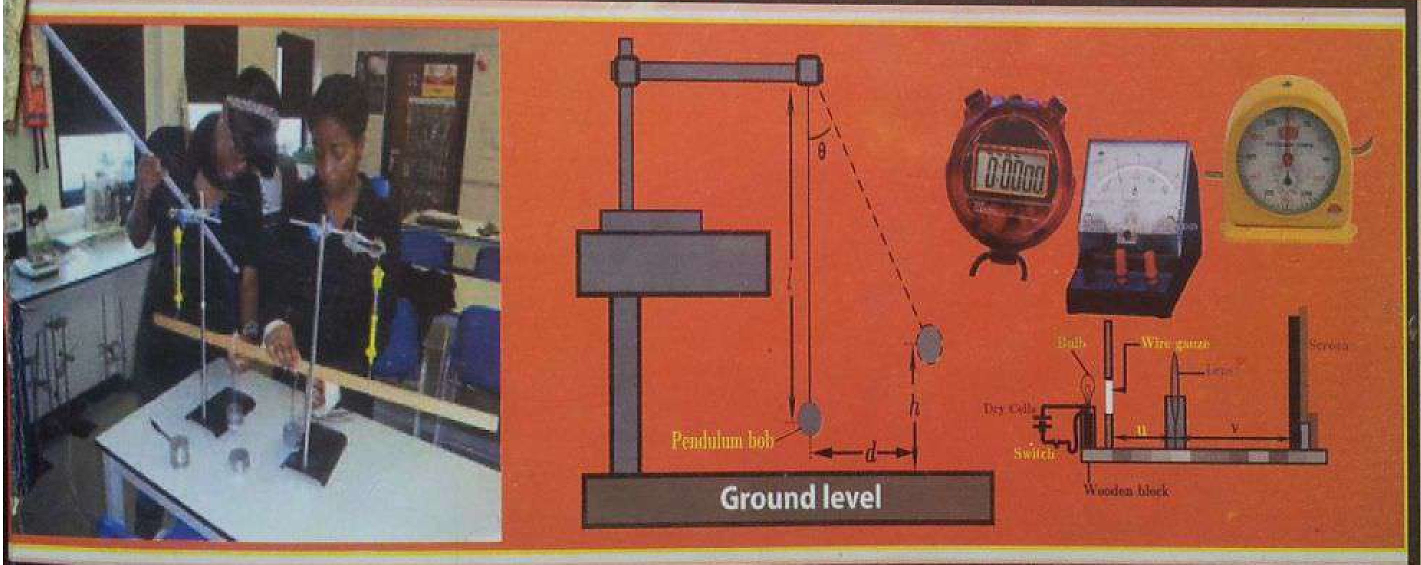
Ordinary Level PHYSICS Practical Guide

A comprehensive guide with techniques on:

- Writing units and symbols
- Reading instruments
- Data manipulation
- Graph work

Making a marking guide (for teachers)



Practical Questions on Various Topics

Enoch Mungati

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ORDINARY LEVEL PHYSICS PRACTICAL GUIDE

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PREFACE

This book is intended for students preparing for ordinary level examinations in practical physics. It's also designed to help teachers easily and effectively conduct lessons in practical physics.

Physics as a subject of study is to a great extent a practical subject. The knowledge acquired in practical physics is not only essential in helping students pass practical and theory examinations but to also develop the practical skills and techniques which may be useful in the development of their careers in future.

It is a common problem that many students put a lot of effort in acquainting themselves with the theoretical knowledge but put less effort in practical physics. This greatly affects their performance not only in the practical examinations but also in the theory examinations. This guide is therefore designed to help students acquire the necessary skills and techniques which are essential in passing physics examinations. It contains simplified notes on measurement and recording of values in an experiment, use of physics instruments, their degree of accuracy and presentation of practical data.

It also contains experiments in mechanics, optics, electricity, magnetism and heat designed to illustrate the various aspects of practical physics.

Students will find this book very useful as it will help them acquire the skills and techniques essential in the manipulation of the apparatus, the use and understanding of the instruments involved.

With the sequence of practical experiments organized in this book, it is hoped that students will be able to do a lot of practice and understand the underlying principles of practical physics.

It is also hoped that teachers will find this book very helpful when organizing practical work for their students.

This comprehensive practical guide also contains guidelines on how to prepare a simple physics practical marking guide which have been included specifically for teachers.

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Last but not least I thank the unsung hero, my wife Lydia Kilande for the love, care and encouragement during the arduous period whilst writing this book.

May GOD bless them abundantly!

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CHAPTER ONE

1.0 INTRODUCTION

Practical physics is an essential part of physics which mainly involves the verification of laws and determination of certain physical constants through experimentation. This book contains a collection of experiments that demonstrate a wide range of physical concepts and processes. We shall look at the verification of laws and determination of constants mainly taught at ordinary level. The practical activities included in this book are not just motivational but they are to help sharpen the students' powers of observation, stimulate questions and also develop new understanding and vocabulary.

For the learners to effectively carry out any physics practical activity, it's imperative that they read and understand the instructions and procedures given for the activity. A significant number of the experiments in this book may also require that the students have some theoretical knowledge about the experiment. However, each experiment is designed with simple procedures and the necessary setup to help students easily conduct the experiment. With the practical notes given in this book, the procedures, the illustrations for each setup and the list of the apparatus provided in the book for each experiment, students should be able to conduct the experiments with less difficulty. Students should always seek for the teacher's guidance when carrying out practical work especially where they are supposed to take some safety precautions. It is also important that after carrying out the experiment and tabulating the practical data, graphical analysis of the experiment (if necessary) should be done.

Every practical activity or experiment in physics has an aim which must be achieved at the end of the activity. This is always indicated at the beginning of the experiment. Students should always, after every experiment evaluate to see whether the aim of the experiment has been achieved.

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1.1 Examination Format and explanatory notes

This sub-section discusses the format of a standard ordinary level examination and also looks at what students are expected to do during the first 15 minutes which is an essential part of a practical physics examination. A standard ordinary level physics practical examination consists of three questions. The first question which is usually a mechanics question is compulsory. The second question is normally set from either optics (light) or heat. Question three is normally set from electricity or magnetism. Students are required to attempt only two questions i.e. one should answer either question one and question two or question one and question three. The duration for an 'O' level physics practical paper is 2 hours and 15 minutes. The actual working time is 2 hours. Students are expected to constructively use the first 15 minutes doing the following:

- ✓ Read through all the questions and carefully choose the right questions to attempt but question one is compulsory
- ✓ Read and understand the aim and the procedure for the experiment
- ✓ Relate the quantities to be measured with the apparatus provided. Ensure that all the required apparatus are provided.
- ✓ Read through all the procedures carefully and identify the quantities to be tabulated.
- ✓ Plan and draw the table of results.
- ✓ Study the setup of the apparatus as shown in the diagram and plan to arrange them.
- ✓ Plan how to present the practical data i.e. note the procedures where you are required to record, measure, determine, find or calculate.

It's been noted that many students start working with the apparatus before they even read through the instructions given in the question paper. Every instruction given in the question paper is very important and must be read and understood.

NB: When writing a physics practical answer, the following are very important;

- ♦ There must be a clear record of experimental results.
- ♦ There is no need for one to copy the procedure {e.g. (a), (b), etc} and the aim of the experiment when writing a practical answer.
- ♦ Units must be recorded correctly where necessary and written once.
- ♦ Neatness and good handwriting are of the essence. Students are advised to carry at least 2 well sharpened pencils, at least 2 pens (blue or black), a geometry set and a 30cm transparent ruler.

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2.0 UNITS AND SYMBOLS OF QUANTITIES

2.1 Convention for writing Units and their Symbols

The following rules are to be followed when writing units and their symbols

1. Units must be stated either in full or using their right symbols. Abbreviations of units should not be used e.g. the unit for time is second or s and not sec, time of 20 seconds must be recorded as 20 seconds or 20s not 20sec, mass of 0.200 in kilograms should be recorded as 0.200 kilograms or 0.200 kg and not 0.200 kgms etc.
2. The symbol for a unit named after a scientist is to be written with a capital letter e.g. newton (N), joule (J), ampere (A), kelvin (K), volt (V) etc. If such a unit is written in full, small letters must be used e.g. joules, amperes, newtons, volts etc. except for Celsius.
3. Units which are not named after scientists should be written with small letters e.g. kg, s, m, cm etc.
4. Symbols of units remain unaltered in plural form but when written in words, plurals can be used e.g. symbol for 20kilograms is 20kg and not 20kgs, symbol for 10 centimetres is 10cm and not 10cms etc.
5. If a quantity is written in the table, the unit must be written once at the top of the column inside the brackets () and not after forward slash / e.g. mass m in kilograms is written as m(kg) not m/kg, length, l in metres is written as l(m) not l/m, period, T in seconds is written as T(s) and not T/s etc.
6. The symbols for units are not to be followed by a full stop. For example, the symbol for metre is m (not m.), the symbol for second is s (not s.), symbol for kilogram is kg (not kg.) e.t.c.
7. Units of derived quantities should be written using scientific notation e.g. m s^{-2} not m/s^2, kg m^{-3} not kg/m^3 etc.
8. When recording experimental values (directly measured values), the unit attached must be the unit of the instrument used unless when required to record otherwise e.g if the values of a given quantity are required in SI units, then they must be recorded in SI units.
9. sines, cosines, tangents of angles and logarithms do not have units.
10. Symbols used must be written clearly and correctly as required. If the symbol used is not given or defined in the instructions, it must be clearly defined. Do not change the symbols and the case of the letters used in the procedure e.g. m to M, x to X, l to L and vice versa etc.

Below are some of the quantities with their SI units

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2.2 Fundamental quantities and their units

Quantity	*Unit*	*Symbol*
Mass	kilogram	kg
Length	metre	m
Time	second	s
Temperature	kelvin	K
Electric current	ampere	A
Luminous intensity	candela	cd
Amount of substance	mole	mol

2.3 Derive quantities and their units

Quantity	*Unit*	*Symbol*
Area	square metre	m^2
Volume	cubic metre	m^3
Force	newton	N
Period	second	s
Frequency	hertz	Hz
Energy, work, heat	joule	J
Electric resistance	ohm	Ω
P.d/Voltage/Electromotive force (e.m.f)	volt	V
Density	kilogram per cubic metre	$kg\ m^{-3}$
Velocity	metre per second	$m\ s^{-1}$
Acceleration	metre per square second	$m\ s^{-2}$
Power	watt	W
Pressure	newton per square metre OR pascal	$N\ m^{-2}$ OR Pa
Momentum	kilogram metre per second	$kg\ m\ s^{-1}$
Temperature	degrees Celsius	°C
Specific Heat Capacity	joule per kilogram per kelvin	$J\ kg^{-1}K^{-1}$

2.4 Smaller and bigger units

Below are some of the small and bigger units used in physics

Multiple	*Prefix*	*Symbol*	*Example*
10^3	kilo-	k	4km $= 4 \times 10^3$m
10^6	mega-	M	30Mbytes $= 30 \times 10^6$bytes
10^9	giga-	G	15Gbytes $= 15 \times 10^9$bytes

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10^{12}	tera-	T	2Tbytes $= 2 \times 10^{12}$bytes
10^{15}	peta-	P	16Pbytes $= 16 \times 10^{15}$bytes
10^{18}	exa-	E	20Ebytes $= 20 \times 10^{18}$bytes
10^{-1}	deci-	d	1dm $= 1 \times 10^{-2}$m
10^{-2}	centi-	c	3cm $= 3 \times 10^{-2}$m
10^{-3}	milli-	m	3mm $= 3 \times 10^{-3}$m
10^{-6}	micro-	μ	2μF $= 2 \times 10^{-6}$F
10^{-9}	nano-	n	16nm $= 16 \times 10^{-9}$m
10^{-12}	pico-	p	6pC $= 6 \times 10^{-12}$C
10^{-15}	femto-	f	24fC $= 24 \times 10^{-15}$C
10^{-18}	atto-	a	40am $= 40 \times 10^{-18}$m

2.5 Symbols of some multiples and sub-multiples of a metre

multiples of a metre		sub-multiples of a metre	
Unit	**Symbol**	**unit**	**Symbol**
kilometre	km	decimeter	dm
hectometre	hm	centimeter	cm
decametre	dam	millimeter	mm

Note:

(i) 1 km = 1000m, 1hm = 100m and 1dam = 10m

(ii) $1 \text{ dm} = \frac{1}{10} \text{ m} = 10^{-1} \text{ m}$, $1 \text{ cm} = \frac{1}{100} \text{ m} = 10^{-2} \text{ m}$ and $1 \text{ mm} = \frac{1}{1000} \text{ m} = 10^{-3} \text{ m}$

3.0 MEASURING INSTRUMENTS.

All experiments in physics and perhaps all other science subjects require the use of measuring instruments. In order to carry out an experiment, one must know how to use these instruments. Students are therefore advised to (with the guidance of their teachers) learn how to use all the physics measuring instruments in the laboratory. They should also know the unit and the degrees of accuracy of each of these instruments.

Below are some of the physics measuring instruments with their units, degree of accuracy and how they are used.

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3.1 MESUREMENT OF LENGTH

3.1 The meter rule

The meter rule is used to measure length of at least 10cm except for light experiments.

It is graduated in centimetres and has 1000 divisions. Each division is equal to 0.1cm.

The meter rule measures length to 1 decimal place (it has a least count of 0.1cm) i.e. values of length obtained using a metre rule must be recorded in cm to 1dp.e.g. 10.2cm, 25.0cm etc.

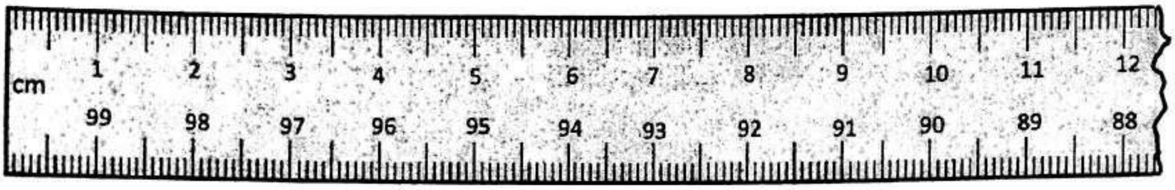

Fig 3.1 metre rule

Note:

If you are required to measure and record the length, l, in meters, then l must be recorded in meters to three decimal places.

(i) E.g. If $l(\text{cm}) = 32.4$ then $l(\text{m}) = 0.324$

(ii) If $l(\text{cm}) = 2.7$ then $l(\text{m}) = 0.027$

3.2 MEASUREMENT OF TIME

3.2(a) The Stop watch

The stop watch measures time in seconds (s) to two decimal places. Values of time obtained using a stopwatch must be recorded to two decimal places e.g. 9.45, 15.57, 49.92 etc.

It's important to note that the stop watch may give values of time in minutes, seconds and hundredths of seconds. These values should be converted and recorded in seconds. Values of time should be recorded in minutes only when required in minutes.

Note :

1 hundredth of a second $= \frac{1}{100}$ seconds $= 0.01$ seconds. This is the **least count** of a stop watch.

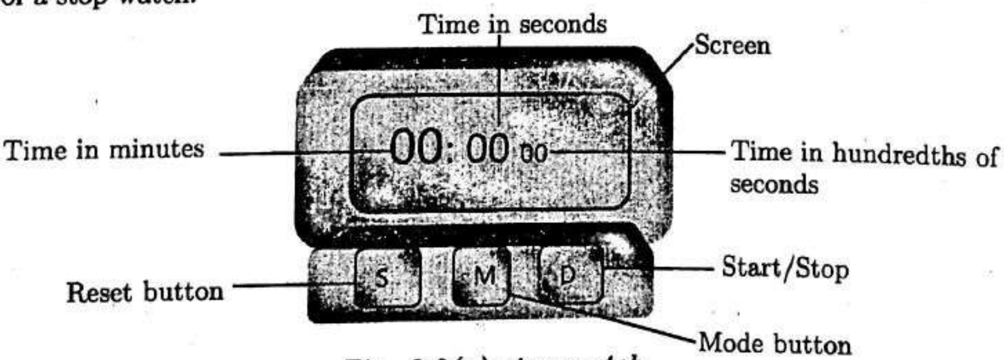

Fig. 3.2(a) stop watch

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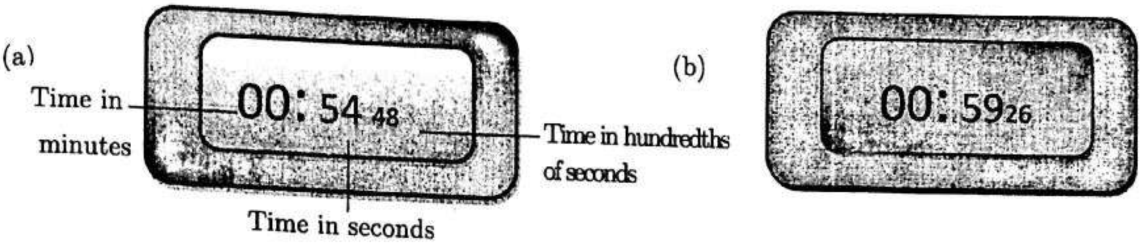
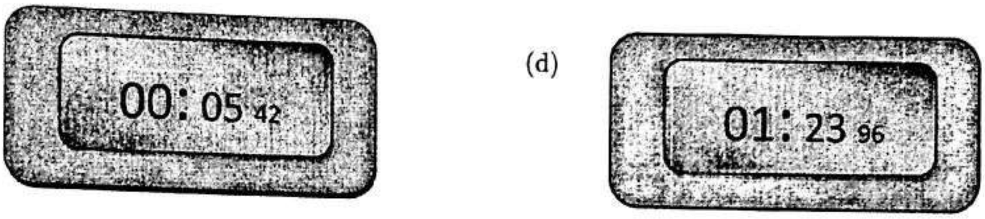
Note: Before using the stop watch, reset it such that its initial reading is zero as in figure above.

