. The bending of the light path is known as refraction. The following diagram illustrates the refraction process for a ray of light passing through a glass block.



The refractive ability of any boundary is measured by the comparison of the angle of refraction to the angle of incidence as per the Snell's law.

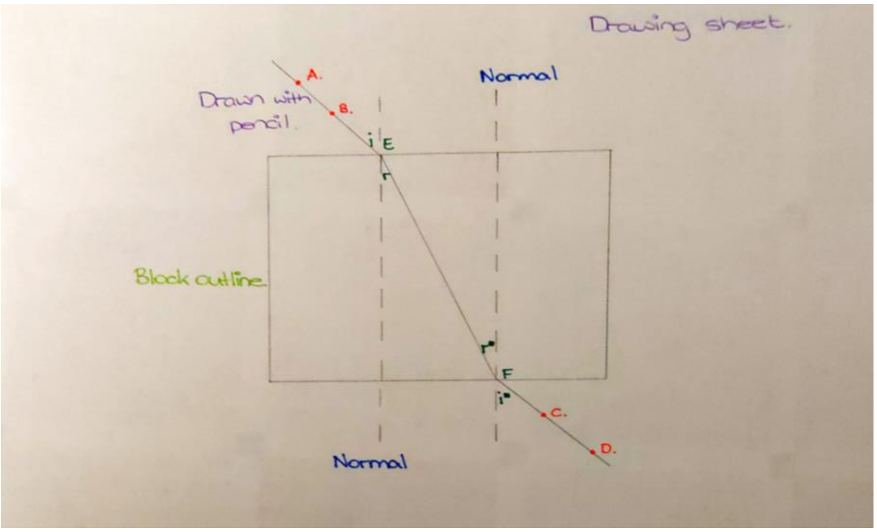
Snell’s Law states that when light travels from air to another transparent medium, $\frac{\mathrm{Sin\ (i)}}{\mathrm{Sin(r)}}$ is a constant called the refractive index of the transparent medium and is denoted by η where I is the angle of incidence in air and r is the angle of refraction in the transparent medium.

In the context of a Perspex glass block, the light will bend toward the normal because of the change from a less dense medium (air) to a denser medium (glass). In this case, the angle of incidence is greater than the angle of refraction.

In the determination of the refractive index of a glass block, a laboratory experiment was carried out and data concerning the angle of incidence and angle of refraction was noted to establish a consistent relationship between the two parameters.

Apparatus

- Transparent block
- Drawing board
- Thumb Tacks
- Drawing sheet
- Locating Pins
- Protractor
- Online simulator



