THOMAS ADEWUMI UNIVERSITY, OKO, KWARA STATE

Science | Technology | Medicine

FACULTY OF COMPUTING APPLIED SCIENCES

DEPARTMENT OF PHYSICS

GENERAL PHYSICS PRACTICAL II

PHY 108 (1 UNIT)

MANUAL

NAME: ………………………………………………………..

MATRIC NUMBER: ……………………………………...

DEPARTMENT: …………………………………………..

SESSION: ……………………………………………….

PREFACE

The General Physics Practical II laboratory manual is for 100Level students. It is to guide the students to successfully carry out the experiments, all of which must be carried out in the Laboratory under the supervision of qualified academic staff and Technologists. The experiments are all designed in a way to assist students to acquire some important skills in Electrical measurements, Optics and calculations involved. During the laboratory experiments, students will be exposed to different laboratory apparatuses and have the opportunity to learn how to handle them and use them for different physical measurements. The experiment to be covered include verification of Ohm's Law, the relationship between Potential difference (PD) across a variable resistor and current passing through it, currently passing through a Tungsten filament and its potential and e.m.f and Internal Resistance of a Cell. Other experiments include refraction in a rectangular glass block determination of refractive index, refraction in a triangular prism and focal length of a convex lens. The experiments in this practical manual form an integral part of the Physics course, PWE 102, and they provide experimental and practical demonstrations of the principles, theories and concepts learnt in the theory Physics course.

DEPARTMENT OF PHYSICS,
THOMAS ADEWUMI UNIVERSITY, OKO, NIGERIA
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INTRODUCTION

GENERAL GUIDELINES FOR EXPERIMENTAL PHYSICS

Physics deals with the investigation of motion, gravity, sound, waves, the structure and behaviour of matter, the generation and transfer of energy, and the interaction between matter and energy. Physics identifies unseen agents that drive these physical interactions. The fundamentals of many of today's advancements in technology and medicine are largely due to experimentation in physical sciences such as Physics. Knowledge is generated from observations and experimentations, and practical Physics as a course provides a basic introduction and skills needed to achieve this. The need to know what to use for your experiment and observation, what to measure, the relationship between two or more variables you are observing, and deductions from the experiment while limiting the error in your observations.

Therefore, practical physics entails the following:

1. Carefully read all the instructions and plan on what to do before starting the experiment. Good background knowledge or theory of the experiment you are to perform is very important. Focus on the objective of the experiment, the condition of the apparatus to be used and a clear procedure to be followed before actually performing the experiment. It is very important that you handle every apparatus carefully and cautiously to avoid damage.
2. Take your readings from the experiment systematically and intelligently. It should then be honestly recorded in the record book. Repeat every observation number of times (even though some of the values from repeated experiments might be the same).
3. Prepare a good composite table from the observations, a good table is one that includes all measured quantities and their units as well as quantities that needed to be derived or evaluated in order to plot a suitable graph.

4. Plot the required or suitable graph with the axes properly labelled. Likewise, choose good scales on both axes. It is better to present your observations in graphical form. It aids easy understanding of the relationship between your observed variables.

5. Estimate and deduce from your graph if necessary. Your calculations should be neatly done.

6. As a student who is still undergoing the rudiments of practical Physics, be comfortable consulting your practical demonstrator whenever you encounter a challenge during the course of the experiment.

A more detailed guide to reporting your observations during a physics experiment is given below.

1. **A COMPOSITE TABLE**: A composite table is one with more than one column; it usually consists of different quantities and their units in each column. It must include all quantities observed from your experiment as well as derived or evaluated ones that are useful towards plotting the desired or suitable graph. If any of the observed quantities are measured and recorded in units other than the International System of units (S.I. units), oftentimes, it is necessary to present them in the S.I. units. Read the instruction and procedure carefully to know the items required to be included in the table.

Present the observational and derived/evaluated values in decimal places. The minimum number of decimal places for the observed quantities is determined by the number of decimal places of maximum (possible) error. By standard, derived or evaluated values are recorded up to three (3) or four (4) decimal places on the table. Note that the number of decimal places must be uniform within each column.

2. **LINEARIZATION:** At this level, you will be expected to present your observations in a graph that is a straight line called a 'linear graph.' A linear graph has an equation of the form $y = mx + c$. Where y is the dependent variable or quantity, x is the independent variable or quantity, m is the slope of the graph (which is the ratio of the change in y to the change in x), and c is the intercept of the graph (i.e. the value of y when x is zero). Many times, the expression from the theory of the experiment may yield equations that cannot be compared with (or not in the form of) the equation of a linear graph. Thus, linearization of the expression may be done. Linearization converts the expression to a form similar to the linear equation. With respect to the nature of the expression, linearization can be done in any of the following ways:

(i) Changing the subject of a formula

(ii) Use of logarithmic expression

(iii) Use of natural logarithmic expression (please, read more on these)

3. **PLOTTING GRAPH**: A Graph is one of the easiest methods of understanding the relationship between two variables; it is required to represent the desired or required pair of variables. Observations from experiments are better represented in graphical form. There are several types of graphs. We focus on the linear graph. The y -quantity (dependent variable) is plotted on the vertical axis called the 'ordinate' while the x -quantity is plotted on the horizontal axis called the 'abscissa.' The graph and the axes must be named correctly and the scale chosen carefully.

The better the scale is chosen, the more accurate the results from the plotted graph and so it is very important you use good and reasonable scales. Use scales such as (0, 1, 2, 3 …) or scales with even numbers such as (0, 2, 4, 6, 8 …) and (0, 4, 8, 12 …), or (0, 10, 20, 30 …) and in multiples of ten (10), hundred (100), or thousand (1000). Using multiples of three such as (0, 3, 6, 9 …) can introduce significant errors to the graph. In addition, avoid holes in your scale and do not match. You match when you transfer values of the quantities to be plotted to the axes; when you do this, the graph appears to be perfect with the line of best-fit passing through all the marked data points.

(i) After careful experimentation and record of observations, with good axes chosen and values correctly marked on the graph sheet, the variation of the dependent variable cannot be perfect. Hence, the line of best fit will not pass through all the marked points. However, it should pass through at least two (2) or three (3) points and as much as possible, distributing the remaining marked points equally or approximately on both sides.

(ii) The line of best fit drawn on the plotted graph can either intersect the ordinate or pass through the origin (0, 0). Whether it passes through the origin or intersects the ordinate is a function of the nature of the given linear equation or the linearized equation.

4. **SLOPE**: There is a systematic approach to determining the slope of a plotted graph. This is stated stepwise below:

(i.) Draw a right-angled triangle that will cover about 2/3 of the graph worksheet.

The triangle must be drawn such that part of the line-of-best fit serves as the hypotenuse (slanting part) of the triangle.