Example

Convert the time t, in the figures below to seconds



(c)



Solution

(i)

Recall *Fig 3.2(a)(i) Measurement of time*

1 hundredth of a second $= \frac{1}{100}$ seconds

54 hundredths of seconds $= 54 \times \frac{1}{100}$

$= \frac{54}{100}$ seconds

$= 0.54$ seconds

Time, t = 0 minutes + 54 seconds + 0.48 seconds

$\Rightarrow$ t = 54.48 seconds

(ii) t = 59.23seconds (iii) t = 6.40seconds

(iv) Time, t = 1 minute + 17.98 seconds

= 60 seconds + 17.98 seconds

= 77.98 seconds

3.2(b) The Stop clock

The stop clock measures time in seconds (s) to zero or one decimal place. **However, for a better accuracy it's advisable for students to record the experimental values (directly measured values) of time (e.g. time for 20 oscillations, time for 10 oscillations etc.) to one decimal place.** In this case, students should be able to estimate the reading between two divisions on the scale of the stop clock but should be mindful of the position of the pointer on the scale. This is illustrated in fig. 3.2 (b)(ii) below. If the values of time obtained using a stop clock are recorded to one decimal place, the last digit must be five (5) or zero (0) e.g. 7.0, 10.0 10.5, 15.0, 33.5, 35.0 etc.

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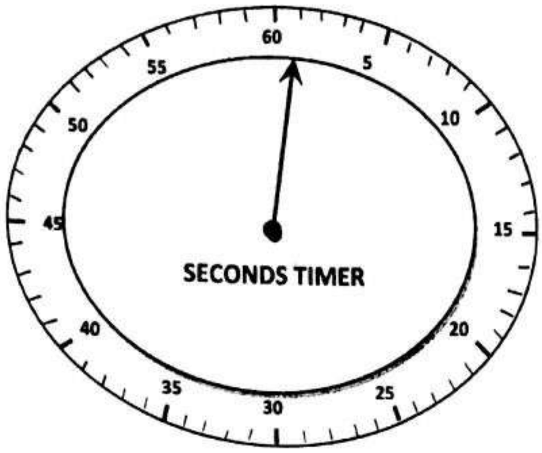
Example

TYPE 1



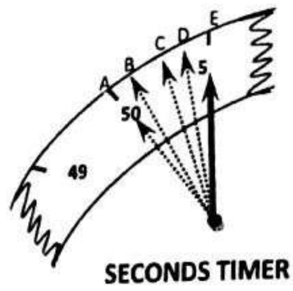


Fig 3.2(b)(i) Reading a stop clock *Fig 3.2(b)(ii) Reading a stop clock*

Fig 3.2(b)(ii) above is an extract from figure 3.2 (b)(i). The reading of the stop clock in figure 3.2(b)(i) is 61s (to 0dp) **but as explained above, it's advisable to record this value to 1 d.p as 61.0** s. In figure 3.2(b)(ii), the readings of the stop clock to 1 decimal place when the pointer is in positions A, B, C, D and E are as follows.

In position A, the stop clock reading = 50.0 s

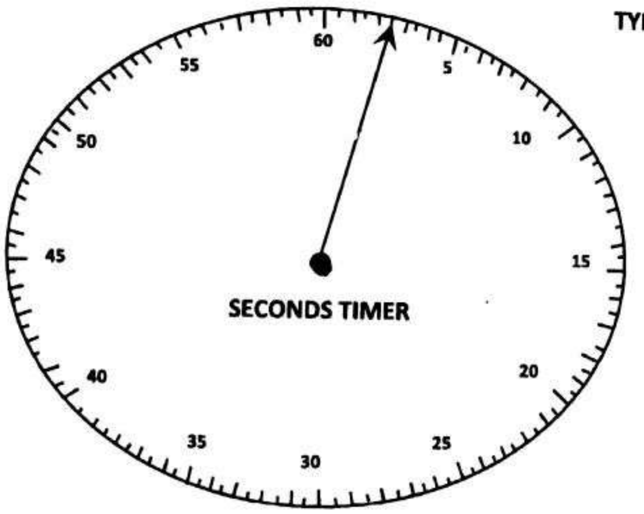
In position B, the pointer is close to the 50th division, hence the stop clock reading = 50.0 s not 50.2s.

In position C, the pointer is half-way between 50.0s and 51.0s. Thus the stop clock reading = 50.5 s.

In position D, the pointer is close to the 51st division. Stop clock reading = 51.0 s.

In position E, the stop clock reading = 51.0 s

TYPE 2



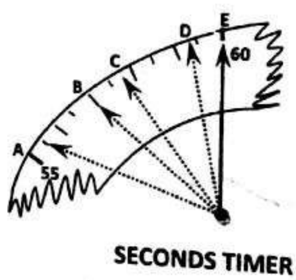


Fig 3.2(b)(iii) Reading a stop clock *Fig 3.2(b)(iv) Reading a stop clock*

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In figure 3.2(b)(iii), the reading of the stop clock is 62.5 s. In figure 3.2(b)(iv)above, the readings of the stop clock when the pointer is in positions A, B, C, D and E are as follows;

In position A, stop clock reading = 55.5 s

In position B, stop clock reading = 57.0 s

In position C, stop clock reading = 58.0 s not 57.6 s

In position D, stop clock reading = 59.0 s not 58.8 s

In position E, stop clock reading = 60.0s.

It's important to note that values recorded to a wrong number of decimal places are marked wrong even if they lie in the range for correct values.

Advise to teachers/laboratory technicians or laboratory assistants

Before giving the instruments to be used to the learners, please ensure that the instruments:

(i) provided are in good working condition.

(ii) are properly checked for zero errors and are tested for any faults.

(iii) provided are the ones specified in the instructions and the learners should be advised work accordingly i.e. students should record the experimental values to the same number of decimal places as the least count of the instrument provided not any other instrument unless told to do otherwise.

Where the instruments or apparatus provided to the students are different from the ones specified in the instructions, a report should be made about it such that when the student's work is marked by a different person, these instruments or apparatus are put into consideration.

3.3 MEASUREMENT OF CURRENT

3.3 (a) AMMETERS

Ammeters measure current in amperes (A) to two decimal places. They are in two types i.e. single scale ammeters and double scale ammeters. The ammeter is always connected in series with other components through which current passes and must be connected in such a way that its positive terminal is connected to the positive terminal of the battery/cell (or any other source of e.m.f) and the negative terminal to the negative terminal of the battery/cell.

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3.3(a)(i) SINGLE SCALE AMMETER

This type of ammeter consists of two terminals and has only one scale. An example of this type of ammeter is shown in the figure below.

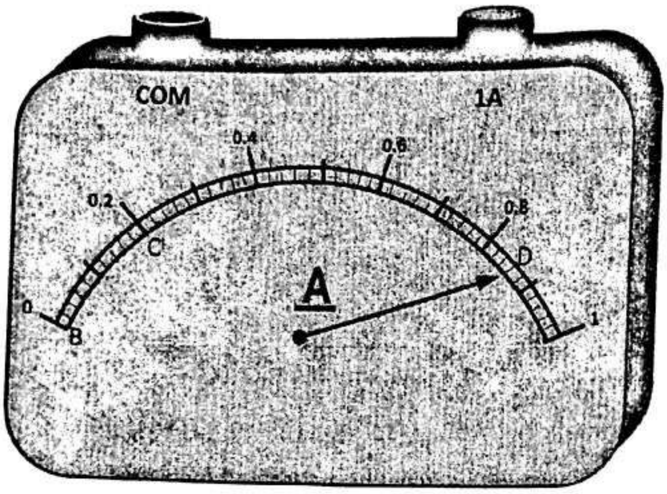

Figure 3.3(a) (i) single scale

How to read the ammeter

The reading of the ammeter is determined as follows:

1) Find what 1 division represents.
2) Count the number of divisions between the zero mark (point B) and the pointer position (point D)
3) Multiply the number of divisions between B and D by what 1 division represents.

In figure 3.3(a)(i) above, the ammeter reading can be determined as fellows;

10 divisions(between B and C) = 0.2A

1division $= \frac{0.2}{10} = 0.02A$

Number of divisions between B and D = 43 divisions

Ammeter reading $= 43 \times 0.02$

Ammeter reading = 0.86A

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3.3(b) DOUBLE SCALE AMMETERS

These are ammeters with two scales. They have three terminals. One of the terminals is labelled COM (usually red in colour) and the other two (usually black in colour) are each labelled with the maximum current that can be measured at full scale deflection.

Note:

✓Only two terminals of the ammeter must be connected. This also applies to a double scale voltmeter.

✓When connecting an ammeter or voltmeter in the circuit, start with the terminal labelled COM and then connect the other terminal (the terminal labelled with least value of current).

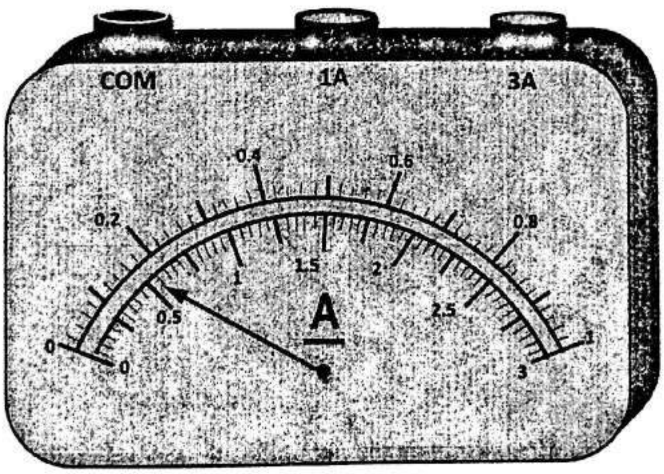
✓ The scale used depends on the terminals connected e.g. if the terminal labelled COM and the 1A terminal are connected, use the scale with range 0 – 1A.

✓When using ammeters and voltmeters, check and see whether the pointer is at the zero mark of the scale before connecting it in the circuit. If the pointer is not at zero, ask for assistance from the teacher.

✓If the voltmeter or ammeter is correctly connected, the first deflection of the pointer must be in the clockwise direction. If the first deflection of the pointer is in the wrong direction (anti-clockwise), interchange the wires to the terminals connected.

Example

TYPE 1



In th *Figure 3.3(b)(i) Double scale ammeter*

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10divions $= 0.2A$

1 division $= 0.02A$

Ammeter reading $= 0.02 \times 9$

$= 0.18A.$

Suppose the terminal labelled COM and the terminal labelled 3A are connected. If the position of the pointer is as in the diagram above, then the ammeter reading is determined as follows.

10 divisions $= 0.5A$

1division $= 0.05A$

Ammeter reading $= 0.05 \times 11$

$= 0.55A$

TYPE 2

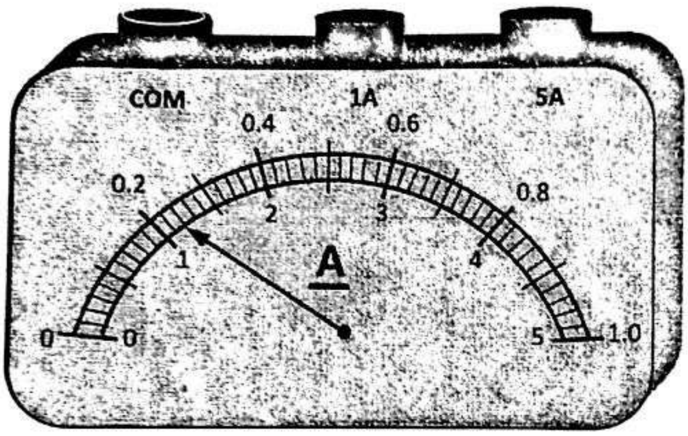

Figure 3.3(b)(ii) Double scale ammeter

Consider the scale with range 0 – 1A

10divisions $=0.2A$

1 division $=0.02$

Ammeter reading $=0.02\times12$

$= 0.24A$

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3 . 4 MEASUREMENT OF VOLTAGE

3 . 4 (a) VOLTMETER

A voltmeter measures voltage (p.d) in volts (V) to two decimal places. The voltmeter is always connected parallel to the resistor /cell or any other component whose p.d is to be determined.

As with the ammeter, the voltmeter must also be connected in such a way that its positive terminal is connected to the positive of the cell/battery and its negative terminal to the negative of the cell/battery.

3.4(a) (i) SINGLE SCALE VOLTMETER

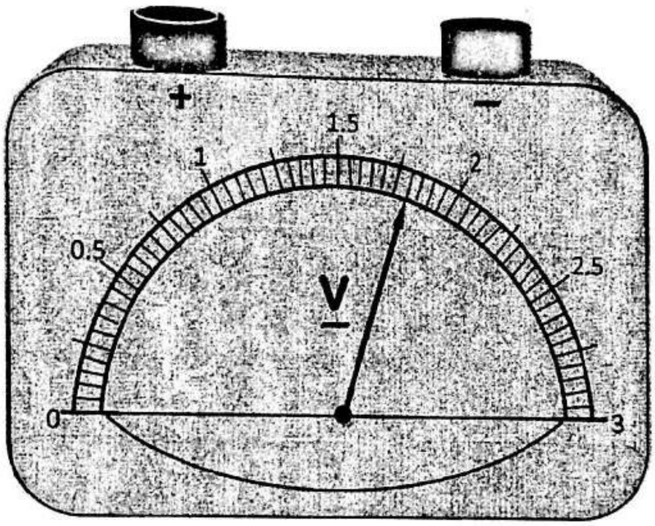

Fig 3.4(a)(i) Single scale voltmeter

In the diagram above;

10 divisions	$=0.5V$
1 division	$=0.05V$
voltmeter reading	$=0.05\times36$
	$=1.80V$

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3.4(a)(ii)DOUBLE SCALE VOLTMETER

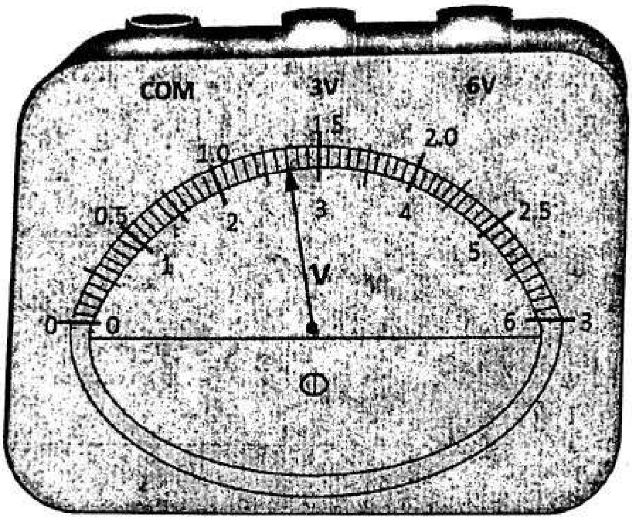

Fig 3.4(a)(ii) Double scale voltmeter

Consider the scale with range 0 - 3V

10divisions $=0.5V$

1 division $=0.05V$

voltmeter reading $=0.05 \times 27$

$=1.35V$

Suppose the voltmeter in the figure 3.4 (a)(ii)above is connected across 3 cells in the circuit and the pointer position remains as shown. The terminals connected in this case would be the terminal labelled COM and the 6V terminal. The scale used in this case would be the one with the range 0 – 6V.

From the diagram,

10divisions $=1V$

1 division $=0.1V$

voltmeter reading $=0.1 \times 27$

$=2.70V$

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3. 5 MEASUREMENT OF TEMPERATURE

3.5(a) THE THERMOMETER

The thermometer measures temperature in degrees Celsius (°C) to zero or one decimal place.

Note:

If the temperature is recorded to one decimal place, the last digit should be 0 or 5 e.g.15.0°C, 38.5°C, 65.0°C etc

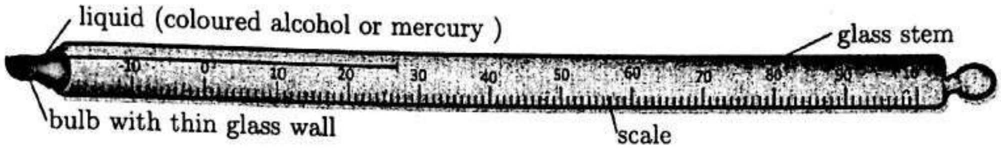

Fig 3.5(a) Thermometer

The reading of the thermometer shown in the figure above is 27°C (to 0dp) or 27.0°C (to 1dp).