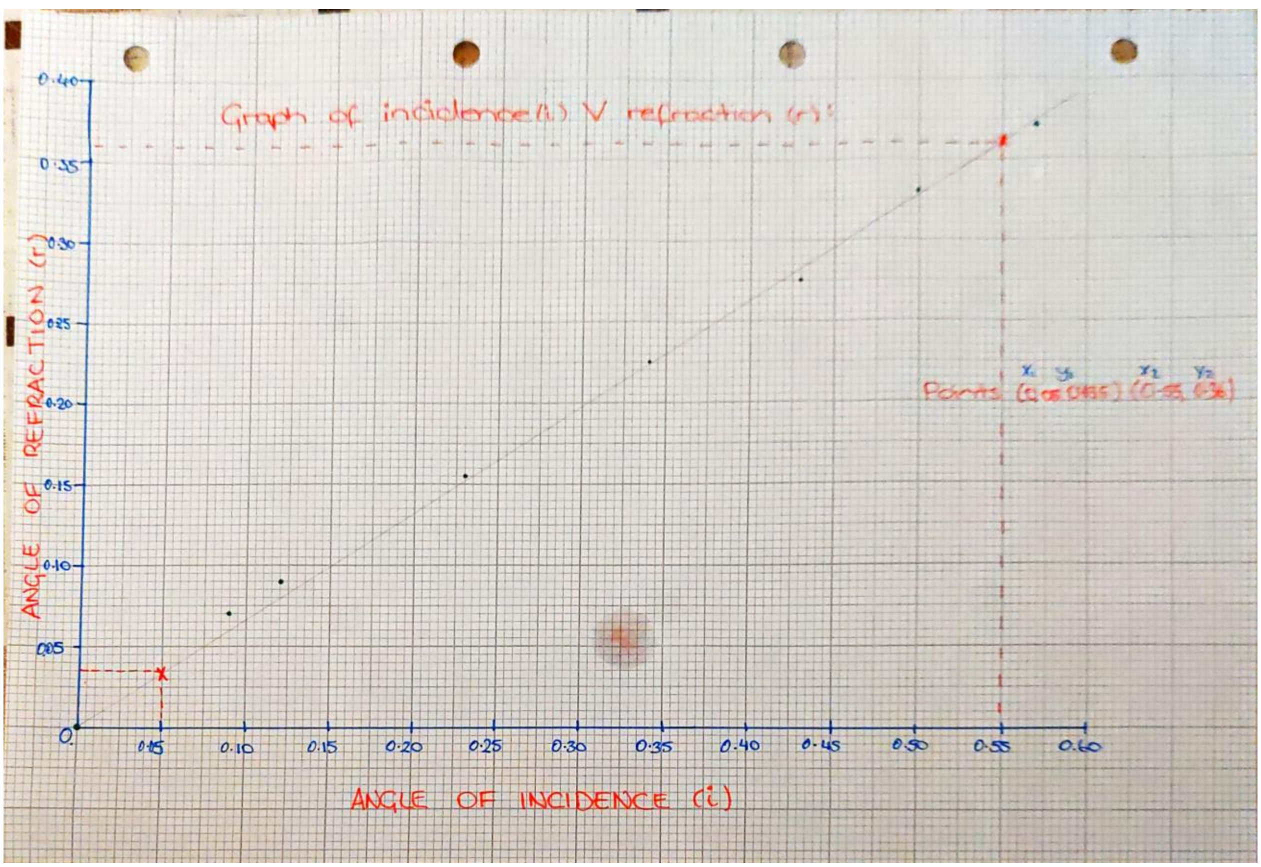
Experiment methodology

- The drawing sheet was mounted on the board using thumb tacks.
- A transparent block was placed on the board and its outline marked.
- Starting at a specific point, say E, an incidence ray of i=60^0 was drawn i.e an angle of 60^0 with the normal line passing point E.
- Two pins (A and B) were driven along the line to enable tracing of the incidence ray from the other side of the block. When looking through the block from the other side, the path of the emerging ray could be traced with the aid of two pins (C and D).
- The transparent block was removed and a straight line joining pin C and B was extended to meet the block outline at point F.
- A normal line at point F was drawn to establish the angle of incidence and the angle of refraction as shown in the figure below.
- The procedures were repeated using angles of incidences, 0°, 9°, 12°, 23°, 34°, 43°, 53° and 57°.
- The data obtained was recorded as shown in the table below.
- This experiment was conducted on an online simulator.

Angle of incidence (i)	Angle of refraction (r)	Sin (i)	Sin (r)
0	0	0	0
9	7	0.16	0.12
12	8.5	0.21	0.15
23	15.5	0.39	0.27
34	22.5	0.56	0.38
43	27.5	0.68	0.46
50	33	0.77	0.54
57	37	0.84	0.56

In order to visualize the relationship between the two angles, a graph of I against r was drawn as well as a graph of sin I versus sin r.

Graph of angle (i) versus angle (r)



Graph of sin (i) versus sin (r)

From the graph; we can determine the slope

Slope= $\frac{0.36-0.035}{0.55-0.05} = \frac{0.325}{0.5} = 0.65$

Data analysis

From the graph of i versus r, most of the plotted points fall on the line. Therefore, there is a linear relationship between the angle of incidence and the angle of refraction. From the graph of sin (i) versus sin (r), most of the plotted points are within the line indicating a linear relationship between the two parameters. With reference to the Snell's law, $\frac{\sin(i)}{\sin(r)} =$ $a\ constant\ known\ as\ the\ refractive\ index$. The slope of the graph was assessed and found to be 0.65 which is the refractive index of the transparent Perspex/glass block. My experimental value for the refractive index reveals a difference between the theoretical refractive index for a Perspex glass block as per the following calculation.