(ii) Mark the points at which the vertical and the horizontal lines of the triangle intersect the slanting part as (x_1, y_1) and (x_2, y_2). The x_1 and x_2 are corresponding points on the abscissa (x-axis), while y_1 and y_2 are corresponding points on the ordinate (y-axis).

(iii) Substitute the values of x_1, x_2, y_1, and y_2 into the expression for estimating the slope. This expression is given as

$$Slope, m = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}.$$

NB: The slope does not have a specific unit that is constant for the variables plotted. The unit of the slope is the ratio of the unit of the quantity on the ordinate to the unit for the quantity on the abscissa. When both quantities have the same unit, the slope will be without a physical unit. Contact good practical textbooks for further explanations on a slope and errors in slope.

5. **INTERCEPT:** By standard, the intercept is the corresponding value of the variable plotted on the ordinate when the value on the abscissa is zero. Unless otherwise stated, intercept must be chosen on the ordinate. You may be required to estimate the error in the intercept, and read further on error analysis in experimental physics.

6. **PRECAUTIONS:** Precautions are statements of actions taken to protect against possible undesirable events during experiments. These actions are taken to reduce or minimize the effects of random errors in the experimental observations. The writing style should reflect that you actually performed the experiment and the step taken to reduce the error. Also, ensure you mention the apparatus or instrument involved. For instance, you should write like this, “I avoided error due to parallax when taking my reading on the voltmeter.”

GENERAL LABORATORY PRECAUTIONS

There are some rules or general precautions in place to ensure maximum safety for every user of the laboratory. Activities that are carried out in laboratories are ones that expose every user to a certain degree of danger. As a student, who is just been introduced to the culture of laboratory work, you are at a greater risk of potential danger. Therefore, we listed below some basic safety preventative measures you must take to ensure your safety and that of others in the laboratory.

(i) Do not come into the laboratory without permission. The laboratory is not a place to eat, read, gist or shout. Your activities in the laboratory other than experimentation may affect those experimenting.

(ii) While in the laboratory, do not run or loiter. There is also a specific time to use the laboratory, so maximize your time.

(iii) Properly wearing a protective laboratory coat is necessary. Loose clothing that might be dragged into an experiment is not allowed. For your safety, be smart with your dressing.

(iv) Do not touch any instrument or apparatus without prior authorization. (v) Always check the set of apparatus given to you to see if they are the ones you need.

(vi) No apparatus must be taken out of the laboratory. They are not your properties.

(vii) The apparatus given to you are not a toy. Do not play with them. They may be damaged or cause injury to you and others.

(viii) Report any careless handling of or damage to any of the apparatus to the instructor.

(ix) Do not tamper with electrical fittings, gas taps, and water taps. Fire extinguishers are to be touched when the need arises for them.

(x) When ready to use the Bunsen burner, light the matches before opening the gas tap or turning on the burner.

(xi) Always put off the Bunsen burner when not in use. You will help manage resources and prevent burnt or fire outbreaks.

(xii) Do not litter the laboratory with your possession. Come into the laboratory with materials needed only and take good care of them.

(xiii) Avoid water spillage on the floor. It could lead to your accident and others, since the wet floor could be very slippery.

xiv) Avoid distraction or divided attention in the laboratory. Focus on your work and get your results with minimal error.

(xv) Any apparatus signed for and not returned or damaged will be replaced by the student concerned.

(xvi) If you encounter any problem, or if there is any splash or burnt on the skin, report to the instructor immediately.

PRESENTATION OF RESULT

No matter how perfect your experiment is, or how tenacious, careful, or systemic you are with your experiment, you are represented only by what you put down. Therefore, the presentation of your result is as important as the experiment itself. It should be done with care and focus. A good report should at least follow the following format:

1. Your "Name," Matriculation number," "Department," and "Group number"
2. The "Experiment title" and the "Date"
3. Circuit diagrams where applicable (especially in electricity experiments).
4. Table of observations (each column should be well labelled with the quantity and the unit). Any constant value to be used (such as the electromotive force, e.m.f., of a cell) must be written out boldly before the table, if possible.
5. Your graph must be plotted using suitable scales and the axes labelled.
6. Painstakingly do the estimates from your graph as required of you.
7. Write out the precautions you took while performing your experiment.

ELECTRICAL SYMBOLS USED IN GENERAL PHYSICS LABORATORY II (PHY108)

Resistor Colour Code

TABLE 1

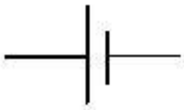
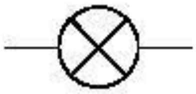
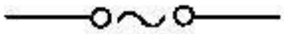
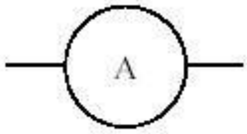
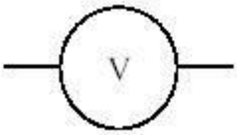
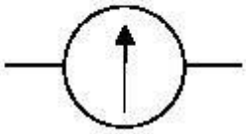
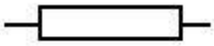
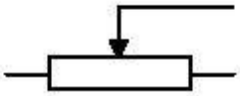
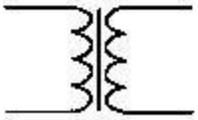
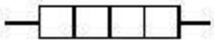
Resistor Color Codes

Bright
Boys
Rise
Over
Your
Grades
By
Very
Good
Work

Color	First Band	Second Band	Third Band (Multiplier)	Fourth Band
Black	0	0	$x10^0$	
Brown	1	1	$x10^1$	
Red	2	2	$x10^2$	
Orange	3	3	$x10^3$	
Yellow	4	4	$x10^4$	
Green	5	5	$x10^5$	
Blue	6	6	$x10^6$	
Violet	7	7	$x10^7$	
Gray	8	8	$x10^8$	
White	9	9	$x10^9$	
Gold				5%
Silver				10%
None				20%

To read a resistance value, the first two bands stand for the first two significant figures, i.e., a number between 10 and 99. The two digits are multiplied by 10 to the power indicated by the third band. For example, if the first three bands are brown-black-red
(by colour code, 1-0-2), then their resistance is ………….. or …………..

Electrical Circuit Symbols

cell		battery	
lamp		ac supply	
switch		ammeter	
voltmeter		galvanometer	
resistor		potentiometer	
transformer		heating element	

INTRODUCTION TO ELECTRICAL EXPERIMENTS

The following simple rules and suggestions are to be followed when wiring up or connecting a circuit for electrical experiments. This is to prevent damage to delicate and expensive electrical equipment (e.g. galvanometers, ammeters, voltmeters) normally involved in such experiments. Each one of the electrical equipment listed and others requires careful handling.