When measuring the room temperature or temperature of the surrounding, hold the glass tube (and not the bulb) until a steady value of temperature is reached. The steady value of the temperature obtained is the room temperature.

3.6 MEASUREMENT OF MASS AND WEIGHT

3.6(a) SPRING BALANCE

A spring balance can be used to measure both mass and weight. It has two scales, one for measuring weight in newton (N) and the other for measuring mass in grams as shown in the figure below.

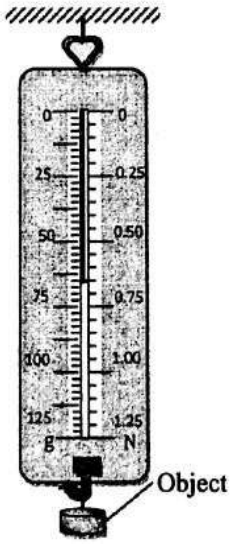

Fig 3.6(a) spring balance

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In the diagram above the mass and weight of the suspended object can be determined as follows.

Mass of object

The mass is obtained using the scale on the left hand side as follows;

$$10\text{divisions} = 25\text{g}$$

$$1 \text{ division} = 2.5\text{g}$$

$$\text{mass of object} = 2.5 \times 26$$

$$= 65.0\text{g}$$

The mass of the object should be recorded to 1 decimal place.

If the mass is required in kg, then it must be recorded in kg to 4 decimal places e.g. 0.0450g

Weight of the object

The weight of the suspended object is obtained using the scale on the right hand side as follows;

$$10\text{divisions} = 0.50\text{N}$$

$$1\text{division} = 0.050\text{N}$$

$$\text{weight of object} = 0.050 \times 13$$

$$= 0.650\text{N}$$

The weight of the object should be recorded to 3 decimal places.

3.6(b) TRIPLE BEAM BALANCE.

A triple beam balance measures mass in grams (g) to one decimal place e.g. 2.5g, 5.8g, 8.0g, 35.8g e.tc. If the mass is required in kilogram (kg), it must be recorded in kg to 4 decimal places e.g. 0.0025kg, 0.0058kg, and 0.0358kg etc.

3.6(c) ELECTRONIC BALANCE

The electronic balance is also used to measure mass in grams (g) to either 1 decimal place e.g. 0.9g, 2.7g, or 2 d.p e.g. 1.35g, 6.50g etc. If the masses are required in kg then they should be recorded to 4 d.p or 5 d.p respectively e.g. 0.0009kg, 0.0027kg or 0.00135kg, 0.00650kg, etc.

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3.7 MEASUREMENT OF ANGLES

3.7 (a) PROTRACTOR

The protractor measures angles in degrees (°) to zero decimal places. Values of angles obtained using a protractor must be recorded to zero decimal places (as whole numbers) e.g. 30°, 8°, 42°, 125° etc.

3.8 LEAST COUNT OF A MEASURING INSTRUMENT.

The least count of a measuring instrument is the smallest value of a physical quantity which can be measured accurately using that instrument. Thus the least count indicates the degree of accuracy of measurement that can be achieved by the measuring instrument. It is determined by dividing one main division by the total number of small division it represents i.e it is equivalent to the value which the smallest division on the scale represents. All measuring instruments in physics have a least count. A metre rule has a least count of 0.1cm, a vernier caliper has a least count of 0.01cm, a voltmeter has a least count of 0.02V, although this may vary: a micrometer screw gauge has a least count of 0.01mm etc. When recording experimental values (directly measured), the least count of the instrument (looked at in terms of the number of decimal places) must be put in consideration i.e. the values obtained using the instrument must be recorded to the same number of decimal places as the least count of that instrument.

SUMMARY

Instrument	Quantity measured	Unit (symbol)	Degree of accuracy (Least count)
Meter rule	Length (l), $l \geq 10$cm.	centimetres (cm) If values of l are required in metres(m)	1 decimal place (0.1cm) 3 decimal places
Vernier caliper	Length (l), 1cm $\leq l <$ 10cm	centimetres (cm) If values of l are required in metres(m)	2 decimal places (0.01cm) 5decimal places
Micrometer screw gauge	Length (l), $l <$1cm	millimetres (mm) If values of l are required in metres(m)	2 decimal places (0.01mm) 5decimal places
Voltmeter	Voltage	volts (V)	2 dpl (If V≤ 3.00 volts) 1 dpl (If V> 3.00 volts)
Ammeter	Current (I)	amperes(A)	2dpl(If I ≤ 1.00 ampere) 1 dpl(If I > 1.00 ampere)

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Stop clock	Time	seconds (s)	0 dpl or 1dpl. If 1dpl then last digit must be 0 or 5
Stop watch	Time	seconds(s)	2 decimal places
Thermometer	Temperature	degrees Celicius (°C)	0 decimal places **OR** 1 decimal place If 1dpl, then the last digit must be 0 or 5.
Measuring cylinder	Volume	cubic centimetres(cm^3) OR millilitres(ml)	0 decimal places
Burette	Volume	cubic centimetres(cm^3)	0 decimal places
Pipette	Volume	cubic centimetres(cm^3)	0 decimal places
Beaker	Volume	cubic centimetres(cm^3) OR millilitres(ml)	0 decimal places
Flasks	Volume	cubic centimetres(cm^3) OR millilitres(ml)	0 decimal places
Triple beam balance	Mass	grams (g)	1 decimal place
Protractor	Angles	degrees(°)	0 decimal places

4.0 RECORDING MEASUREMENTS IN AN EXPERIMENT

There are two types of measurements i.e. single and repeated measurements.

4.1 Recording Single measurements

These are measurements taken on quantities like diameter of wire, width/breadth of glass block/ruler, thickness of glass block /ruler etc. Single measurements should be measured three times and entered in a small table. The average of the recorded values should be calculated outside the small table. When calculating the average, the working must be clearly shown.

Example:

If you are required to measure and record the width w, of the meter rule.

Measure it three times and record in a small table as shown below.

$w_1(cm)$	$w_2(cm)$	$w_3(cm)$
2.67	2.68	2.68

The required breadth will then be the average of the three recorded values.

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$$w = \frac{w_1 + w_2 + w_3}{3}$$

$$= \frac{2.67 + 2.68 + 2.68}{3}$$

$$\therefore w = 2.68cm$$

If the quantity to be measured is required in SI units, then measure and record in SI units.

E.g. if you are required to measure and record the width w in meters then record as follows;

$w_1(m)$	$w_2(m)$	$w_3(m)$
0.0267	0.0268	0.0268

$$w = \frac{w_1 + w_2 + w_3}{3}$$

$$= \frac{0.0267 + 0.0268 + 0.0268}{3}$$

$$\therefore w = 0.0268m$$

4.2 Recording repeated measurements

Repeated readings are readings that are noted twice in the procedure. These readings are usually taken on variable quantities like extension, angle of refraction, current, voltage etc. Such readings must be recorded in the main table of results.

5.2 HOW TO RECORD DATA IN THE MAIN TABLE OF RESULTS

The main table of results must contain only values of varying quantities. Constant values must be recorded outside the main table of results.

(i) **Given values of a varying quantity**. These are usually given in the procedure. They must be recorded the way they are given in the instructions unless when told to record otherwise. They should be recorded in the first column of the table.

(ii) **Experimental values (measured values).** These are values of a varying quantity that are determined using an instrument. They should be recorded to the accuracy of the instrument used. E.g. If required to measure and record length, l, in cm using a metre rule, then the values of l obtained should be recorded to 1 decimal place.

(iii) **Values of a derived quantity (calculated values).** These values normally come from experimental values (measured values). Calculated values in the table of results at this level are usually written to at least 2 decimal places but preferably 3 decimal places for a better accuracy and easy plotting.

(iv) **Values of sine, cosine, tangent and log** must be recorded to three decimal places.

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6.0 PRESENTATION OF PRACTICAL WORK

The following must be considered when writing the practical answer.

(i) Aim or Title of the experiment

(ii) Recording the single measurements

(iii) The main table of results

(iv) The graph(s)

(v) Calculations

(vi) Precautions taken if necessary

6.1 Aim or Title of the experiment.

The aim of the experiment should not be written down on the answer sheet but it's advisable to read and understand it in order to know the purpose of the experiment.

6.2 Recording single measurements.

If the value of a non-variable quantity is required, measure the quantity at least three times and then calculate the average but the degree of accuracy of the instrument should be maintained.

6.3 The main table of results

- The table of results must be a column table i.e. it must be drawn in columns not rows
- All the columns in the table must appear side by side in a single block.
- The first column is for the given variables followed by measured variables and lastly derived quantities.
- Each column in the table must be correctly labelled, with correct quantity and unit. The quantities should be separated from their units by use of brackets () and not a forward slash / or back slash \ e.g. m (kg), t(s), T(s), T^2 (s^2) etc.
- When labeling columns, write the quantity once using the symbol or letter given in the procedure e.g. if you are required to tabulate values of magnification $m = \frac{v}{u}$, then the label for the column of magnification should be *m* and not $m = \frac{v}{u}$.
- The table must be continuous i.e. should not be split into two or more parts.
- The table should be closed at the top and bottom with individual columns demarcated using bold vertical lines.
- The table of results must include only variable observations (quantities). Readings taken on non-variable quantities (single measurements) like focal length, initial position of the pointer (if it is constant), centre of gravity etc. should be recorded outside the table of results.

(i) It must be as detailed as possible i.e. In case a derived quantity is obtained from other quantities; all these quantities must be included in the table of results e.g. if values of $\frac{1}{x^2}$ and $\frac{1}{\sin^2\theta}$ are required in the table of results, then the values of x, x^2, $\frac{1}{x^2}$, θ, sinθ, $\sin^2\theta$, and $\frac{1}{\sin^2\theta}$ must all be included in the table of results.

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- The table of results should be self-explanatory. All symbols used in the table of results should be well defined if they are not standard symbols and have not been defined in the procedures of the experiment e.g. If 20T or t is used to represent the time for 20 oscillations, it must be clearly defined outside the table of results.

6.4 Graph work

When drawing graphs, the following must be considered.

6.4 (a) Title:

✓ The graph must have a title clearly written at the top of the graph paper.

✓ The title should be properly written in only one line e.g. A graph of V against I or A graph of V versus I. This means the values of V are to be plotted along the vertical axis and values of I along the horizontal axis. Do not use Vs in place of versus.

✓ Units of the physical quantities must not be included in the title.

(b) The axes:

✓ The axes must be drawn perpendicular to each other with an arrow on each axis to show the direction in which values are increasing.

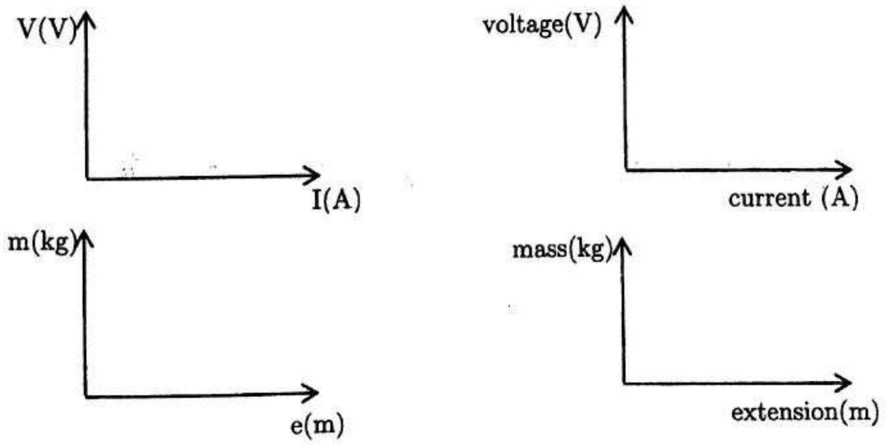
✓ Each axis must be clearly and correctly labelled **horizontally** with the quantity and the appropriate unit where applicable. The quantity and its unit must be at the same level except for degrees e.g.

m(kg) and not $m(_{kg})$ or $m(^{kg})$. The unit degrees (°), should be written slightly above the level of the quantity e.g. $r(^{\circ})$, $i(^{\circ})$, $\theta(^{\circ})$ etc.

Note:

Students must avoid labeling the axes as the y-axis and x-axis. The symbols used in the labels should be those that represent the actual quantities to be plotted i.e. the axes should be labelled using the correct symbol or letter and the appropriate unit where necessary.

Acceptable ways of labeling the axes of the graph



N.B:

✓The axes must not be drawn using broken lines

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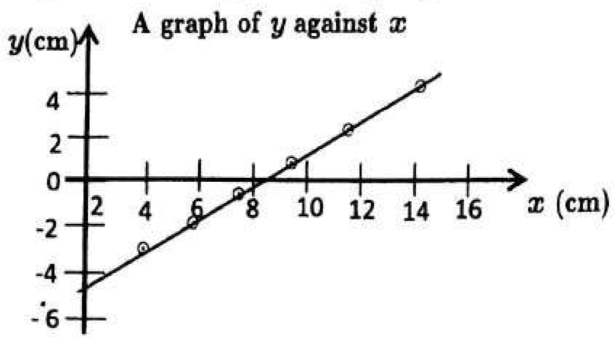
✓Each axis must be clearly marked after every 10 small squares (2cm) starting from the origin.
It's important to note that the graph may not necessarily start from the origin (0, 0).
When drawing the axes, select a suitable position on the graph paper and draw the axes so as to cover all the values (positive and negative if any) in your table. This is illustrated below.



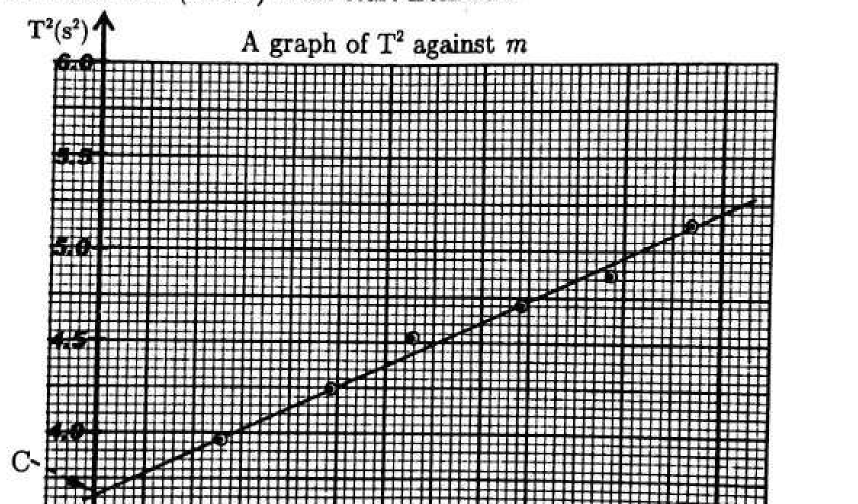
The starting points on both axes must be clearly indicated for proper interpretation of the scale.

6.4(c) Intercept.

The intercept on a particular axis is the value for the quantity plotted along that axis for which the quantity plotted along the other axis is zero.