Theoretical refractive index for Perspex glass block= 1.495

Experimental value= 0.65

Difference; 1.495 – 0.65 = 0.845

% error= $\frac{0.65}{1.495}$ x 100= 43.5%

The error incurred may be attributable to inaccurate readings of the online simulator or a badly drawn graph.

Conclusion

The refractive index value obtained from the experiment (0.65) for Perspex glass block is not acceptable since the difference with the theoretical value is large considering the environmental challenges encountered during the experiment.

Name:

Date: 13th of March 2021.

Title of Experiment: Electric Circuits-Ohm's Law, Resistors in Series and in Parallel

Aim: To investigate the relationship between current flowing through a resistive circuit and voltage drop across a resistive circuit.

To verify Ohm's Law

To determine the value of a resistor

Apparatus

- Resistors (230Ω, 560Ω, 1.1KΩ)
- Digital voltmeter
- Digital ammeter
- D.C Power Supply
- Digital multimeter
- Online simulator

Theory

Electrical devices such as generators, batteries, wall outlets, etc. are referred to as voltage sources because they create a potential difference that is responsible for driving current throughout the circuit. The voltage source applies a potential difference V when conducted to a conductor, and then an electric field is generated that in turn exerts pressure on charges to produce current.

The potential difference across an element of the circuit is a measure of the difference in electrical pressure across the element.

Current, I- refers to the rate of flow of charge in a circuit and is measured in amps (A)

The current flowing through a given circuit is directly proportional to the applied voltage ($I \propto V$). This kind of a cause-and-effect relationship is called the Ohm's Law, with voltage as the cause whereas current is the effect.

Resistance is an electric property that tends to impede the driving of current by the applied voltage crudely similar to air resistance of friction. Collisions of moving charges with electrons or atoms in an element transfer charges to the element and limit current. Resistance is measured in ohms, denoted by the symbol Ω and defined to be inversely proportional to the current ($I \propto \frac{1}{R}$).

Combing the two relationship, $I \propto V$ and $I \propto \frac{1}{R}$, we get; $I = \frac{V}{R}$

The resultant equation is known as the Ohm's Law.

An object with simple resistance is called a resistor. When current is flowing in a resistor, the resistance offered by the resistor causes to accumulation of energy that can be detected by a heating effect. This principle is applicable in electrical heaters. The heat energy can also be referred to as power;

Power developed in a resistor is given by;