1. Connection to the battery or power supply should be done last after the circuit has been correctly wired and necessary checks have been made by the Lecturer, Technologist or Instructor.
2. If a drycell is being used as a source of E. M.F., one lead should be disconnected until the circuit has been checked.
3. The positive terminal of an ammeter or voltmeter must be connected to the positive terminal of the supply and similarly negative terminal of the ammeter or voltmeter must be connected to the negative side of the supply.
4. If a bench socket is being used as a source of supply, then a switch must be included in the circuit and left open. The plug must not be put in the socket until the circuit has been checked. Overload must be avoided as this can damage the equipment.
5. Ammeters must be connected in series and voltmeters must be connected in parallel in a circuit.
6. The center of a dry cell is positive and the outside case is negative.
7. Resistors and switches have no polarity and therefore it does not matter which end is connected to the positive side of the circuit.
8. For the most part, capacitors and inductors have no polarity and can be treated like resistors. If some polarity is indicated, then they must be connected positive-to-positive and negative-to-negate
9. When using an ammeter or voltmeter, always use the highest.

QUANTITIES MEASURED IN ELECTRICAL EXPERIMENTS

An electric current consists of the flow of large numbers of electric charges along a conductor. The conductor usually offers some resistance to the flow and therefore it is necessary to have some source of electrical energy that offers electromotive force (E.M.F) in the circuit to keep the current flowing. In these experiments, the source of E.M.R will either be a dry cell or an E.C.2 power supply. In setting up the experiments it is necessary to have a complete circuit because the electrical current passes completely which is lost by the current against the resistance of the circuit.

The following symbol is used:

QUANTITY	SYMBOL	UNIT
Current	(I)	Ampere
E.M.F	(E) or Voltage (V)	Volt
Resistance	(R)	Ohms

The three quantities are connected by Ohms's Law:

$$V = IR$$

In order to carry out quantitative experiments in electricity, it is necessary to have instruments to measure these three quantities. The basic instrument is the 'galvanometer'. This may be modified from an 'ammeter' to measure current to form a 'voltmeter' to measure voltage, or an 'Ohmeter to measure resistance.

The ammeters provided for the laboratory have a zero at the left end of the scale and the current must be sent through the instrument in the correct direction or it may be damaged. The ammeters have three current ranges, i.e, three shunt resistances are provided inside the case and there are four terminals. The one marked (+) must be connected to the positive side of the supply and the other connection made to one of the other terminals. These are marked 1.53 and 30, in most cases to indicate the maximum current in amperes for the connection.

- **Initial connection must always be made to the highest ampere range. After ensuring that the current is correct and determining that it is safe to do so, reconnection to a suitable lower current range may then be done.**

VOLTMETER

The voltmeter is a device used to measure the potential difference or E.M.F between two points. It is essentially a galvanometer with a high resistance connected in series with the rotating coil. This high resistance results in a low (but well-known) current through the coil. The scale was then calibrated in volts. Usually, voltmeters are constructed with several different resistances built in to allow for scale selection. The voltmeters must always be connected in parallel across the source of E.M.F.

The multi-range voltmeters provided for this laboratory have three series resistance built in the case and four terminals. The one marked (+) must be connected to the positive of the supply and a negative connection must be made to one of the other terminals.

Initial connection should always be made to the highest volt terminal. After ensuring the connection are correct and determining that it is safe to do so, the connection may then be made to one of the lower voltage ranges.

Figure B: Voltmeter

GALVANOMETER

The galvanometer is a sensitive instrument used to detect and measure very small currents. The 'moving coil' type used in this laboratory consists of a small coil or wire pivoted between the poles of a permanent magnet as shown in Figure 2. When a current pass through the coil, the coil act as a small magnet and tries to line itself up with the permanent magnet poles. This swings the attached pointer across the scale. A small spring (not shown in the figure) tends to prevent this motion and when no current flow through the coil it holds it in such a position that the pointer is the zero on the scale. Since the magnetic effect of the movable coil is directly proportional to the current flowing through it then the deflection of the pointer over the scale will also be proportional to the current.

The direction of pointer movement for direct current instruments depends upon which way the current through the coil. The zero-current position of the pointer on the galvanometers used here is arranged at the centre of the scale because the current may flow in either direction while the instrument is in use for the particular experiment.

The wire of the coil is very fine and will only carry a very small current (less than 0.001 amp). It cannot be used to measure alternating currents. However, by modification, it can be converted into an ammeter or voltmeter.

Figure C: Galvanometer

AMMETER

To measure large currents that can be passed directly through the coil of a galvanometer is usually added by-pass or ‘shunt resistance which carries the greater part of the current and only permits a small (but accurately known) proportion to pass through the coil itself.

Figure D: Ammeter

EXPERIMENT 1

TOPIC: VERIFICATION OF OHM'S LAW

AIM: To verify Ohm's law

APPARATUS: resistor of unknown value, Ammeter, Voltmeter, Rheostat, connecting wires and Accumulator (3 V) or power supply

INSTRUCTION

1. Connect the circuit as shown in the circuit diagram
2. Close the key and record the ammeter reading *Io*.
3. Open the key and connect the voltmeter across the resistors
4. Adjust the rheostat to make the ammeter reading I = 0.2 and record the corresponding value of the voltmeter reading V.
5. Repeat the experiment for the values of I = 0.4A, .6A, 0.8A and 1.0A.

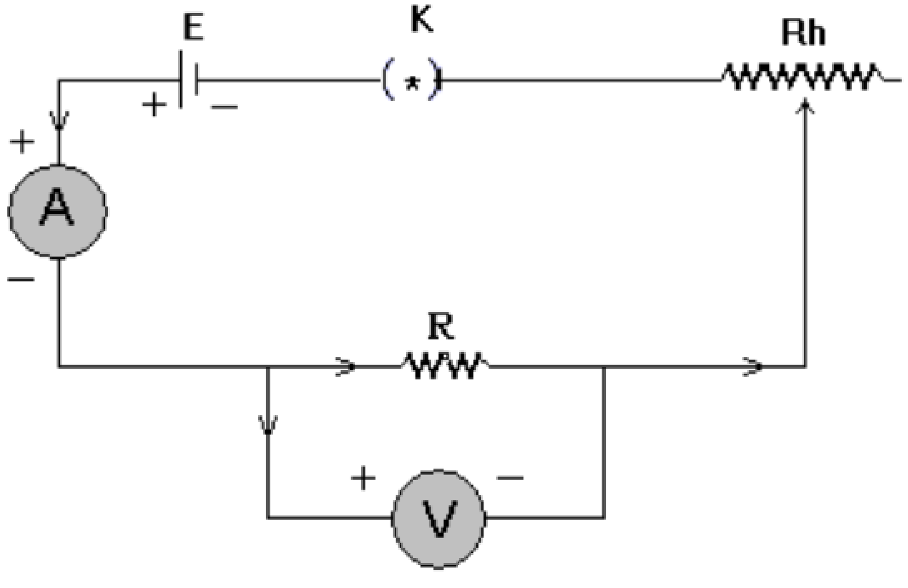


Figure 1: Verify Ohm's law

ANSWER THE FOLLOWING QUESTIONS

(a) From the reading obtained plot a suitable graph to verify Ohm’s law

(b) Determine the slope of the graph and calculate the value of the resistance R

(c) State Ohm’s law and does the experiment agree with the law? Give reason(s)

(d) State two precautions to ensure accurate results.