Vertical intercept

If the intercept on the vertical axis (y-axis) is required, the starting point for the vertical axis can be anywhere but the horizontal axis (x-axis) must start from zero



From the figure above, the *vertical intercept*, C = 3.65 s^2

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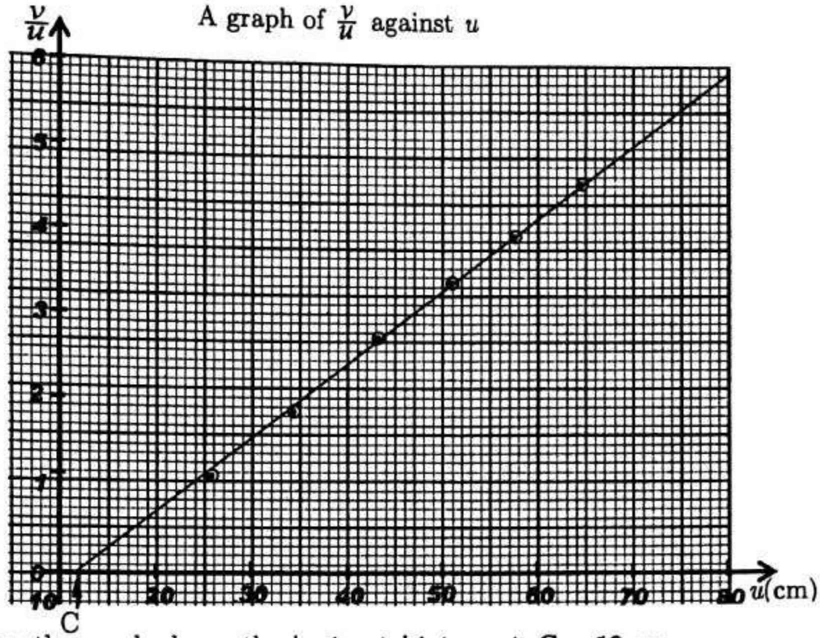
Horizontal Intercept

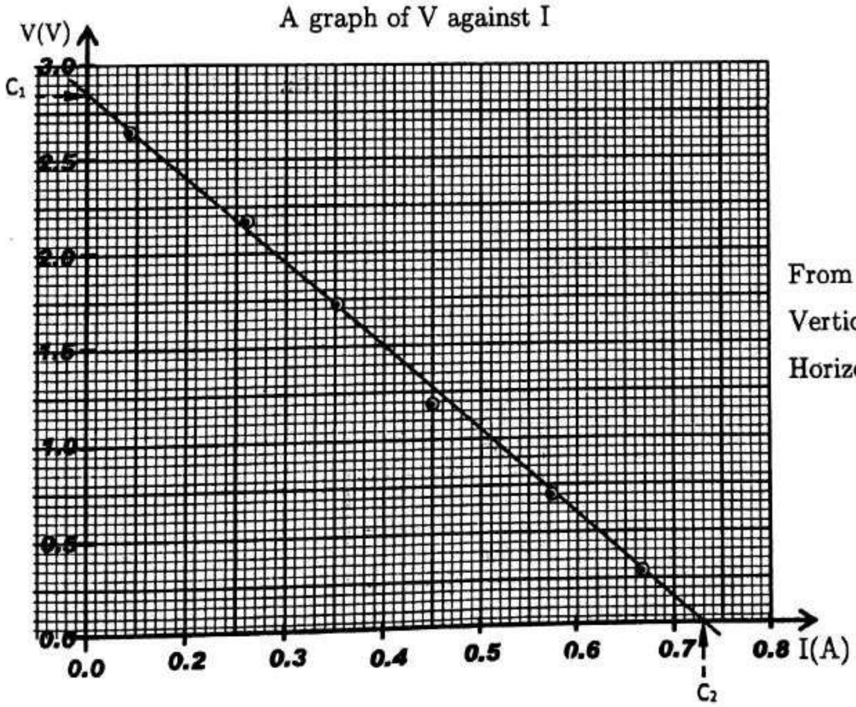
If the intercept on the horizontal axis (x-axis) is required, the values on the vertical axis (y-axis) must start from zero.



From the graph above, the *horizontal intercept*, **C = 12 cm.**

Intercept on both axes

If both the horizontal and vertical intercepts are required, then both axes must start from zero. This is illustrated in the example below.



From the graph;

Vertical intercept, $C_1 = 2.85V$

Horizontal intercept, $C_2 = 0.73A$

6.4(d) Scale

It's been noted that student ; find a lot of (ifficulty when plotting values on the graph.

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This may be attributed to use of inconvenient scales which are not.

When plotting values on the graph, the scales used must;

- ✓ Cover at least 50% of the graph paper on both axes i.e. 12cm (6 big squares) on the vertical axis and 10cm (5 big squares) on the horizontal axis for UNEB (type) graph papers.
- ✓ Be uniform.
- ✓ Be suitable and convenient.

The only convenient scales are 1, 2, and 5 and other generated scales from these digits (their multiples and submultiples), e.g.

0.1, 0.2, 0.5
0.01, 0.02, 0.05
0.001, 0.002, 0.005
10, 20, 50
100, 200, 500 e.t.c

The scales above and other scales that can be generated from the digits 1, 2 and 5 constitute a set of convenient scales.

Scales involving digits 3, 4, 6, 7, 8 and 9 are not convenient and should not be used.

NB: For easy plotting, the scales must be in terms of what 1(one) small square represents.

How to obtain a convenient scale from table values

Example

Consider the table of results below.

You are required to plot a graph of T^2 against l, determine suitable and convenient scales that can be used to plot the values given in the table below.

t = *time for 20 oscillations*

l(m)	t(s)	T(s)	$T^2(s^2)$
0.900	37.0	1.85	3.42
0.800	36.0	1.80	3.24
0.700	34.5	1.73	2.99
0.600	32.0	1.60	2.56
0.500	29.5	1.48	2.19
0.400	26.0	1.30	1.69
0.300	23.0	1.15	1.32

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Solution

Vertical scale (T^2 – axis)

Range $= 3.42 - 1.32$

$= 2.10$

$\Rightarrow$ 10 big squares(20cm) $= 2.10$

1 big square(2cm or 10 small squares) $= \frac{2.10}{10} = 0.21$

since 0.21 lies between 0.2 and 0.5 from the set of convenient scales , for suitability we shall take 0.5 and not 0.2 as our convenient scale.

Thus 1big square(2cm or 10 small squares) $= 0.5$

and 1 small square $= 0.05$

NB: If the scale obtained after dividing the range by the number of big squares on the axis is not convenient but lies between two convenient scales, for suitability, take the upper convenient scale. E.g. If the scale obtained is 2cm (10 small squares) = 0.132, since this scale lies between 0.1 and 0.2 from the set of convenient scales, for suitability, we use a scale of 2cm to represent 0.2 and not 0.1.

Horizontal scale (l - axis)

Note: If the values to be plotted are increasing or decreasing uniformly like in the case for l, it may not be necessary to calculate the scale the way we did for values of T^2. For such values, it's possible to choose a suitable and convenient scale without calculating.

In this case we can use a scale of 1big square (2cm or 10 small squares) to represent 0.1 $\Rightarrow$1 small square will represent 0.01.

However, it's advisable to calculate the scale if you are not sure of the scale to use. This can be done as follows;

Range $= 0.90 - 0.30$

$= 0.60$

$\Rightarrow$ 8 big squares $= 0.60$

1 big square $= \frac{0.60}{8} = 0.075$

since 0.075 lies between 0.05 and 0.1 from the set of convenient scales, we shall use a scale of ;

1 big square $= 0.1$

$\Rightarrow$ 1 small square $= 0.01$

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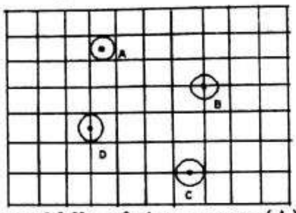
6.4(e) Signs used when plotting points

Accepted signs for plotting points include, . , ×, ⊙, ⊗ and ⊕. Very thick dots and the asterisk * should not be used to plot points. It's advisable to use a sharp pencil for graph work.

If ⊙ or ⊗ or ⊕ are used in plotting points, the circle must be of half a small square radius. This is illustrated in the diagram below.



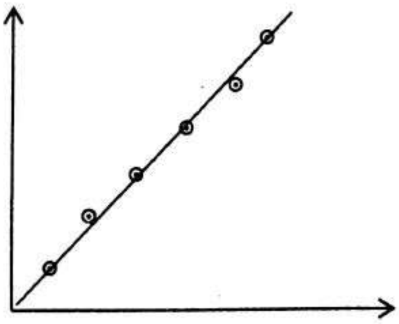
- If the point is in the middle of the square (A), the enclosing circle should not go beyond the boundaries of the square.
- If the point is at the intersection of lines (B), then the circle must cut the midpoints of the perpendiculars from it.
- If the point is on a horizontal line (C), the enclosing circle must be between the boundaries of the vertical lines before and after the point and should not touch the upper and lower lines.
- If the point is on a vertical line (D), the enclosing circle must be between the boundaries of the upper and the lower lines and should not touch the lines before and after the point.

6.4(f) The line of best fit or the best straight line.

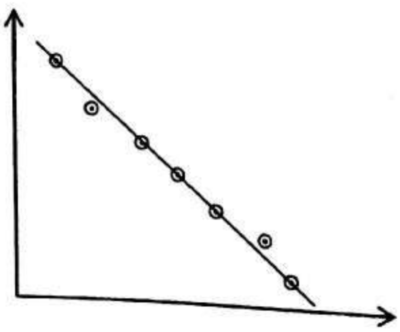
The best straight line also called the line of best fit in most elementary work is drawn according to ones judgment. It must be drawn to move in the trend of the plots.

For straight line graphs, the line of best fit to the data is that line which passes through most of the plotted points leaving out an equal or almost an equal number of points on either side if there is any scatter. This is illustrated bellow;

(i)



(ii)



If a line that satisfies the above condition cannot be obtained, then draw a line that averages the plotted points. This is illustrated in the diagram below

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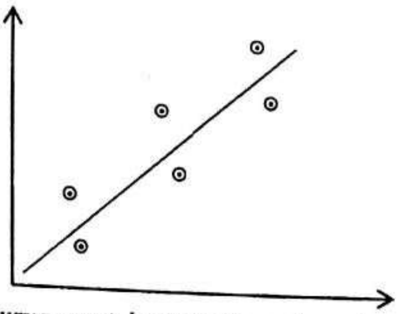


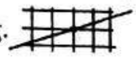
If the graph is a curve, the best curve must be smooth and needs not to pass through all the plotted points. Avoid sharp points or waves on curves.

6.4 (g) Slope

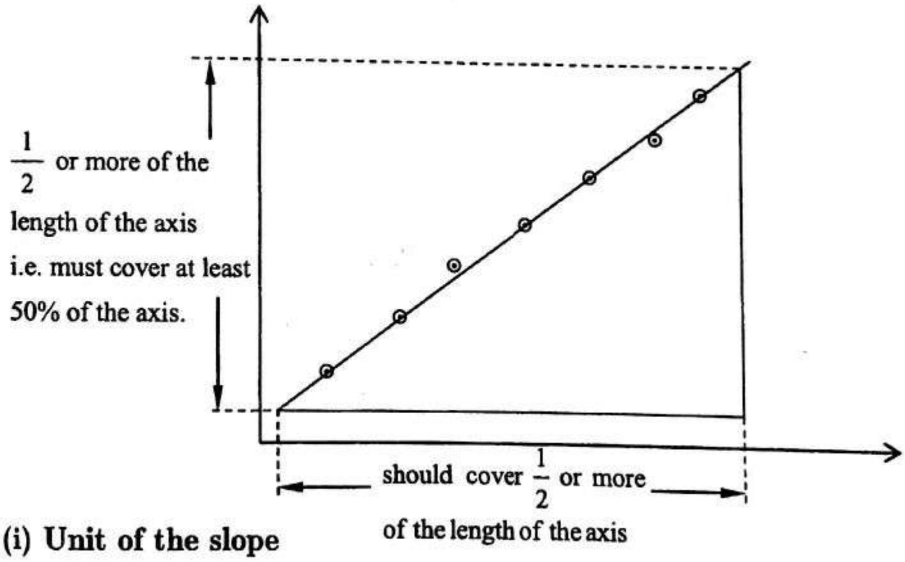
✓ When determining the slope (gradient) of the graph, use as much of the graph paper as possible.

✓ If the graph is a straight line graph, draw a large right angled triangle covering all the plotted points.

✓ The triangle drawn must touch the line of best fit.

✓ The two points selected for calculating the slope must enclose the plotted points where possible. They must be on the crossing points of squares which lie on the line of best fit and they should not be the plotted points. e.g. 

✓ The big triangle drawn, with two sides parallel to the axes, should cover half or more of the axes. This is illustrated in the sketch below



6.4 (g) (i) Unit of the slope

The slope must have units derived from the axes of the graph e.g. if a graph of T^2 against m is plotted and the units of T^2 and m are s^2 and kg respectively, then the unit of the slope should be $s^2\ kg^{-1}$.

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NB: If the unit of the slope derived from the axes is not S.I, convert to S.I unit before substituting the value of the slope into the final expression except for light. For light experiments, it's not necessary to convert the unit of the slope to S.I before substituting in the final expression given.

6.4 (g)(ii) Unit of the final constant or quantity determined.

The unit of the constant or quantity to be determined should be obtained from the slope and the other quantities substituted in the given expression. However, if the final quantity is a known quantity and not a constant, it should bare its SI unit e.g. if the final quantity to be determined is acceleration due to gravity, the unit attached should be m s^{-2}.

Example

(a) Calculate the acceleration due to gravity, g, from; $g = \frac{40\pi^2}{S}$,

Where $\pi = 3.14$ and slope, $S = 40.1\ s^2\ m^{-1}$

(b) Calculate the density , ρ, of water from; $2.5\ S = \rho\pi r^2$,

Where $\pi = 3.14$, r = 1.15cm and slope, S = 0.1661 kg m^{-}

Solution

(a) $$g = \frac{40 \times (3.14)^2}{(40.1)s^2\ m^{-1}}$$

$$\therefore\ g = 9.84\ m\ s^{-2}$$

(b) from $$\rho = \frac{2.5S}{\pi r^2}$$

$$\Rightarrow\ \rho = \frac{2.5 \times (0.1661)\ kg\ m^{-1}}{3.14 \times (1.15 \times 10^{-2})^2\ m^2}$$

$$\Rightarrow\ \rho = \frac{0.4153\ kg\ m^{-1}}{4.153\times 10^{-4}\ m^2}$$

$$\therefore\ \rho = 1000\ kg\ m^{-3}$$

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FURTHER EXAMPLES.

Example 1

In this experiment, you will investigate the relationship between the depression of a load beam and the distance between the supports.

Apparatus:

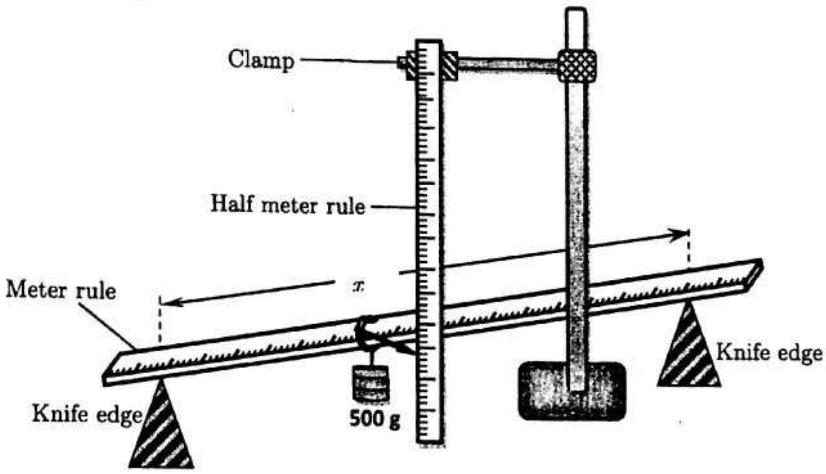
Metre rule, half metre rule, 2 knife edges, a 500 g mass and a retort stand with a clamp.

Procedure:

a) Attach a pointer at the 50.0 cm mark of the metre rule, using a piece of sellotape.

b) Place the metre rule so that it lies horizontally on the two knife-edges provided.

c) Clamp a half metre rule vertically and place it near the 50.0 cm mark of the metre rule as shown in the figure below.



d) Adjust the knife-edges such that the distance x between them is equal to 90.0 cm and they are equidistant from the 50.0 cm mark of the metre rule.

e) Read and record the position of the pointer on the scale.

f) Suspend a mass of 500 g at the 50.0 cm mark of the metre rule.

g) Read and record the position, P, of the pointer on the scale. Hence find the depression, d, of the midpoint of the metre rule.

h) Remove the mass from the metre rule.

i) Repeat procedures (d) to (h) for values of x = 80.0cm, 70.0 cm, 60.0 cm, 50.0 cm, and 40.0 cm.

j) Enter your results in a suitable table including values of $\log_{10} d$ and $\log_{10} x$.

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k) Plot a graph of $\log_{10}d$ (along the vertical axis) against $\log_{10}x$ (along the horizontal axis).

l) Find the slope, N, of the graph.

Solution

Let P_o be the initial position of the pointer and P be the new position of the pointer.