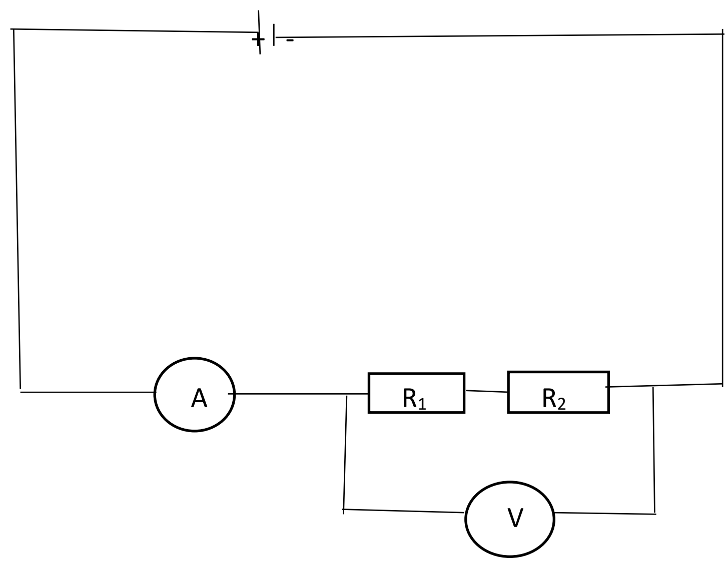
$P = RI^2 = VI$

Measurement of resistance

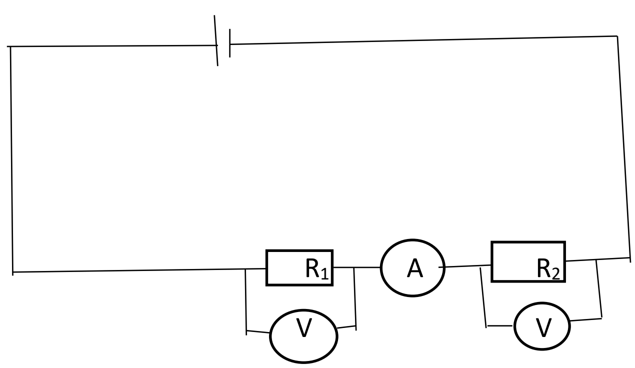
Measurement of resistance can be directly executed using a Digital Multimetre (DMM). DMM has the capability to measure the three parameters of Ohm's Law, ie. Voltage, Current and Resistance. The device exhibits a section marked V, A and Ω to facilitate the appropriate measurement of the parameters.

Experimental Procedure

- The resistance of the resistors was directly measured using an ohmmeter and the values noted in a table.
- Two resistors (R_1 and R_2) were connected in series with the power supply per the diagram below.



- The circuit was modified as shown below to determine the voltage drop across each resistance as well as current flowing through each resistor.