ASSIGNMENT

1. What is ohmic resistance? Give two examples.
2. What is the S.I. Unit of resistance?
3. Why ammeter connected in series only?
4. Why the internal resistance of a voltmeter is very high, whereas that of an ammeter is very low?
5. What is the function of the rheostat in the circuit?
6. Wis are the application of Ohm`s law.
7. What are the limitations of Ohm`s law?
8. What is the difference between the emf and terminal voltage of the cell?
9. State Ohm`s law.
10. What is non-ohmic resistance? Give two examples.

EXPERIMENT 2

TOPIC: RELATIONSHIP BETWEEN P.D ACROSS A VARIABLE RESISTOR AND THE CURRENT PASSING THROUGH IT

AIM: To investigate the relationship between the potential difference (p.d) across a variable resistor and the current passing through it.

APPARATUS: Drycell, ammeter A, Voltmeter V, key, rheostat R and connecting wires

INSTRUCTIONS

1. Set up the circuit as shown below
2. By varying her rheostat suitably, obtain five values of current I and the corresponding values of the potential difference V across the variable resistance respectively. One of your readings must correspond to the mid-point of your rheostat.

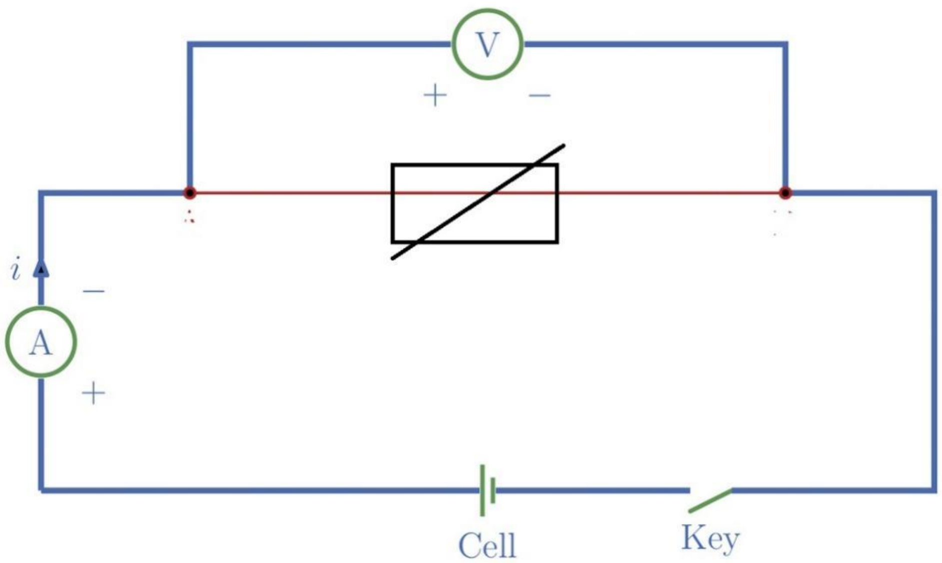


Figure 2: Circuit Diagram

ANSWER THE FOLLOWING QUESTIONS

a. State the resistance and voltage rating of your rheostat

b. Set up a data table

c. Plot a graph of V against I

d. Determine the slope and the intercept V_a and I_o respectively on their axis

e. State two precautions are taken to ensure accurate results.

EXPERIMENT 3

TOPIC: THE INTERNAL RESISTANCE OF A CELL USING A POTENTIOMETER

AIM: To determine the internal resistance of a cell using a potentiometer

APPARATUS: A potentiometer, a resistor pack, two (2) on-off switches or keys, a jockey, a 2-V accumulator, a 1.5 V dry cell, and a centre-zero galvanometer

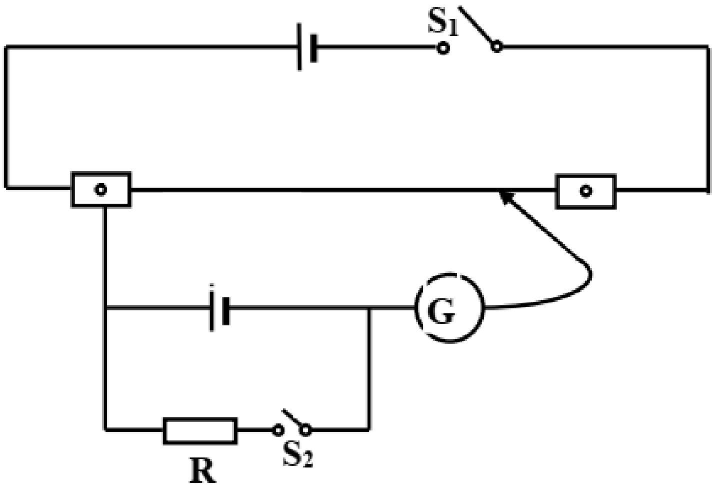


Figure 3: Circuit Diagram

E.m.f. of the cell $E = V + Ir$

Where r is the internal resistance of the cell

$$r = \frac{E-V}{I}$$

$$r = \frac{E-V}{V/R} \qquad \text{Since, } V = IR$$

$$r = \left(\frac{E-V}{V}\right)R \qquad \Rightarrow r = \left(\frac{E}{V}-1\right)R \qquad \Rightarrow r = \left(\frac{l_o}{l}-1\right)R$$

$$\frac{l_o}{l} = \frac{r}{R} + 1$$

With switch S_1 closed while switch S_2 open, obtain the balance length l_o. With both S_1 and S_2 closed, obtain the balance length l.

PROCEDURE:

With Switch *Si* closed while Switch *S2* opened, determine the balance length *lo* (when the current through the galvanometer is zero). With both *S1* and *S2* closed, determine the balance length *l* for various values of *R*.

1. Plot a graph of ***lo*/*l*** *against* **1/R**.
2. From your graph, determine the value of the internal resistance r, of the cell.
3. Estimate the error in the slope.
4. Mention TWO precautions taken while performing this experiment.

EXPERIMENT 4

TOPIC: DETERMINING THE RESISTANCE OF A VOLTMETER

AIM - To determine the unknown resistance of the given voltmeter

APPARATUS - A voltmeter, a battery or accumulator of negligible internal resistance, a variable resistance box, a key or a circuit switch.