$P_o = 80.0cm$

x(cm)	P(cm)	d(cm)	$\log_{10} x$	$\log_{10} d$
90.0	84.8	4.8	1.954	0.681
80.0	82.8	2.8	1.903	0.447
70.0	81.7	1.7	1.845	0.230
60.0	81.2	1.2	1.778	0.079
50.0	80.6	0.6	1.699	-0.222
40.0	80.3	0.3	1.602	-0.523

Horizontal scale ($\log_{10}x$ - axis)

Range $= 1.954 - 1.602$

$= 0.352$

8 big squares(20cm) $= 0.352$

1big square(10 small squares) $= 0.044 \cong 0.05$

$\therefore$ 1 small square $= 0.005$

Vertical scale($\log_{10}d$ – axis)

Range $= 0.681 - (-0.523)$

$= 0.681 + 0.523$

$= 1.204$

$\Rightarrow$ 10 big squares $= 1.204$

1big square(10 small squares) $= \dfrac{1.204}{10} = 0.1204 \cong 0.2$

$\Rightarrow$ 1 small square $= 0.02$

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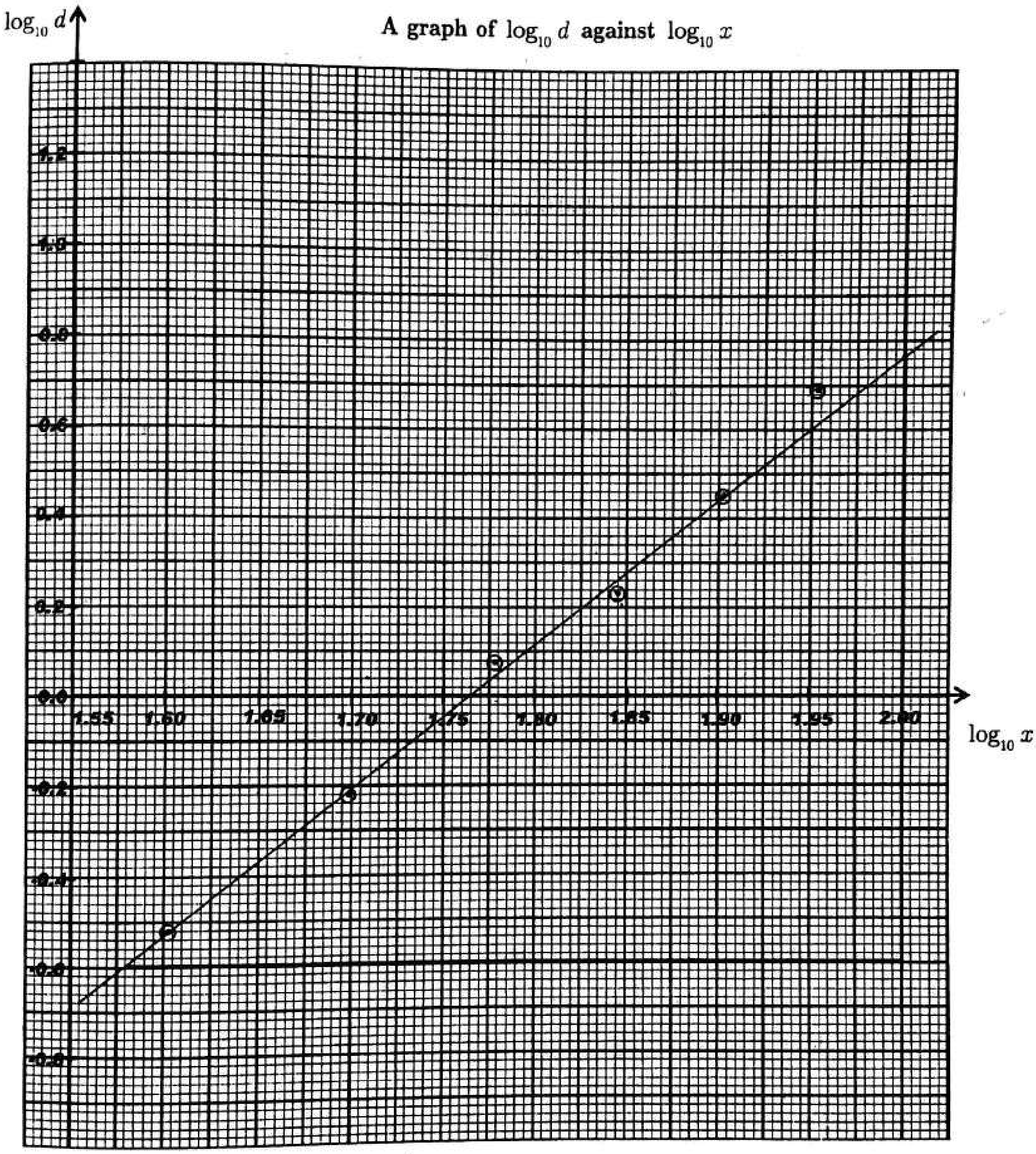
A graph of $\log_{10} d$ against $\log_{10} x$



From the graph,

$$\text{slope}, N = \frac{0.76-(-0.60)}{2.00 - 1.58}$$

$$= \frac{0.76+0.60}{2.00 - 1.58}$$

$$= \frac{1.36}{0.42}$$

$$\therefore N = 3.24$$

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Example 2

In this experiment, you will determine the resistances per unit length of the resistance wire P provided.

Apparatus:

2 cells, 1 resistor of 4Ω labelled Q, 100.0cm of clean bare resistance wire P (resistance per metre in the range 7 – 10 Ω), 1 metre rule, connecting wires and 1 voltmeter (0 – 3V).

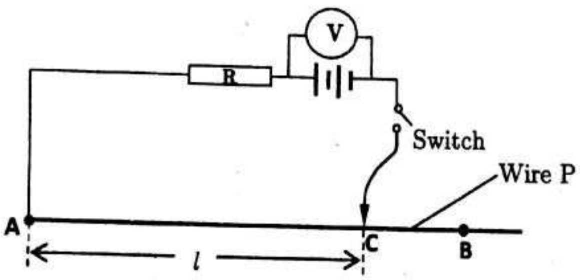
PART I

(a) Record the resistance, R_q, of the resistor Q.

(b) Connect P, Q and the cell in series and use the voltmeter to determine the p.d 'V_c' across the cell.

PART II

(a) Setup the circuit shown in the figure below.



(b) Connect the jockey to point C where l = 10.0cm. Read and record the voltmeter reading.

(c) Repeat procedure (b) for values of l = 20.0, 30.0, 40.0, 50.0, 60.0, 70.0 and 80.0cm.

(d) Record your results in a suitable table.

(e) Plot a graph of V against the length l.

(f) Find the intercept V_0 on V- axis.

(g) Find the value of l_0 where $V = \frac{V_0}{2}$

(h) Calculate the resistance per metre, R, of the wire P, from the expression, $R = \frac{100 R_q V_c}{l_0 V_0}$.

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Solution

PART I

$R_q = 4\Omega$

$V_e = 2.50V$

PART II

l(cm)	V(V)
10.0	1.40
20.0	1.25
30.0	1.10
40.0	1.00
50.0	0.90
60.0	0.85
70.0	0.75
80.0	0.70

Scales

Vertical scale(V – axis)

Range = 1.40 - 0.70 = 0.70

$\Rightarrow$ 10 big squares = 0.70

$$1 \text{ big square} = \frac{0.70}{10} = 0.07 \cong 1$$

$\Rightarrow$ 1 big square(10 small squares) = 1

1 small square = 0.1

Horizontal scale (l-axis)

Since the values of l are increasing uniformly, there is no need to calculate the scale because we can easily choose a suitable and convenient scale for plotting these values from scales generated from the digits 1, 2 and 5.

The most convenient and suitable scale that can be used in this case is

1big square (10 small squares) to represent 10

$\Rightarrow$ 1 small square = 1.

Note:

Calculations for the scale should be done as side work and should not be included in the practical answer because no marks are awarded for the working.

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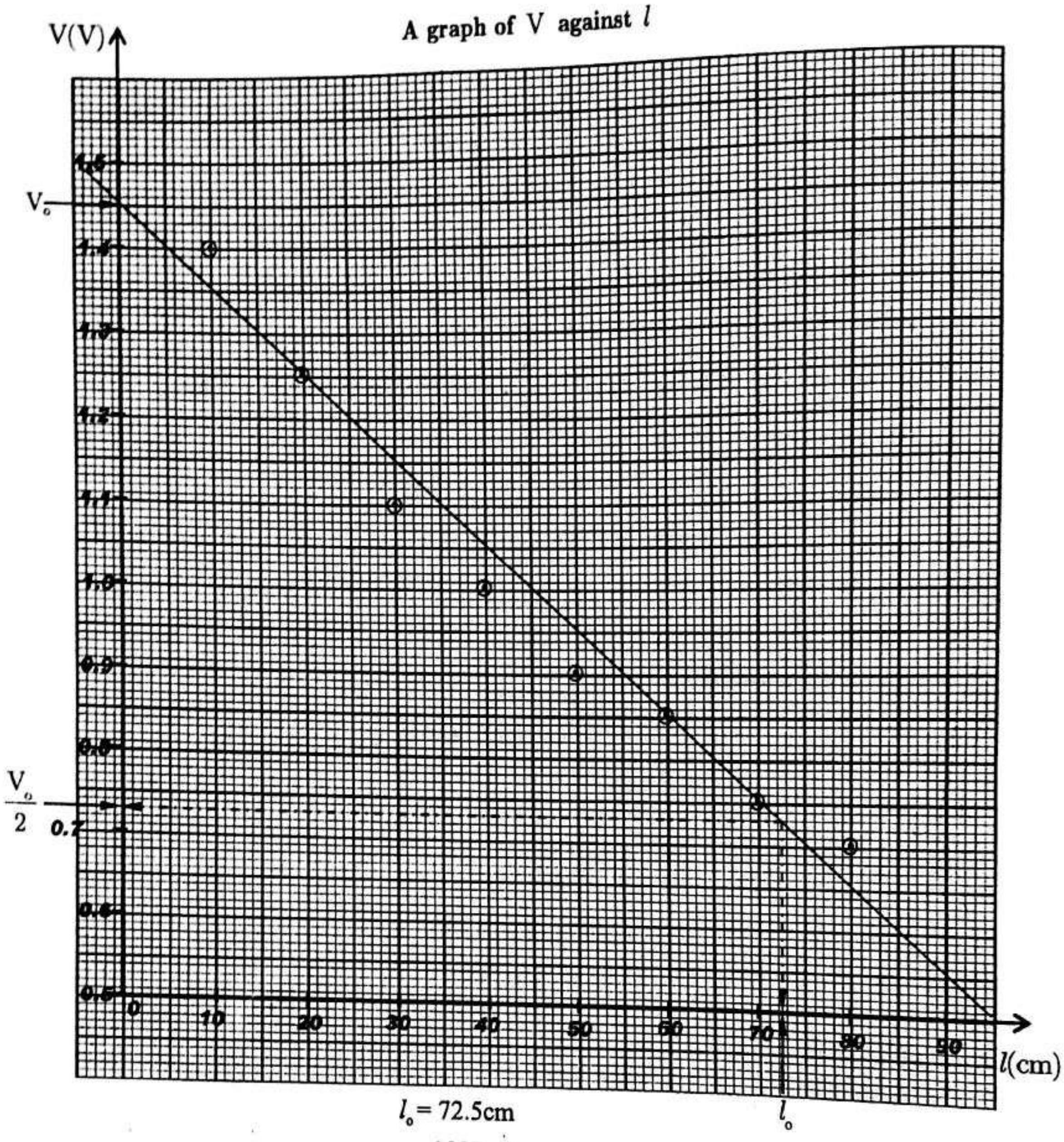
A graph of V against l



$l_o = 72.5$cm

From $R = \dfrac{100R_q V_C}{l_o V_o}$

$$R = \frac{100 \times 4 \times 2.50}{72.5 \times 1.45}$$

$$= \frac{1000}{105.125}$$

$\therefore\ R = 9.51\ \Omega\ m^{-1}$

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Example 3

In this experiment you will determine the focal length of the lens provided.

Apparatus:

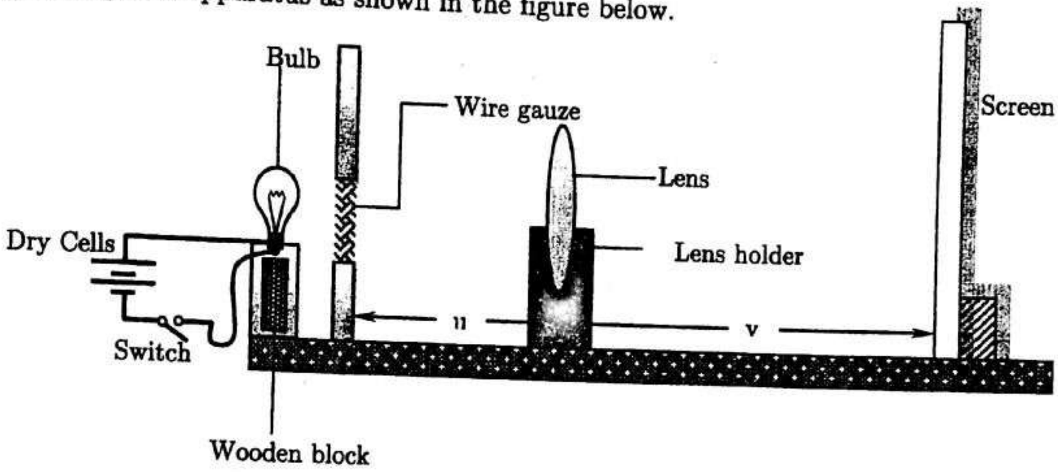
1 convex lens, 1white screen, 2 dry cells in a cell holder, 1 torch bulb in a bulb holder and wire gauge fixed certainly in a vertical board with a hole.

Procedure:

a) Focus a distant object onto the screen.

b) Measure and record the distance, F, between the lens and the screen.

c) Arrange the apparatus as shown in the figure below.



d) Starting with u = 1.5 F adjust the position of screen to obtain a sharp image of wire gauze on the screen.

e) Measure and record the image distance v.

f) Repeat procedures (d) and (e) for values of u = 2.0F, 2.5F, 3.0F, 3.5F, 4.0F and 4.5F.

g) Tabulate your results in a suitable table including values of (u+v).

h) Plot a graph of (u+v) against u.

i) Find the minimum value W of (u+v).

j) Find the focal length f of the lens from the expression, W = 4f.

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F = 10.0cm

u(cm)	v(cm)	(u + v)(cm)
15	29.0	44.0
20	19.6	39.6
25	17.2	42.2
30	16.0	46.0
35	15.0	50.0
40	13.0	53.0
45	12.5	57.5

SCALES

Vertical scale $\{(\mathbf{u}+\mathbf{v})-\mathbf{axis}\}$

Range $= 57.5 - 39.6 = 17.9$

$\Rightarrow$ 10 big squares $= 17.9$

1 big square $= 1.79 \cong 2$

Thus, 1 big square(10 small squares) $= 2$

$\Rightarrow$ 1 small square $= 0.2$

Horizontal scale $(\mathbf{u}-\mathbf{axis})$

1 big square(10 small squares) $= 5$

1 small square $= 0.5$

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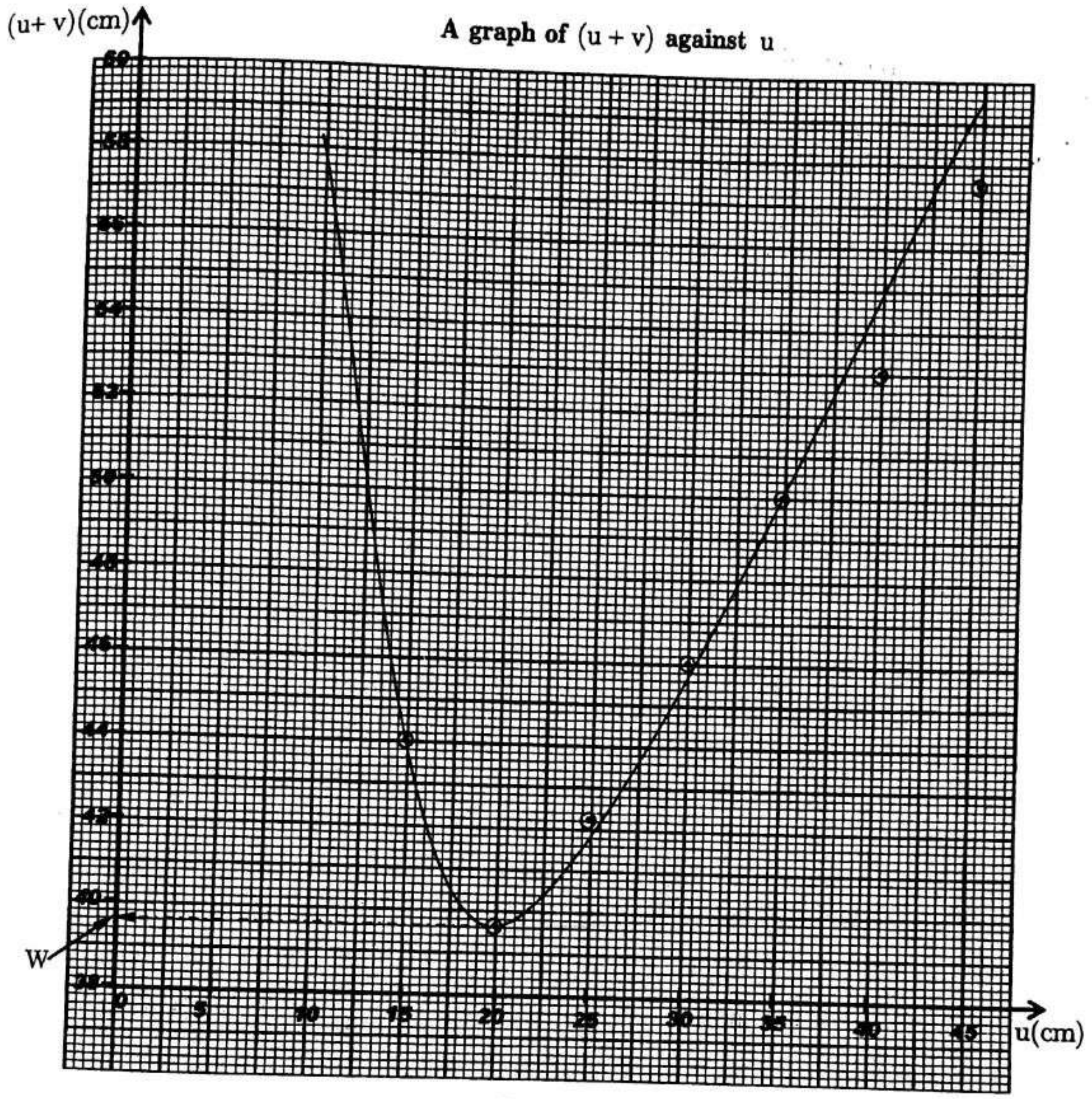
A graph of (u + v) against u



From the graph,

W = 39.6cm

From $f = \frac{W}{4}$

$\Rightarrow f = \frac{39.6}{4}$

$\therefore$ f = 9.9 cm

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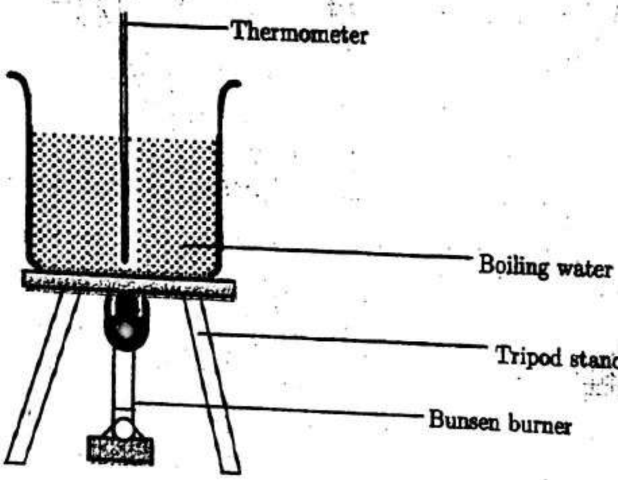
Example 4

In this experiment, you will determine the rate of cooling R of a body.