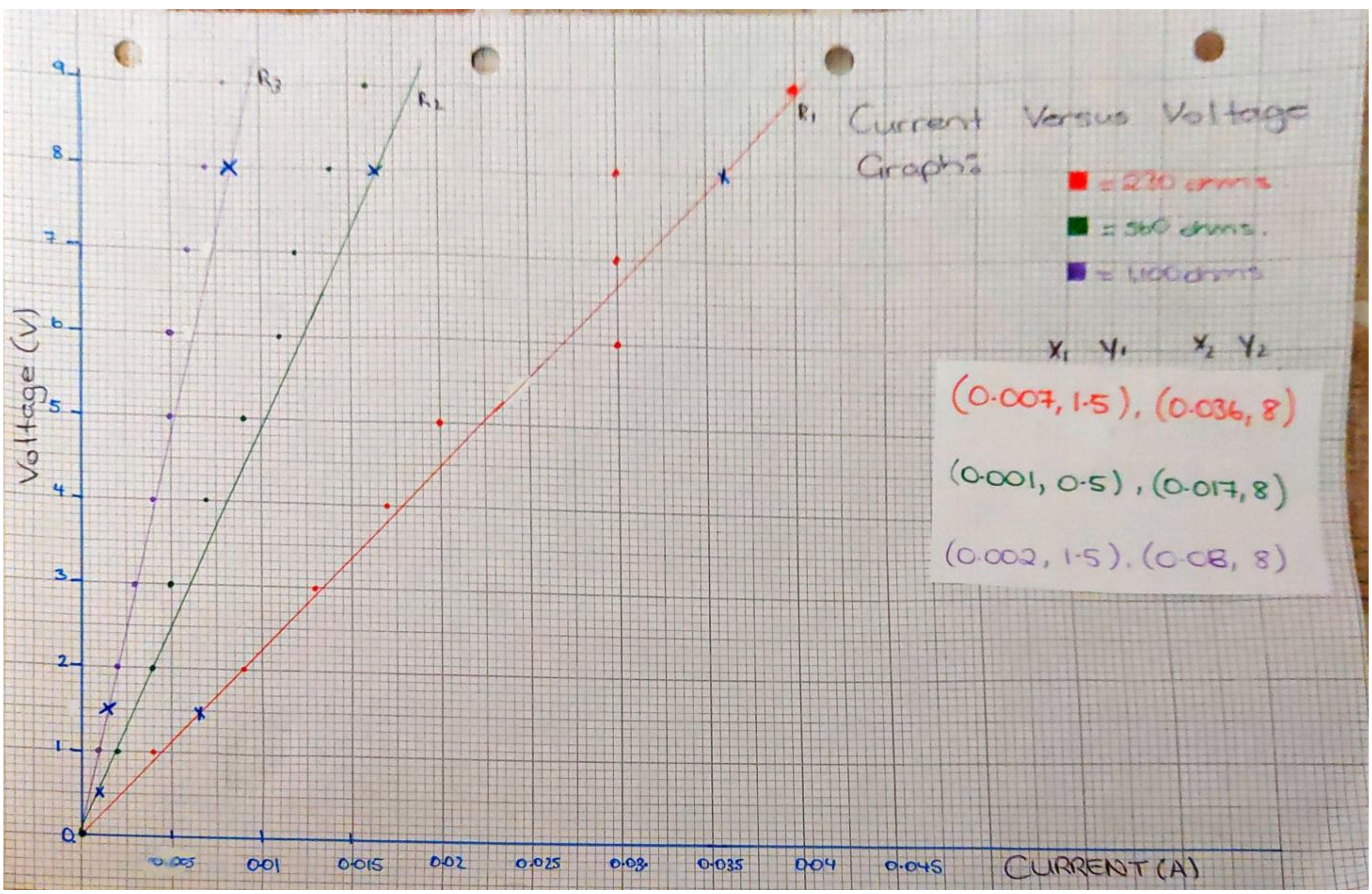


- The voltage supplied was varied to obtain a potential difference across the combination of resistors in series that changes from 0V to 9V at an interval of 1V and record the range of current measurements as well.
- Voltage drop across each resistor and the current flowing through the resistors were recorded for every applied voltage. However, I relied on the DMMs readings but not from the power supply.

- This experiment was conducted on an online simulator.

The table below present the findings of the experiment.

Voltage (V)	Current (A) 230 ohms	Current (A) 560 ohms	Current (A) 1,100 ohms
0	0	0	0
1	0.004	0.002	0.001
2	0.009	0.004	0.002
3	0.013	0.005	0.003
4	0.017	0.007	0.004
5	0.02	0.009	0.005
6	0.03	0.011	0.005
7	0.03	0.012	0.006
8	0.03	0.014	0.007
9	0.04	0.016	0.008



Analysis

From the graphs of the potential difference drop versus current flowing through the resistors, the values for resistors R_1, R_2 and R_3 were found to be 224.14Ω, 468.75Ω and 83.3Ω respectively. These values are obtained from the slopes of the respective graphs. However, there is a slight difference between these values and the theoretical values achieved after direct measurement of the resistance using an ohmmeter. The difference is attributable to the experimental errors incurred. Below is calculation of the percentage errors that resulted from the tests.

Resistor R_1

Theoretical resistance value = 230Ω

Experimental value = 224.14Ω

Difference=230Ω - 224.14Ω = 5.86Ω

% error=$\frac{5.86}{230}$ x 100 = 2.55%

Resistor R_2;

Theoretical Value = 560 Ω

Experimental value = 468.75Ω

Difference= 91.25Ω

%error= $\frac{91.25}{560}$ x 100 = 16.29%

Resistor R_3;

Theoretical value = 1.1kΩ

Experimental value = 83.3Ω

Difference=1100Ω -83.3Ω = 1016.7Ω

% error= $\frac{1016.7}{1100}$ x 100 = 92.43%

Discussion

From the graph, it can be noted that the summation of the resistance of the two resistors in the series circuit i.e. 550Ω +214.29Ω= 764.29Ω is approximately equal to the value of the resistance of the series circuit combination of the resistors. Neglecting the small errors, we can conclude that the total resistance for several resistors in a series arrangement is given by the total sum of the individual's resistors.

i.e.

$R_{Total} = R_1 + R_2 + R_3$…………

Conclusion

The maximum power developed in the resistance can be calculated as follows;

Maximum voltage applied = 9V

Current = 0.0114A

P=VI

= 0.1026 Watts

References

Zhang, J., Zhao, X., Zheng, Y., & Chen, X. (2019). Generalized nonlinear Snell's law at χ (2) modulated nonlinear metasurfaces: anomalous nonlinear refraction and reflection. *Optics letters*, *44*(2), 431-434.

Torbert, R. B., Burch, J. L., Giles, B. L., Gershman, D., Pollock, C. J., Dorelli, J., ... & Bounds, S. (2016). Estimates of terms in Ohm's law during an encounter with an electron diffusion region. *Geophysical Research Letters*, *43*(12), 5918-5925.