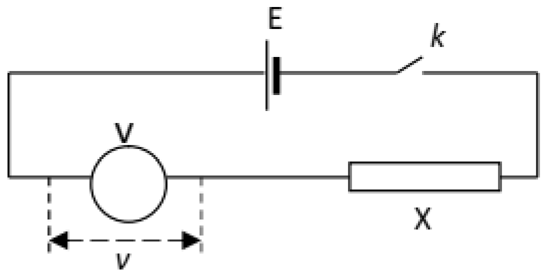


Figure 4: Circuit Diagram

THEORY

Resistance is known to be the opposition to the flow of current in a circuit. This implies that as the resistance of a circuit increases, the current flowing through it decreases and vice-versa. Recall that the electromotive force (E.M.F.) of a cell, *E* is given by the equation.

$$E = I(R + r) \quad \ldots\ldots (1)$$

Where *I* is the current that flows through the voltmeter and will be denoted by I_V, hence, *R* is the total resistance in the circuit, and *r* is the internal resistance.

$$E = I_V R \quad \ldots\ldots (2)$$

[Since *r* is negligible]

$$E = I_V (R_X + R_V) \quad \ldots\ldots (3)$$

R_x is the resistance of the resistance box, X, and R_V is the required resistance of the voltmeter

From Ohm's law, the potential difference across the terminals of the voltmeter due to the current flowing through it will be

$$V = I_V R_V \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Thus, $E = \frac{V}{R_V}(R_X + R_V)$ and $V = \left(\frac{R_V}{R_X + R_V}\right)E$

$$\frac{1}{V} = \frac{1}{E R_V} R_X + \frac{1}{E} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

PROCEDURE

Connect all the given apparatus as a series circuit. This is illustrated in the diagram above. Choose a resistance value, R_X (say 1000 Ω) and determine the potential difference (p.d.) across the terminals of the voltmeter.

(i) Repeat for other resistance values in steps of 1000 ohms and note the corresponding p.d., V

(ii) Using equation (5), prepare your table and enter your readings.

(iii) Plot a graph of $1/V$ against R_X..

EXPERIMENT 5

TOPIC: RESISTIVITY OF A CONDUCTING WIRE

AIMS: To determine the resistivity of a wire.

APPARATUS: A wire whose resistivity is to be determined (about 100cm), a micrometer screw gauge, an ammeter, a voltmeter, connecting wires, an accumulator, a rheostat, a jockey, and a key

THEORY

Given that $R = \frac{\rho l}{A}$ Hint: $Area, A = \frac{\pi d^2}{4}$

Where R = Resistance in Ohms, ρ = Resistivity in Ohm-meter

l = Length of the wire in meter, A = Cross-sectional area of the wire

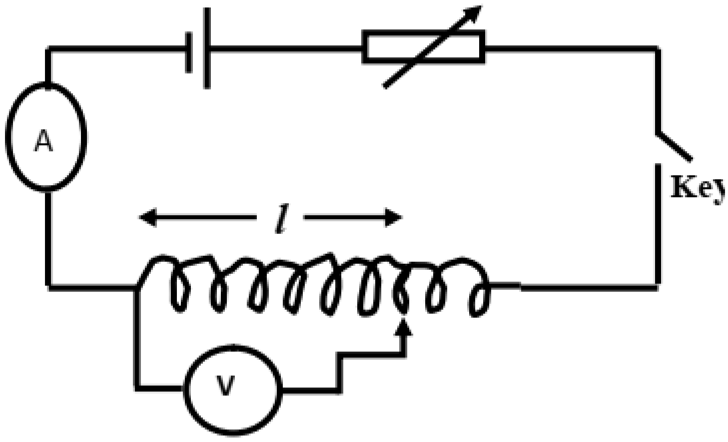


Figure 5: Circuit Diagram

PROCEDURE

Connect the circuit with the key in the open position as shown above. The voltmeter is connected in parallel to the wire whose resistivity is to be determined. With the length l = 20 cm, close the circuit, read and record the current, *I*, and voltage, *V* from the ammeter and voltmeter respectively. Using ohm's law, estimate the resistance, *R*. Repeat the procedure

Four (4) more times by varying the length *l* in a step increase of 20 cm.

(i) Tabulate your readings.

(ii) Using the expression given above, plot a suitable graph.

(iv) From your graph, determine the resistivity of the wire.

(iv). Estimate the error in your slope.

(v) State TWO precautions you took while performing the experiment.

(vi) What are the factors on which the resistance of a given wire depends?

GENERAL INSTRUCTION ON OPTICS LABORATORY

1. **ALWAYS ENSURE THAT YOUR HANDS ARE THOROUGHLY WASHED WITH SOAP, RINSED WITH WATER AND DRIED BEFORE COMING TO THE LABORATORY.**
2. **OPTICAL AND LENS SURFACES MUST NEVER BE TOUCHED WITH BARE HANDS.** Lenses are to be held by their edges only. Soft cotton gloves should be worn when handling lenses. The glass surfaces of the projection lamp concentrated are clamps, photocells etc must not be touched.
3. **AVOID SURFACE ABRASION.** Never lay a lens on a table, for this can scratch the lens surface. When lenses must be set aside, they must be laid on a soft cloth or sheets of foam plastic provided at a teaching lab station.
4. **ALWAYS PROTECT THE FRONT SURFACE OF MIRRORS.** The reflecting surfaces of mirrors are easily scratched and damaged through careless handling. Students who have not been trained on how to do it should never attempt to clean front surface mirrors.

EXPERIMENT 6

TOPIC: REFRACTION IN A RECTANGULAR GLASS BLOCK

AIM: To measure the path of light rays when it passes through a rectangular slab (made up of glass), measuring the various angles: Angle of incidence, angle of emergence, and angle of refraction, and finding a relationship between these angles.

APPARATUS: A normal sheet of white paper, a drawing board,5-6 paper pins, a rectangular glass slab, a protractor to measure the angles, and thumb pins.