Apparatus:

1 thermometer, water, 1 beaker, 1 calorimeter, 1 stop clock/stop watch and 1 measuring cylinder.



Procedure:

a) Pour 300 ml of water in the beaker provided.

b) Heat the water until it boils.

c) Place a thermometer in the beaker of boiling water. Read and record the steady temperature T_0 of the water.

d) Remove the thermometer and immediately start the stop clock.

e) While holding the thermometer in air, record the reading T of the thermometer at half-a minute-time interval for five minutes.

f) Record the results in a suitable table.

g) Plot a graph of T against time t.

h) Determine the time t_1 taken for the temperature to fall from 60^0 C to 50^0 C.

i) Calculate R from the expression: $R = \frac{10}{t_1}$.

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$T = 35°C$

t(minutes)	T(°C)
0	65
2	62
4	59
6	56
8	53
10	51
12	50
14	48

SCALES

Vertical scale(T − axis)

Range = 65 - 48 = 17

10 big squares = 17

1 big square = 1.7 ≅ 2

1 small square = 0.2

Horizontal scale(t − axis)

1 big square = 2

1 small square = 0.2

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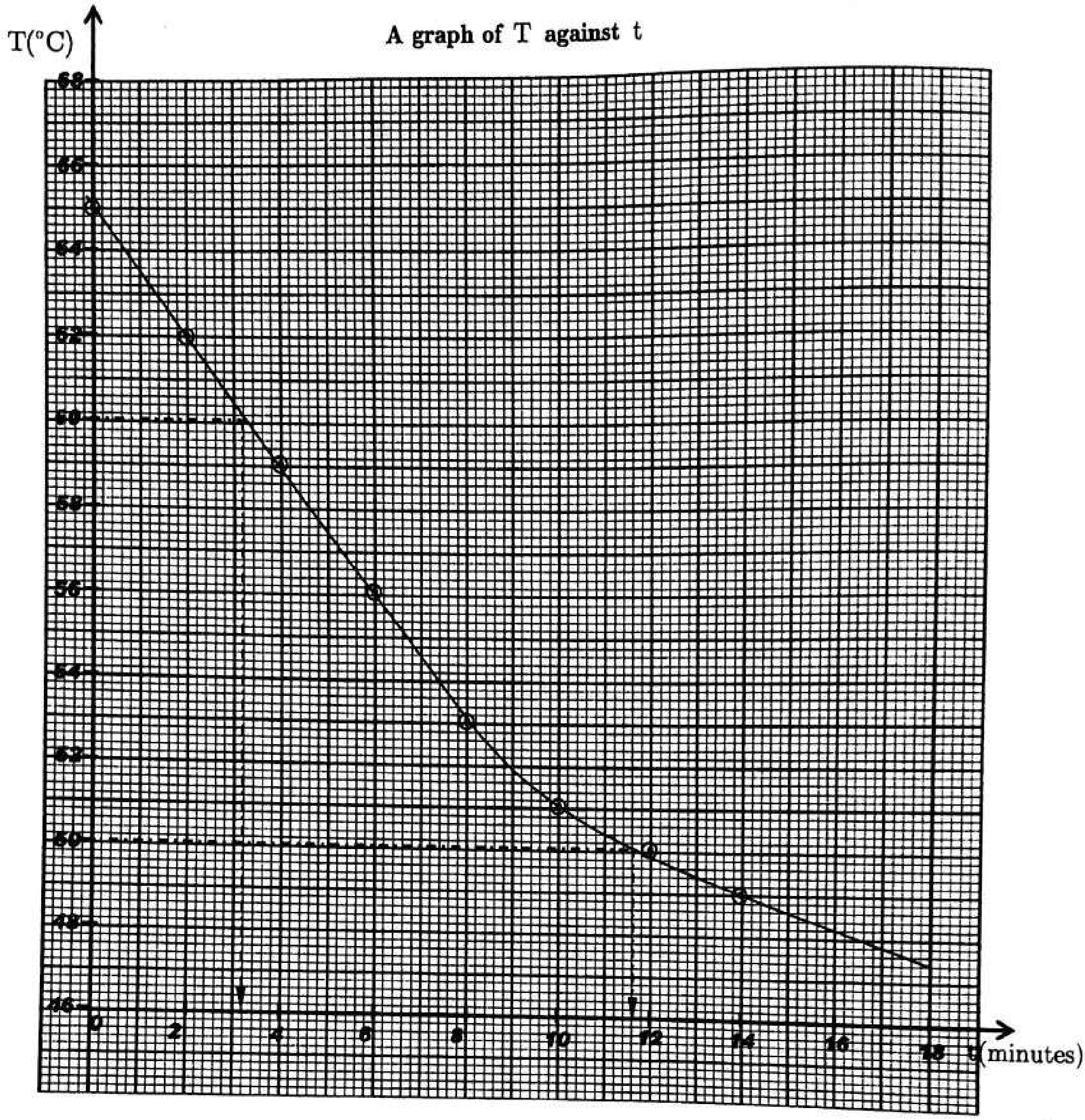

From the graph,

$t_1 = 11.6 - 3.2$

$t_1 = 8.4$ minutes

from $R = \frac{10}{t_1}$

$\Rightarrow \quad R = \frac{10}{8.4}$

$\therefore \quad R = 1.2^{\circ}C\ \text{minute}^{-1}$

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7.0 HOW TO MAKE A SIMPLE MARKING GUIDE

There are three physics practical papers examined at ordinary level i.e. paper 535/3, paper 535/4 and paper 535/5. Paper 535/4 and paper 535/5 are normally done by candidates in schools with a big number of students. However the format for setting these practical papers is the same. A standard physics practical paper consists of three questions. Candidates are required to answer two questions but question 1 is compulsory. Each question carries 20 marks. Total mark is 40.

The marking schemes for these practical papers are coded (letters are used.)

These codes are:

D's - D_1, D_2, D_3, etc. (D's are used for diagrams) – Each should be awarded $\frac{1}{2}$ or 1 mark.

Diagrams are for questions on light involving tracing of rays of light through a prism and a glass block.

Note: All the traces should be included in the answer booklet and should bear name and the index number of the candidate where necessary.

R's – R_1, R_2, R_3 etc. - Normally awarded $\frac{1}{2}$ or $1\frac{1}{2}$ marks

These are used for marks scored on recording the indicated quantities (non-variable quantities) e.g. recording the mass of the meter rule, recording initial position of the pointer, recording the width or breadth of a glass block or a meter rule, recording the thickness of a meter rule or a glass block, recording the diameter of a wire, centre of gravity of a meter rule etc.

Note: Marks may be given for the value **and** the unit or for the value **with** the unit.

-Value with unit; means both the value and unit must be correct for the mark to be given. If only one is correct the candidate scores zero.

-Value and unit – means the value scores and the unit also scores.

T's – T_1, T_2, T_3. Only 3 T's are recommended.

✓ They are used for marks scored on the table of results.

✓ Data should be presented in table form. The table drawn should be a columnar table.

✓ Related values should be next to each other. However candidates should not be penalized if they are not put next to each other.

T_1 –For labeling the columns of the independent variable (given variables) (Normally $\frac{1}{2}$ a mark)

✓ Candidates should record the units given in the question paper. They should not change the units. E.g. y(cm), x(cm), m(kg), t(s), T(s), $T^2(s^2)$ etc.

✓ All variable quantities should be recorded in the same table of results. The table of results should not be split into two or more parts.

✓ All the values of the independent variable should be entered in the table of results in the order and unit given.

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✓ When labeling the columns, the units should be in brackets and not after a forward slash or a backward slash.

T_2 – For labelling the columns of the remaining quantities with appropriate units.

Here the marks may be awarded as follows;

1 mark for one extra column or

$\frac{1}{2}$ mark for each extra column or

$\frac{1}{2}$ mark for any 2 or 1 mark for all 3 columns or

$\frac{1}{2}$ mark for a pair

T_3 – Direct measurements (experimental values)e.g. read and record V, I, l, etc.

($\frac{1}{2}$, 1, $1\frac{1}{2}$ marks)

✓ recording the remaining values

– recording the derived quantities e.g. $\frac{V}{I}, \frac{l}{V}, \frac{V}{U}$, etc.

– recording the remaining derived quantities

Note;

✓ If data is presented in table form and the table is not closed on both sides but the values are correct, marks should be awarded.

✓ No marks are awarded for wrong values recorded in the table

✓ The sub - total mark up to this stage(table stage) should be (10 or 11 or 12)

G's – (G_1, G_2, G_3, ...). These are for marks awarded on graphs.

G_1 – Title of the graph (Normally $\frac{1}{2}$ mark)

✓ Accept the use of verses, Vs, variation with in stating the title of the graph.

✓ There should be no unit in the title of the graph .e.g. A graph of T^2 Vs x,

A graph of sin$i$ against sin$r$, A graph of $\frac{v}{u}$ verses u, A graph of V variation with I.

G_2 – labeling the axes with appropriate units (Normally $\frac{1}{2}$ mark @)

Correct quantity **with** unit (correct symbols).Units should be put in the brackets e.g. x(cm) and not x/cm or x\cm

G_3 – Suitable and convenient scales, with all other conditions satisfied (Normally $\frac{1}{2}$ mark @)

G_4 –Plotting of the points. (award $2\frac{1}{2}$ or 3 or $3\frac{1}{2}$ marks, each correctly plotted point $\frac{1}{2}$ mark)

✓ Accepted signs for plotting points include, ×, ⊗, . , ⊙, + and ⊕

✓ Wrong plotting should be penalized but correct reading of the values for intercept and calculation of slope is awarded marks.

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✓ Wrong values in the table obtained through suspected values and over rounding off are not awarded marks for the plotted points but correct reading of a point for intercept or calculations for the slope is awarded marks.

G_5 –For the line of best fit or best straight line. (Normally $\frac{1}{2}$ mark)

Conditions:

✓ There must be at least three correctly plotted points.

✓ The line drawn must pass through all or most of the plotted points and leave out either an equal number or almost an equal number of points on either side.

✓ The best straight line can also be a line that averages the plotted points i.e. a line that does not pass through any plotted point but averages them as earlier explained.

G_6 – For the method of finding the slope (Normally $\frac{1}{2}$ mark)

Conditions

✓ The big right angle triangle drawn must cover all plotted points and must touch the line of best fit.

✓ The two points selected for calculating the slope must enclose the plotted points where possible.

✓ The big triangle drawn with two sides parallel to the axes should cover half or more of the axes.

✓ If the large triangle is drawn in the area of the distorted scale, no mark is awarded for the slope. i.e. $G_6 = 0$

C's –For calculations; e.g. C_1, C_2, C_3, etc. (Usually awarded $\frac{1}{2}$, or 1or $1\frac{1}{2}$ marks)

These are normally used when awarding marks for the following;

✓ Correct formula used

✓ Correct substitution into the formula.

✓ Correct arithmetic.

✓ Correct unit

✓ Accuracy of the calculated value i.e. is the value within the stipulated range?

I's – Used on the intercepts. (Usually awarded $\frac{1}{2}$, or 1 or $1\frac{1}{2}$ or 2 marks)

I_v – Intercept on the vertical axis.

I_h – Intercept on the horizontal axis.

Note: The intercept may be awarded for correct value **with** unit or correct value **and** unit.

Conditions

✓ There must be a best straight line

✓ The scales must not be distorted (non – uniform).

✓ The intercept must be read correctly from the axis.

✓ For intercept on vertical axis, the horizontal axis must start from zero.

✓ For horizontal intercept, the vertical axis must start from zero.

✓ If the intercept on both axes is required, both axes must begin from zero.

Total marks for the whole question should be 20.

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Example 1

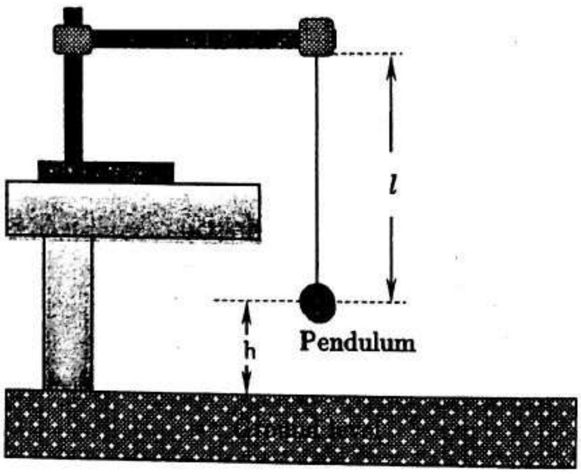
In this experiment, you will determine the acceleration due to gravity using a pendulum bob.

Apparatus:

A string (130.0cm long), 1 pendulum bob, 1 retort stand with a clamp and 1 stop clock.

Procedure:

a) Arrange the apparatus as shown in the figure below such that the length, l, of the pendulum is equal to 1.200m and the height h = 0.100m.



b) Set the pendulum bob into a small horizontal oscillation and measure the time for 20 complete oscillations.

c) Find the time T for one oscillation.

d) Repeat procedures (a) to (c) for values of h = 0.200, 0.300, 0.400, 0.500 and 0.600m from the ground level.

e) Tabulate your results in a suitable table including values of T, T^2 and h.

f) Plot a graph of T^2 against h.

g) Find the slope S of the graph.

h) Calculate the value of acceleration due to gravity, g, from $g = -\frac{4\pi^2}{S}$

(Take $\pi = 3.14$).

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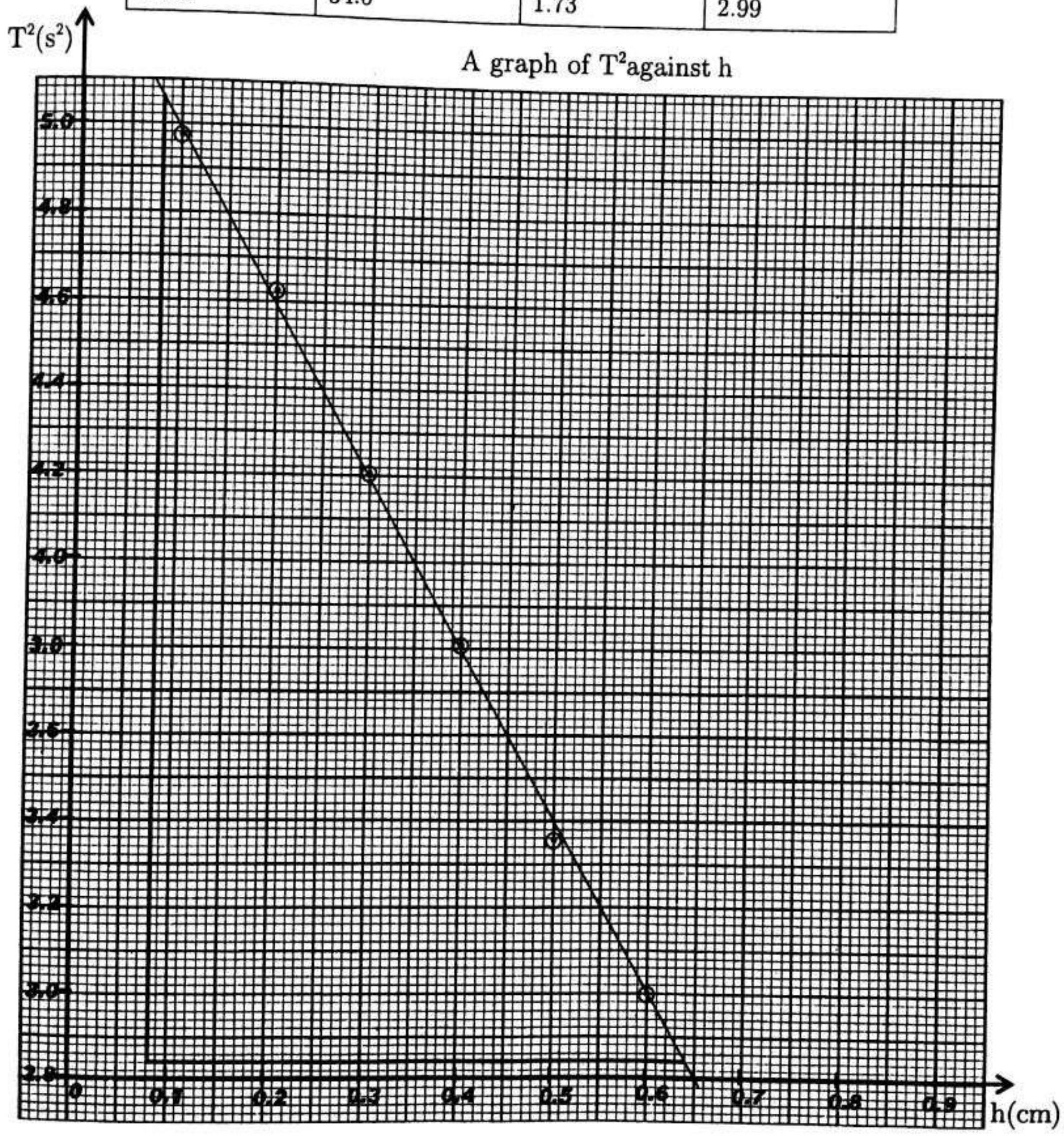
Solution

Let t be the time for twenty oscillations

h(m)	t(s)	T(s)	$T^2(s^2)$
0.100	44.5	2.23	4.97
0.200	43.0	2.15	4.62
0.300	41.0	2.05	4.20
0.400	39.0	1.95	3.80
0.500	36.5	1.83	3.35
0.600	34.5	1.73	2.99



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From the graph;

$$\text{slope S from A to B} = \frac{2.84 - 5.06}{0.64 - 0.08}$$

$$\Rightarrow S = \frac{-2.22}{0.56}$$

$$S = -3.96\ s^2m^{-1}$$

$$\text{From } g = \frac{-4\pi^2}{S}$$

$$\Rightarrow g = \frac{-4 \times \left(\frac{22}{7}\right)^2}{-3.96}$$

$$\therefore g = 9.90\ m\ s^{-2}$$

MARKING GUIDE

CODE	MARKS
R_1–Recording the value of t when h = 0.10m and unit {value = 1mrk ; unit (s) = $\frac{1}{2}$mrk } 0 or 1dp for stop clock and 2dp for stop watch: *Range (42.0 – 46.0)* (s)	$=1\frac{1}{2}$ mrks
T_1– Design of the table of values with 4 columns, h - column labelled with unit {h(m)}and all h values entered	= $\frac{1}{2}$ mrk
T_2–label of the rest of the columns with unit; t(s), T(s) and $T^2(s^2)${all 3 correct -1mrk, any 2 Correct - $\frac{1}{2}$ *mrk* , 1 correct - 0}	= 1mrks
T_3 – Recording 5 values of t decreasing {(42-44),(40- 42),(38-40),(35- 38) & (32-36)(s)(@*1mrk*)	= 5mrks
– Recording 6 values of T correctly calculated {any 2 correct = $\frac{1}{2}$mrk }	$=1\frac{1}{2}$ mrks
– Recording 6 values of T^2 correctly calculated {any 2 correct = $\frac{1}{2}$mrk }	$=1\frac{1}{2}$ mrks
G_1 – Title of the graph, A graph of T^2 against h.	$=\frac{1}{2}$ mrk
G_2 – The label for each axis with unit; $T^2(s^2)$and h(m) (@$\frac{1}{2}$mrk)	=1mrk
G_3 – Suitable and convenient scales for the axes covering at least 50% of graph paper(@$\frac{1}{2}$ *mrk*)	=1 mrk
G_4 – 6 correctly plotted points ($\frac{1}{2}$mrk @)	=3mrks
G_5 – The best straight line to fit the plotted points.	$=\frac{1}{2}$ mrk
G_6– The method of finding the slope. Big triangle covering all plotted points.	$=\frac{1}{2}$ mrk
C_1 – Calculation of the slope, S.	
– Correct substitution	$=\frac{1}{2}$ mrk
– Arithmetic	$=\frac{1}{2}$ mrk
C_2 – Calculation of acceleration due to gravity g	
– Correct substitution	$=\frac{1}{2}$ mrk
– Accuracy and unit g =(9.0 – 10.0)m s^{-2}{value - $\frac{1}{2}$mrk , unit: m s^{-2} - $\frac{1}{2}$mrk }	=1mrk
TOTAL	**=20MRKS**

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Example 2

In this experiment, you will determine the refractive index 'n' of a glass block provided.

Apparatus:

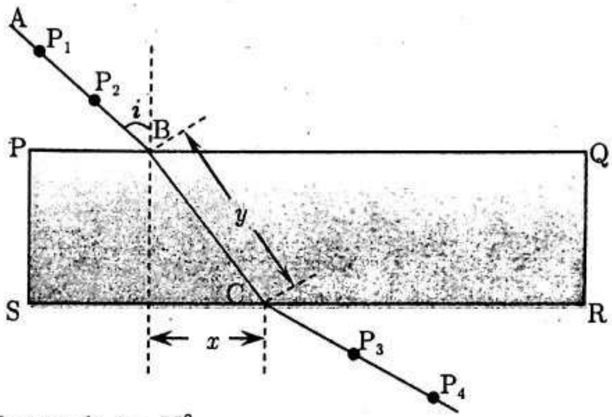
1 glass block, 1white sheet of paper, 4 optical pins, 4 drawing pins, soft board and a complete geometry set.

Procedure:

a) Using the drawing pins provided, fix the plain white sheet of paper on a soft board.

b) Place the glass block in the middle of the white sheet of paper and using a pencil, mark the outline PQRS of the glass block.

c) Remove the glass block. Draw a perpendicular to PQ at point B, 1.5 cm from P.



d) Draw a line AB such that angle $i = 10^0$.

e) Replace the glass block on white sheet of paper on the soft board.

f) Stick two pins P_1 and P_2 along AB and looking through the glass block from the opposite face SR, stick two other pins P_3 and P_4 in line with the images of P_1 and P_2. Remove the glass block.

g) Join C and D.

h) Measure and record the distances x and y.

i) Repeat procedures (d) to (h) for values of $i = 20^0, 30^0, 40^0, 50^0, 60^0$ and 70^0.

j) Enter your results in a suitable table including values of $\sin i$ and $\frac{x}{y}$.

k) Plot a graph of $\sin i$ against $\frac{x}{y}$.

l) Find the slope, n, of your graph.

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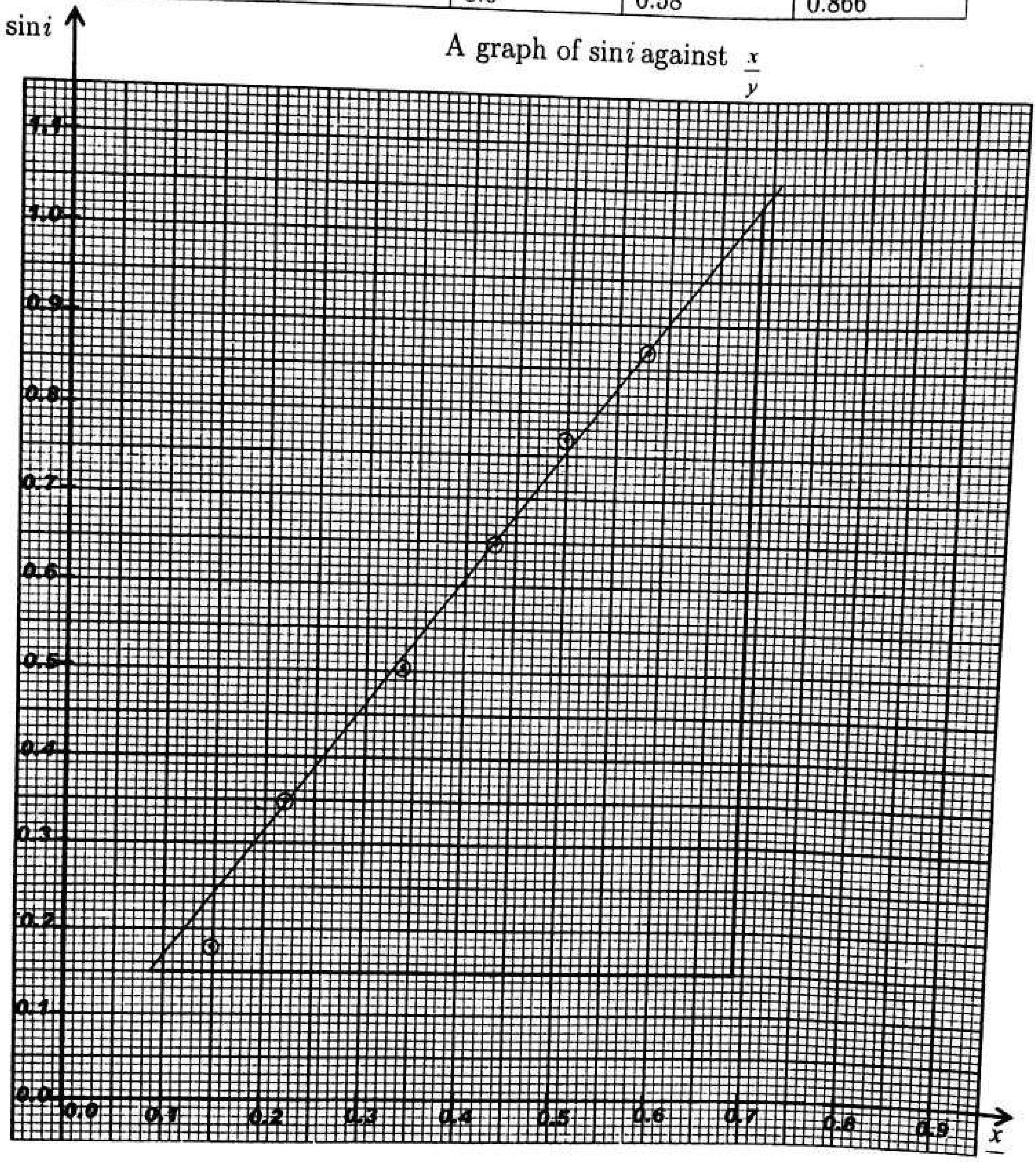
Solution

$i(°)$	x(cm)	y(cm)	$\frac{x}{y}$	sin$i$
10	1.0	6.6	0.15	0.174
20	1.5	6.7	0.22	0.342
30	2.4	7.0	0.34	0.500
40	3.2	7.4	0.43	0.643
50	3.8	7.6	0.50	0.766
60	4.6	8.0	0.58	0.866

A graph of sin$i$ against $\frac{x}{y}$



$$\text{Slope, } n = \frac{1.06 - 0.15}{0.69 - 0.09} = \frac{0.91}{0.60}$$

$$\therefore \quad n = 1.52$$

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MARKING GUIDE

CODE	MARKS
D_1 - Tracing the outline PQRS of the glass block	$=\frac{1}{2}$ mrk
D_2 - Drawing a perpendicular at point B, 1.5cm from P	$=\frac{1}{2}$ mrk
D_3 - Drawing a line AB such that angle $i = 10°$ and sticking pins P_1 and P_2 along AB	$=\frac{1}{2}$ mrk
D_4 - Sticking pins P_3 and P_4 in line with the images of P_1 and P_2	$=\frac{1}{2}$ mrk
D_5 - Drawing a line through pin marks P_3 and P_4 to meet SR at C and joining C to B	$=\frac{1}{2}$ mrk
Sub – total	$=2\frac{1}{2}$ **mrks**
R_1- Recording the value of x to 1dp when $i = 10°$ and unit; *Range (0.8 – 1.2)* (cm) {value $=\frac{1}{2}$ mrk ; unit:(cm) $=\frac{1}{2}$ mrk }	=1mrks
R_2- Recording the value of y to 1dp when $i = 10°$ and unit; *Range (6.4 – 6.8)* (cm) {value $=\frac{1}{2}$ mrk ; unit (cm) $=\frac{1}{2}$ mrk }	=1mrks
T_1 -Design of the table of results with 5 columns, i - column labelled with unit {i(°)}and all i values entered	$=\frac{1}{2}$ mrk
T_2- Label of the rest of the columns with unit; x(cm), y(cm), $\frac{x}{y}$ and sin$i${ any 2 correct - $\frac{1}{2}$ *mrk* }	=1mrk
T_3 –Recording 5 values of x increasing to 1 dpl {(1.3 -1.7),(2.2 – 2.6),(3.0 – 3.4),(3.6 – 4.0) and (4.4 - 4.8)(cm) (@ $\frac{1}{2}$ mrk)	$=2\frac{1}{2}$ mrks
– Recording 5 values of y increasing to 1 dpl {(6.5 -6.9),(6.8 – 7.2),(7.2 – 7.6),(7.4 – 7.8) and (7.8 - 8.2)(cm) (@ $\frac{1}{2}$ mrk)	$=2\frac{1}{2}$ mrks
– Recording 6 values of sin$i$, correctly calculated to 3 dp(any 3 correct - $\frac{1}{2}$ *mrk*)	= 1mrk
Sub – total	$=9\frac{1}{2}$ **marks**
G_1 – Title of the graph, A graph of sin$i$ against $\frac{x}{y}$	$=\frac{1}{2}$ mrk
G_2 – The label of the axes with units; sin$i$ and $\frac{x}{y}$ (@ $\frac{1}{2}$ mrk)	=1mrk
G_3 – Suitable and convenient scales for the axes covering at least 50% of graph paper(@ $\frac{1}{2}$ *mrk*)	=1 mrk
G_4 – 6 correctly plotted points ($\frac{1}{2}$ mrk @)	=3mrks
G_5 - The best straight line to fit the plotted points	$=\frac{1}{2}$ mrk
G_6 – The method of finding the slope. Big triangle covering all plotted points	$=\frac{1}{2}$ mrk
C_1 – Calculation of the slope, n	
– Correct substitution	$=\frac{1}{2}$ mrk
– Arithmetic	$=\frac{1}{2}$ mrk
– Accuracy	$=\frac{1}{2}$ mrk
Sub – total	**=08marks**
TOTAL	**=20MRKS**

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Example 3

In this experiment, you will determine the mass 'M_P' of the pendulum bob provided.

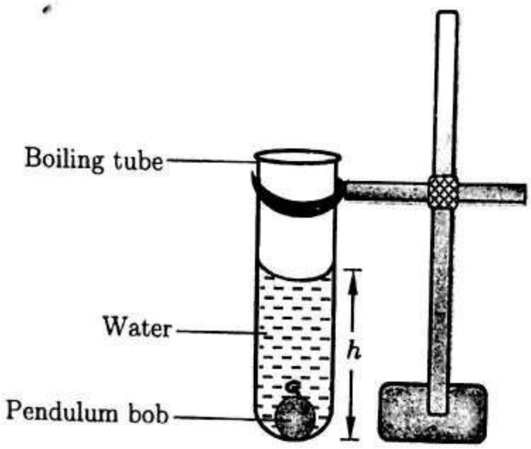
Apparatus:

1 boiling tube, 1 retort stand with a clamp, 1 pendulum bob, 1 measuring cylinder, 40 cm^3 of water in a beaker and 1 half metre rule.