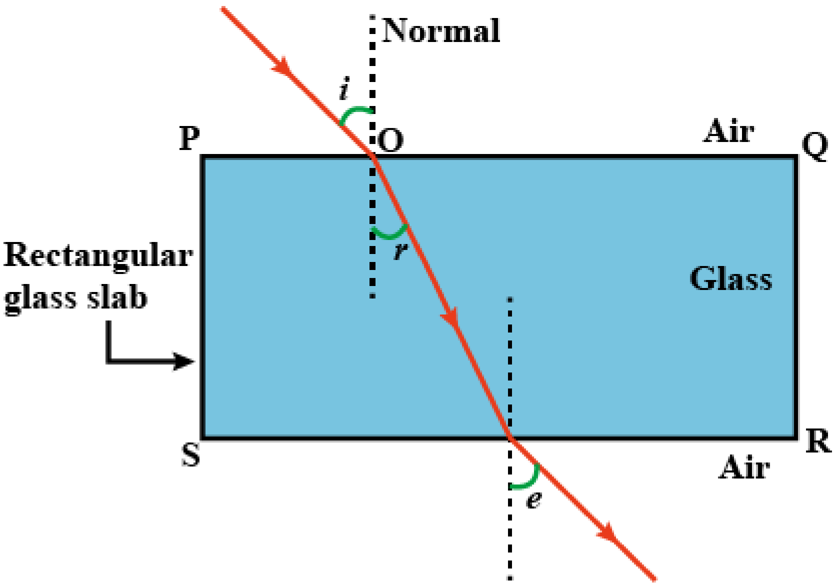


Figure 6: Diagram

Procrdures:

- The first step is to take a white sheet and fix it on the drawing board with the usage of thumb pins which will allow the sheet to remain in its position.
- Take a rectangular glass slab and place it on the centre position of the white sheet and mark its outline boundary with the help of a pencil and name the rectangular figure obtained as PQRS.
- Choose one side of the figure, PQ and take a point O and construct a perpendicular and name it as ON and mark it as a normal ray.
- With the usage of a protractor, draw an angle of 30 degrees with the perpendicular EN and fix two paper pins and name it as P and Q on the ray of the angle created.
- Look through a rectangular glass slab from another side, and attach pins R and S such that P, Q, R, S should lie in a straight line.
- Measure the angles formed at r and e.
- Repeat the experiment for angle 40°, 50°, 60°, 70°.

Hence answer the following questions

a. If the refractive index of the material of the glass is given by

$$_an_g. = Sin\ i/Sir\ r$$

Plot a suitable graph and obtain the value of $_an_g$.

b. Determine the slope of your graph?

c. Deduce the value of $_an_g$ in the above experiment

d. State two precautions you would take to obtain an accurate result. (e). State Snell's law of refraction.

EXPERIMENT 7

TOPIC: REFRACTION THROUGH GLASS SLAB

AIM: To trace the course of different rays of light through a rectangular glass slab at different angles of incidence, measure the angle of incidence, refraction and verify Snell`s law. Also, measure the lateral displacement.

APPARATUS: Drawing board, a sheet of paper, board pins, rectangular glass slab.

THEORY:

Consider a rectangular glass slab EFGH as shown in fig. A ray of light AB incident at an angle of incidence ***i*** with the normal NN1 at the point of incidence B. This ray is refracted along BC and bent towards the normal because it is going from air to glass. The refracted ray again suffers refraction at the surface GH and bents away from the normal MM` and emerges along CD which is thus the emergent ray. The emergent ray is parallel to the incident ray but is displaced. The distance between the incident ray produced forward and the emergent ray i.e. distance CP gives us the lateral displacement.

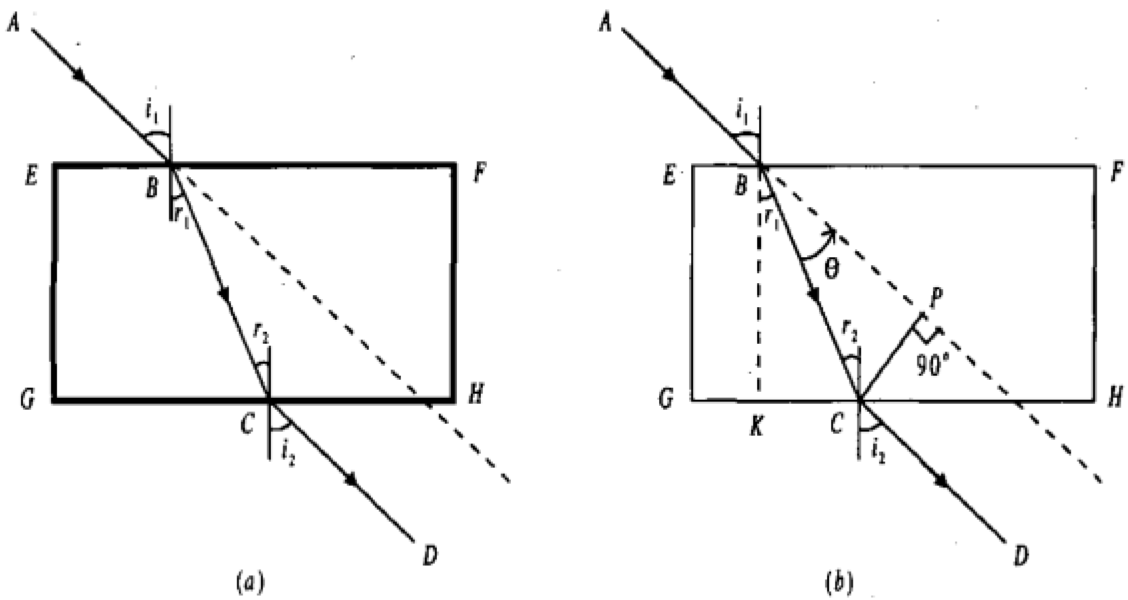


Figure 7: Diagram

PROCEDURE:

a) Fix a sheet of white paper on the drawing board with the help of drawing pins at the four corners of the sheet.

b) Place a glass slab at the centre of the paper and mark its boundary EFGH with fine pencil.

c) Remove the glass slab. Draw any line AB making an angle of 40^0 with the normal at the point B, the middle point of EF approximately.

d) Put the glass slab back in position on the boundary line. Fix two pins P1 and P2 vertically on the line AB at least 5cm apart- and one pin close to the slab.

e) Look for the image of these pins in the slab from the opposite side GH and fix two pins P3 and P4 so that they are in the line with the image of P1 and P2 as seen through the slab and at least 5cm apart.

f) Join the pricks of P3 and P4 to obtain the emergent ray. Draw a normal to GH at the point C. join BC to get the refracted ray.

g) Measure the angle of incidence and angle of refraction. Produce AB forward and draw a perpendicular from C on AB produced to meet it at P. Then the lateral displacement = CP.

h) Repeat the experiment with different angles of incidence 45^0, 50^0, 55, $60^{0,}$ 65^0 and 70^0.

EXPERIMENT 8

TOPIC: REFRACTION IN A TRIANGULAR PRISM

AIM: To understand the concept of refraction through a triangular prism

APPARATUS: A 60^{o} triangular prism, drawing board, plain paper, four optical pins, at least two tacks

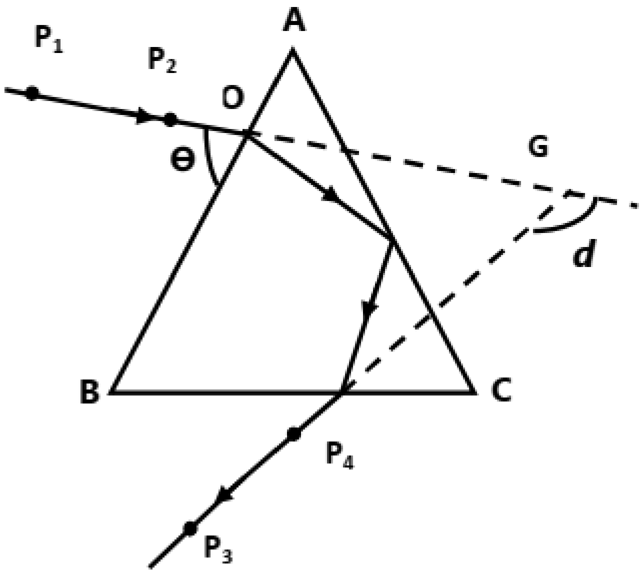


Figure 8: Diagram

PROCEDURE

Pin the plain paper to the board using the tacks. Place the prism at the centre of the paper, with the refracting angle, A, pointing towards the top of the paper. Using a very sharp pencil, trace out the outline of the prism. Now, remove the prism. At a point nearer to the edge of A than B, draw a line that makes an angle Θ = 60o with side AB of the prism at O (as shown). Place two optical pins P1, P2 on the line (as objects: to define the incident ray); replace the prism in its outline (take note of the refracting angle A). On the side BC of the prism, obtain the emergent ray using the other two optical pins P3, P4. Remove the pins and the prism. Draw a line joining the two points marked by pins P3, P4 to touch the prism at E. Project the incident ray and the emergent ray to intersect (as denoted with the broken lines) at G. Measure the angle of deviation, *d*.

Repeat the procedure for five (5) other values of Θ at increasing interval of 5o.

Tabulate your observations.

b. Plot a graph of *d* against Θ.

c. Calculate the slope of the graph and the error in the slope.

d. From your graph, determine the value of *d* when Θ equals (i) 68o, (ii) 82o.

e. State TWO precautions you took when performing the experiment.

f. Explain the reason why the emergent ray passed through the side BC.

g. Derive the theoretical relation between Θ and *d*.

EXPERIMENT 9

TOPIC: REFRACTION IN A TRIANGULAR GLASS PRISM

AIM: To investigate the refraction in a triangular prism

APPARATUS: Triangular prism, Optical pins, drawing pins, drawing paper, protractor and ruler.

INSTRUCTIONS

1. Place the prism on the drawing paper and trace its outline ABC
2. Remove the prism, and draw normal across the line AB at N near A.
3. Draw the incident tray ON to the normal such that I = 30^o.
4. Fix two pins P_1 and P_2 at a reasonable distance.
5. Replace the prism and erect two other pins at P_3 and P_4 such that the pins appear to be in a straight line with the image of P_1 and P_2 when viewed from the side AC of the prism as shown.
6. Remove the prism and produce P_3 ad P_4 to meet ON at P.

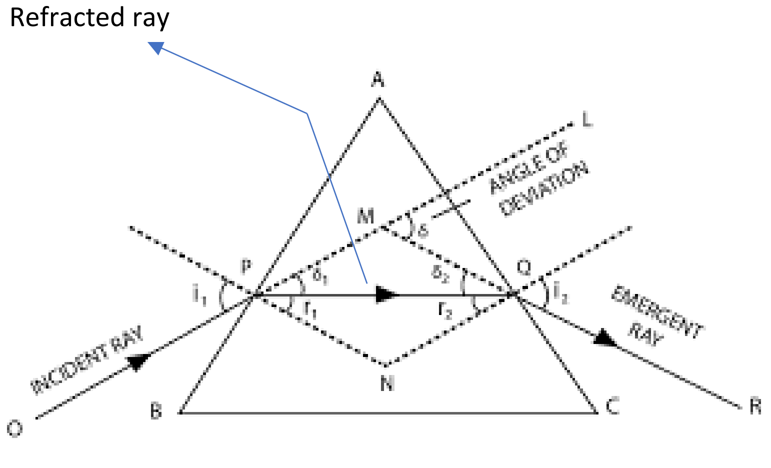


Figure 9: Ray passing through a triangular prism

7. Draw the normal XY. Measure and record the angle of deviation, *d* and emergence *e*.
8. Repeat the experiment for the values of $I = 35^o, 40^o, 45^o$ and 50^o respectively.
9. Tabulate your readings as shown in the table below.

Table

s/n	i_1(°)	i_2(°)	d(°)

ANSWER THE FOLLOWING QUESTION

a. Plot a graph of d against i:

b. Determine the slope

c. From your graph, obtain the minimum deviation D_m.

d. Hence, calculate the refractive index of the glass prism using

$$\mu = \frac{\sin\left(\frac{A + \delta_m}{2}\right)}{\sin\frac{A}{2}}$$

Where

δ_m = angle of minimum deviation

A = angle of the prism.

e. State two precautions taken to ensure accurate results.

EXPERIMENT 10

TOPIC: DETERMINATION OF THE FOCAL LENGTH OF A CONVERGING (CONVEX LENS)

AIM: Using U-V method to determine the focal length of a convex lens.

APPARATUS: Convex lens (L) of focal length 15-20cm), Optical bench, Meter scale or meter rule, and Needles

THEORY: a converging (convex) lens forms a real and inverted image of any object. But when the object distance is less than the focal length of the lens, an erect, virtual and magnified image is formed. When the position of the object is known to us, then our basic exercise is to locate the position of the image. This can be done by the method of parallax. Parallax is the apparent motion between an object and its image, situated along eh line of sight, relative to each other.

Noparallax means that the two objects are coincident. When an object is place in from of a convex lens L between F and 2F, are a land inverted image is formed.

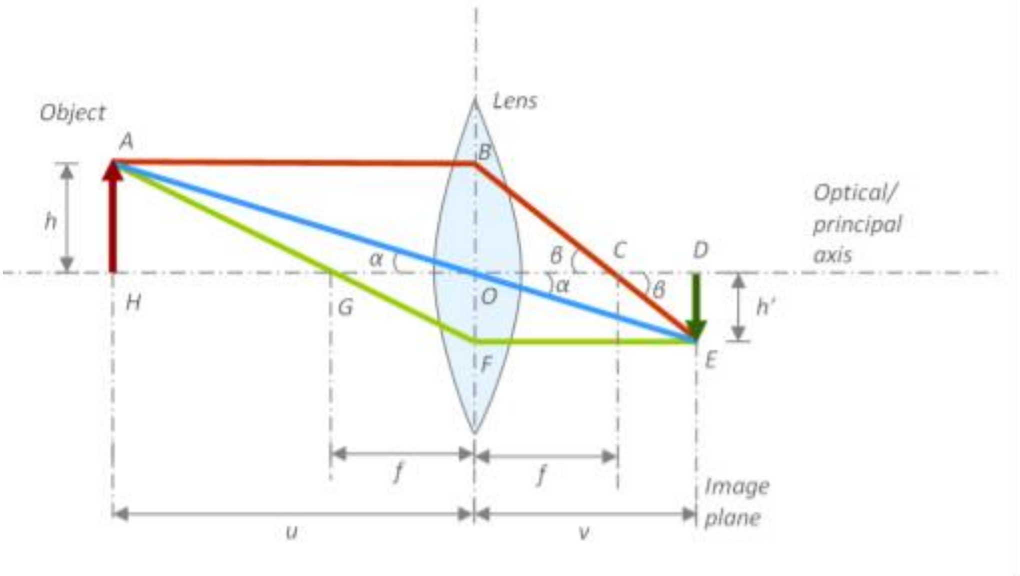


Figure 10: Ray diagram for a convex lens when an object is placed in front of a convex lens.

Let the distance of object and image formed by a convex lens be u and v respectively, the focal length of a convex lens is given by

$$1/f = 1/v - 1/u$$

Or $f = uv/(u - v)$

Here is the focal length of a convex lens.

The concept of parallax is used in carrying out experiments in optics

INSTRUCTION

1. Estimate the rough focal length of the convex lens.
2. Now the object needle O and the image needle I as shown above on an Optical bench. The tip of the object needle, image needle and centre of lens should be on the same height. The object needle should be on the left end of the optical bench.
3. Record its position
4. Take beu. Move image needle *I* on right hand side of the lens. Place it at the estimated position of the image.

Table

S/N	**Object position U (cm)**	**Image position V (cm)**	**U^{-1} (cm^{-1})**	**V^{-1} (cm^{-1})**	**F = UV /(U + V (cm)**

5. Adjust it at the position of no parallax. Note the position of image needle *I*. L1 is the distance of the needle's image which is usually denoted by *v*.
6. Repeat the six (6) different values of *u*. every time you should change the position of object needle beyond **F** (say at a distance of about f/6).

PARAMETER TO BE DETERMINED

1. The rough focal length of the convex lens = …………cm
2. Actual lenth of index needle = ……………...cm
3. Observed distance between Objct needle and the lens = ………… cm
4. Observed distance btween Image needle I and the lens = ………… cm

ANSWER THE FOLLOWING QUESTIONS

a. Tabulate your readings
b. Plot a graph of V^{-1} against U^{-1} and determine the slope of the graph

c. Obtain the value of focal length of a convex lens by using the formula:
d. From the graph determine the value of focal length f of the convex lens
e. Determine the value of focal length of the convex using the formular and using the graph, compare the two values obtained theoretically and graphically.
f. What conclusion can you draw from this experiment and state the precaution taken during the experiment?

EXPERIMENT 11

Topic: DETERMINATION OF THE FOCAL LENGTH OF A DIVERGING (CONCAVE) LENS

AIM: (1) To determine the focal length of a concave lens by virtual image method using a concave mirror.

(2) To determine the focal length of a concave lens by virtual image method using a convex lens.

THEORY: A concave lens produces a virtual erect and diminished image for all position of a real object. With converging rays from a virtual object, a concave lens can produce a real converging ray, and both approaches will be used in this experiment. If an optical pin is placed beyond the focus of a convex lens, a real image will be formed at some point C.

APPARATUS: Concave mirror, convex lens, optical pin, optical bench, meter rule.

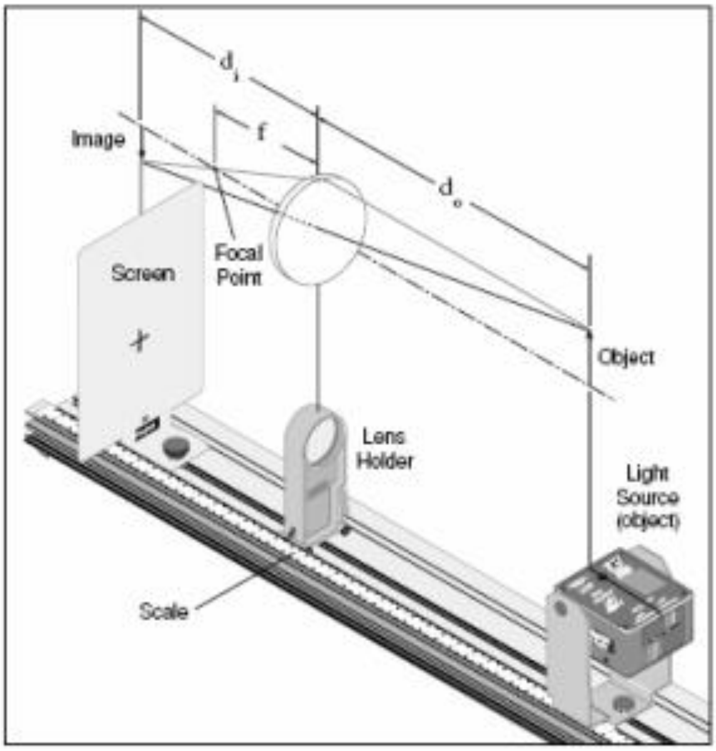


Figure 11: Diagram

Procedures:

1. Place an optical pin in front of a concave mirror on an optical bench or an appropriate arrangement and adjust it until at point C, where there is no parallax between the object pin and the inverted image.
2. Now, introduce a concave lens and if necessary, adjust the position of the lens without disturbing the mirror.
3. Mark the position of the lens as N and that of the mirror as P, to find position C' where the object pin coincides with its image. This position must be obtained by the method of no parallax.
4. Determine **do** which will act as the object distance and **di** which will serve as the image distance.
5. Shift the lens to five other positions and determine the object and image distance for the concave lens.

Note: In this experiment, the object distance from the lens u is positive (real object) and the image distance from the lens v is negative (virtual image)

INSTRUCTIONS FOR (2)

1. Obtain the approximate focal length of the convex lens using the method described above.
2. Now, place an object about twice the focal length from the lens. Locate the positions with the help of another pin by the method of no parallax
3. Place the concave lens at some position N, between C and the convex lens. This will produce a real image at C', using the original image at C as a virtual object.
4. Determine CN and C'N which correspond the virtual object and the real convex lens.

Note: In this experiment, it is possible to make the image of the pin coincide with the pin itself only if the optical axes of the concave lens and the concave mirror or convex lens coincide. Also, a real image will not be formed at C' if CN is greater than the focal length of the concave lens.

ANSWER THE FOLLOWING QUESTIONS

a. From the first set of data (instructions 1), plot 1/u against 1/v and deduce the focal length from the graph.
b. From the second set of data (instructions 2), plot a graph of 1/u against 1/v and deduce the focal length f from the graph.
c. Compare the results obtained from the two experiments
d. What are the major sources of error in this experiment?
e. State the precautions to take to get good results.