Procedure:

a) Carefully place the pendulum bob provided into the boiling tube.

b) Clamp the boiling tube such that the bottom sits on the base of the retort stand as shown in the figure below.



c) Measure out a volume $V = 5$ cm^3 of water and pour it into the boiling tube.

d) Measure and record the height, h, of the water level from the base of the retort stand.

e) Repeat the procedures in (c) and (e) for values of $V = 10, 15, 20, 25$, and 30 cm^3.

f) Record your values in a suitable table.

g) Plot a graph of V against h.

h) Find the intercept, V_1, from your graph.

i) Calculate the mass, M_P, of the pendulum bob from the expression, $M_P = -9.15 \times V_1$

Solution

Sample results

$V(cm^3)$	h(cm)
5	2.0
10	3.3
15	4.6
20	5.9
25	7.1
30	8.4

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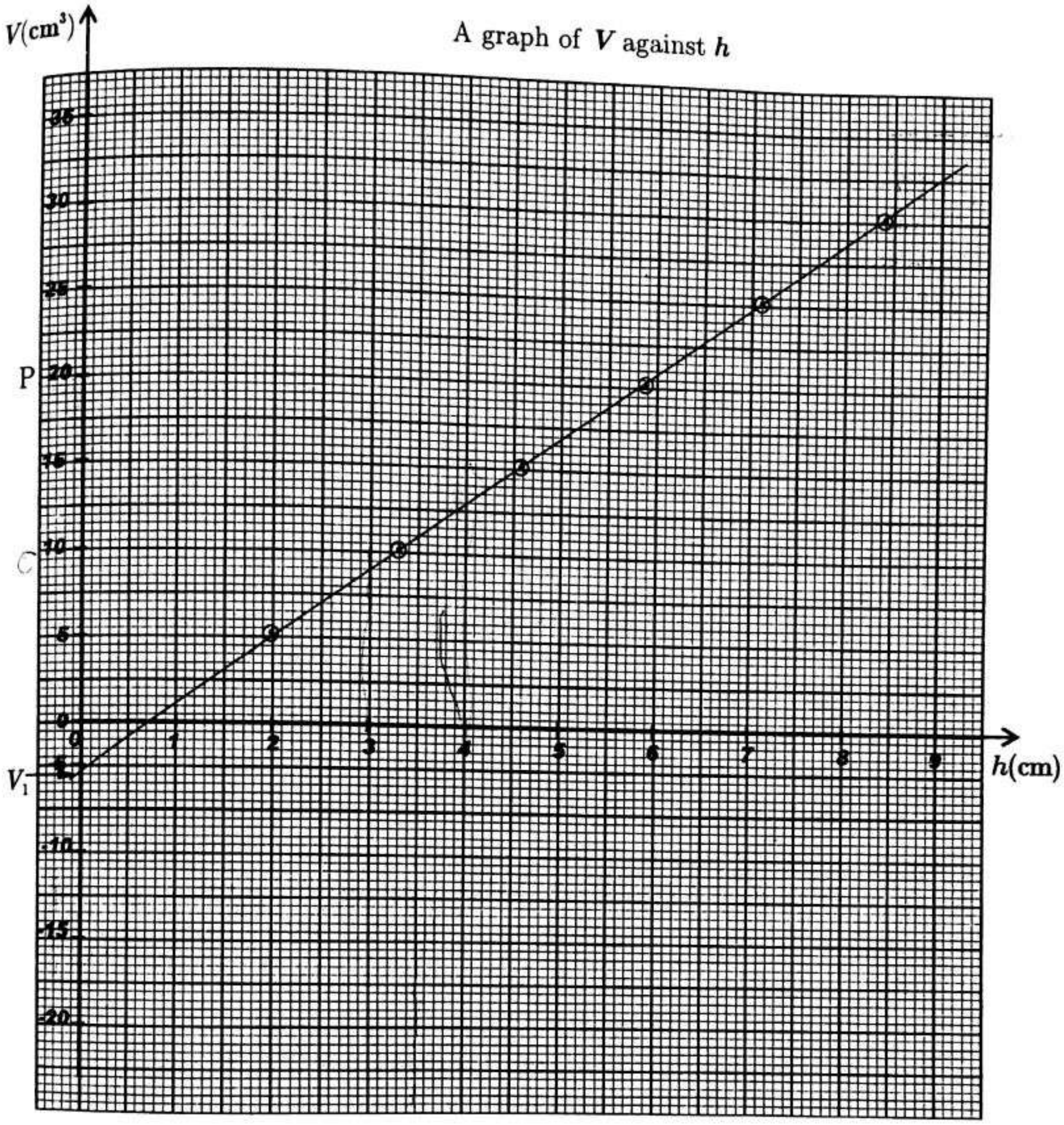

From the graph, intercept $V_1 = -3\ cm^3$

$$\text{From, } M_P = -9.15 \times V_1.$$
$$M_P = -9.15 \times (-3)$$
$$\therefore \quad M_P = 27.5\ g$$

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MARKING GUIDE

CODE	MARKS
R_1- Recording the value of h when V = 5 cm^2 to 1 d.p and unit {h = (1.6 – 2.4)cm^3}.........	=1mrk
T_1- Design of the table of values with 2 columns, V - column labelled with unit {V(cm^3)} And all V- values entered in the stated order in the question paper........................	=1mrk
T_2–Labeling the second column (h-column) and unit; h(cm) {value - $\frac{1}{2}$*mrk*, unit - $\frac{1}{2}$*mrk* }.	=1mrk,
T_3 –Recording 5 more values of h increasing to 1dp *Range (1.8 – 13.0)* (cm)(@1mrk).........	.=5mrks
Sub – Total	**= 08 marks**
G_1 – Title of the graph (without unit), A graph of V against h....................................	=$\frac{1}{2}$mrk
G_2 – The label for each axis with unit; V(cm^3)and h(cm)(@$\frac{1}{2}$mrk)................................	.=1mrk
G_3 – Suitable and convenient scales for the axes covering at least 50% of graph paper(@$\frac{1}{2}$ *mrk*).........	.=1mrk
G_4 – Correctly plotting 6 points ($\frac{1}{2}$mrk @)..	=6mrks
G_5 – The best straight line to fit the plotted points..	=$\frac{1}{2}$mrk
Sub – Total	**= 09 marks**
C_1 – Recording the value of the intercept V_1 and unit. *Range*: V_1 = (-2 to - 4)cm^3.............	.=1mrk
C_1 – Calculation of M_P from the expression; $M_P = -9.15 \times V_1$.	
– Correct substitution..	=$\frac{1}{2}$mrk
– Arithmetic...	.=$\frac{1}{2}$mrk
– Accuracy and unit {value - $\frac{1}{2}$mrk, unit: g - $\frac{1}{2}$mrk }..	=1mrk
Sub – Total	**=03 marks**
TOTAL	**=20MRKS**

Example 4

In this experiment, you will determine the constant 'μ' of the glass block provided.

Apparatus:

1 glass block, 1 white sheet of paper, 4 optical pins, 4 drawing pins, 1 soft board and a complete geometry set.

Procedure:

a) Fix the plain sheet of paper onto the soft board using drawing pins.

b) Place the glass block on the sheet of paper so that it rests on the broader face

c) Trace the outline ABCD of the glass block.

d) Remove the glass block.

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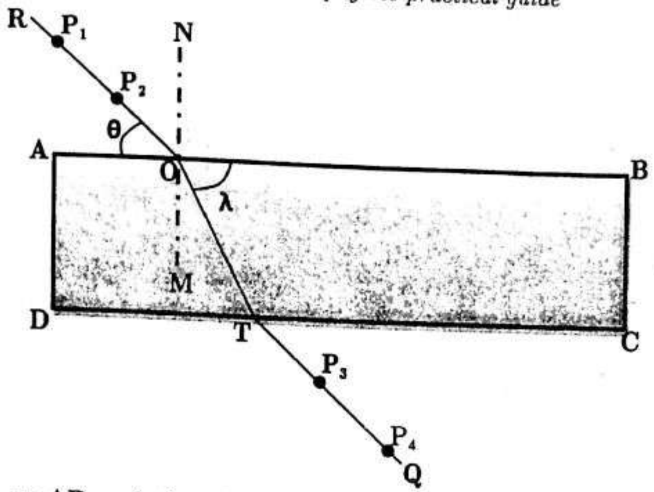

e) Mark a point O on AB such that AO is about 2.0 cm from A.

f) Construct a perpendicular line NM to AB.

g) Draw a line RO at an angle $\theta = 80^0$ to AB as shown in the figure above.

h) Fix pins P_1 and P_2 vertically along RO.

i) Replace the glass block on its outline.

j) Looking through side DC, fix pins P_3 and P_4 in line with the images of P_1 and P_2.

k) Remove the pins and the glass block.

l) Draw a line QT through P_3 and P_4 to meet DC at T.

m) Join P to O.

n) Measure angle λ.

o) Repeat procedures (g) to (n) for values of $\theta = 70^0, 60^0, 50^0, 40^0$ and 30^0.

p) Record your results in a suitable table including values of $\cos\theta$ and $\cos\lambda$.

q) Plot a graph of $\cos\theta$ **(along the vertical axis)** against $\cos\lambda$ **(along the horizontal axis)**.

r) Find the slope 'μ' of your graph.

Solution

Sample results

θ (°)	λ (°)	$\cos\theta$	$\cos\lambda$
80	84	0.174	0.105
70	78	0.342	0.208
60	72	0.500	0.309
50	65	0.643	0.423
40	60	0.766	0.500
30	54	0.866	0.588

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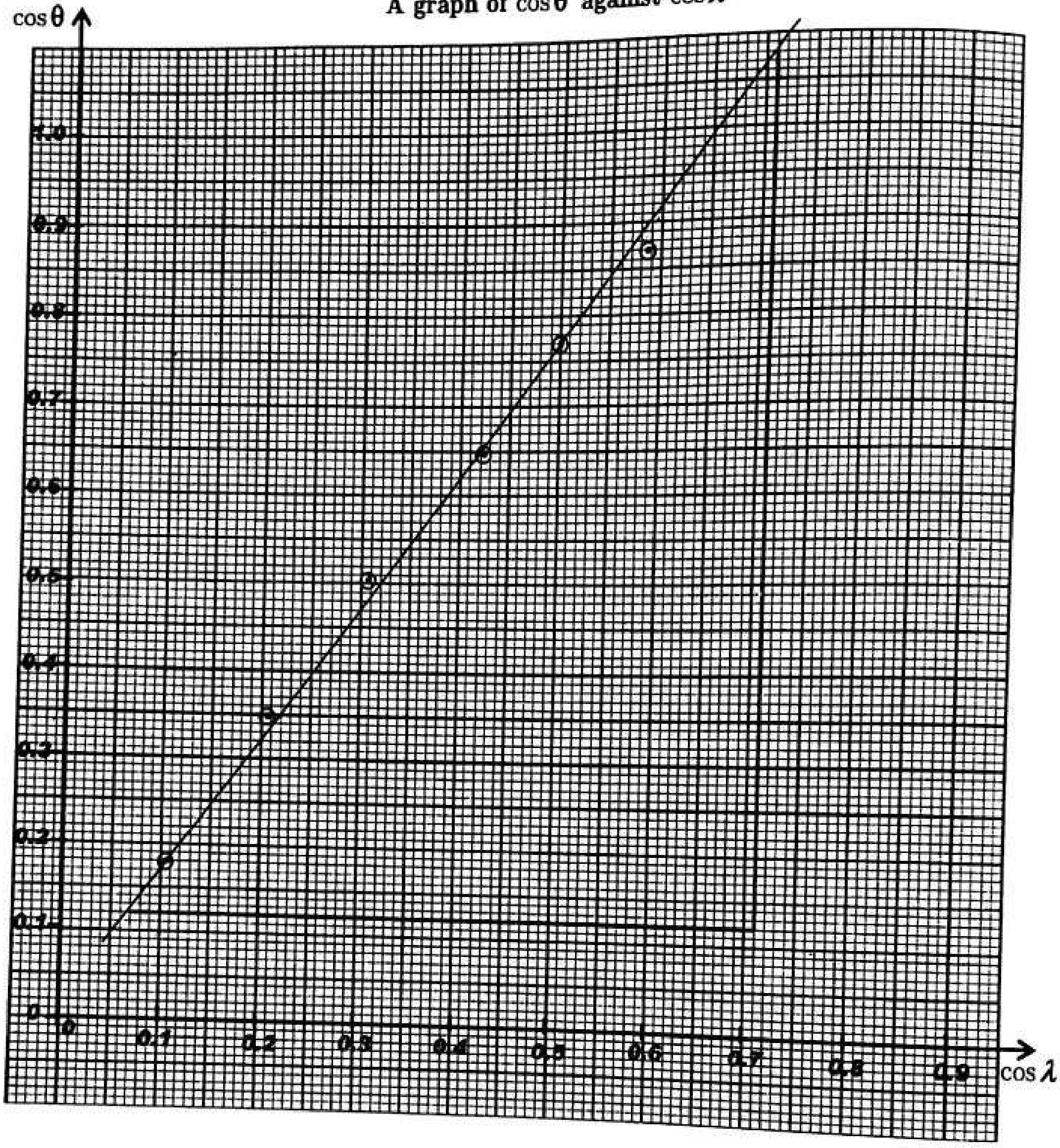
A graph of $\cos\theta$ against $\cos\lambda$



From the graph,

$$\text{Slope, } \mu = \frac{1.08 - 0.12}{0.71 - 0.07}$$

$$= \frac{0.96}{0.64}$$

$$\therefore \quad \mu = 1.5$$

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MARKING GUIDE

CODE	MARKS
D_1 - Tracing the outline ABCD of the glass block, marking a point O about 2cm from A and drawing a perpendicular line NM to AB........	$=\frac{1}{2}$ mrk
D_2 - Drawing a line AB at an angle $\theta = 80°$ to AO, fixing pins P_1 and P_2 along AB and fixing pins P_3 and P_4 in line with the images of P_1 and P_2	$=1$ mrk
D_3 - Drawing a line QT through pin marks P_3 and P_4 to meet DC at T and joining T to O...	$=\frac{1}{2}$ mrk
Sub – total	$=2$ mrks
R_1- Recording angle of λ to 0 dp when $\theta = 80°$ and unit; *Range:* $\lambda = (82 - 85)°$ {value $=\frac{1}{2}$ mrk ; unit:(cm) $=\frac{1}{2}$ mrk }	$=1$mrks
T_1 -Design of the table of results with at least 4 columns, θ- column labelled with unit {θ (°)} and all its values entered in the stated order in the paper........	$=\frac{1}{2}$ mrk
T_2- Labelling of the rest of the columns {λ with unit; $\cos\theta$ and $\cos\lambda$ without unit} (each -$\frac{1}{2}$ *mrk* }	$=1\frac{1}{2}$ mrk
T_3 – Recording 5 more values of λ increasing to 0 d.p (1mrk @)........	$=5$ mrks
– Recording 6 values of $\cos\theta$ correctly calculated to at least 3 d.p (any 3 correct=$\frac{1}{2}$ *mrk*)	$=1$ mrks
– Recording 6 values of $\cos\lambda$, correctly calculated to at least 3 dp (any 3 correct=$\frac{1}{2}$ *mrk*).	$=1$ mrk
Sub – total	$=10$ mrks
G_1 – Title of the graph, A graph of $\cos\theta$ against $\cos\lambda$	$=\frac{1}{2}$ mrk
G_2 – Drawing and labeling the axes with units; $\cos\theta$ and $\cos\lambda$ ($\frac{1}{2}$ mrk @)........	$=1$mrk
G_3 – Suitable and convenient scales for the axes covering at least 50% of graph paper($\frac{1}{2}$ *mrk* @	$=1$ mrk
G_4 – Correctly plotting 6 points ($\frac{1}{2}$ mrk @)........	$=3$ mrks
G_5 – The best straight line to fit the plotted points........	$=\frac{1}{2}$ mrk
G_6 – The method of finding the slope. Big triangle covering all plotted points........	$=\frac{1}{2}$ mrk
Sub – total	$=6\frac{1}{2}$ **marks**
C_1 – Calculation of the slope, μ	
– Correct substitution........	$=\frac{1}{2}$ mrk
– Arithmetic........	$=\frac{1}{2}$ mrk
– Accuracy, *Range,* $\mu = (1.4 - 1.7)$........	$=\frac{1}{2}$ mrk
Sub – total	$=1\frac{1}{2}$ **marks**
TOTAL	**=20MARKS**

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Example 5

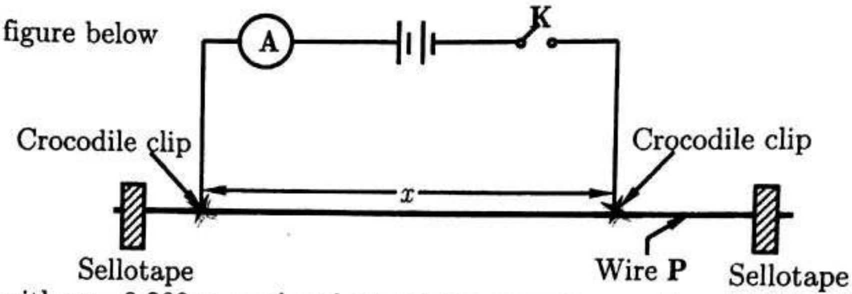
In this experiment, you will compare the current through resistance wires labelled P and Q.

Apparatus:

2 dry cells, 1 constantan wire labelled P(SWG 28), 1 constantan wire labelled Q (SWG 30), 2 pieces of sellotape, 2 crocodile clips, 1 ammeter (0-1)A, 1 metre rule, connecting wires and 1 switch labelled, K.

Procedure:

(a) Connect the dry cells, the ammeter ***A***, the switch **K** and the wire **P** in series as shown in figure below



(b) Starting with $x = 0.200$m, read and record the ammeter reading, I_1 when **K** is closed.

(c) Open switch, **K**.

(d) Repeat the procedures in (b) and (c) above for values of $x = 0.300$, 0.400, 0.500 and 0.600 m

(e) Replace wire **P** with the wire labelled **Q** in the circuit shown above.

(f) Repeat procedures (b) to (d) and record the currents through wire Q as I_2.

(g) Tabulate your results.

(h) Plot a graph of I_2(**along the vertical axis**) against I_1 (**along the horizontal axis**).

(i) Determine the slope, S, of your graph.

Solution

Sample results

When $x = 0.200$m,

$\mathbf{I_1} = 0.80$ A

$\mathbf{I_2} = 0.40$ A

x(m)	I_1(A)	I_2(A)
0.200	0.80	0.40
0.300	0.76	0.36
0.400	0.70	0.32
0.500	0.60	0.28
0.600	0.56	0.24

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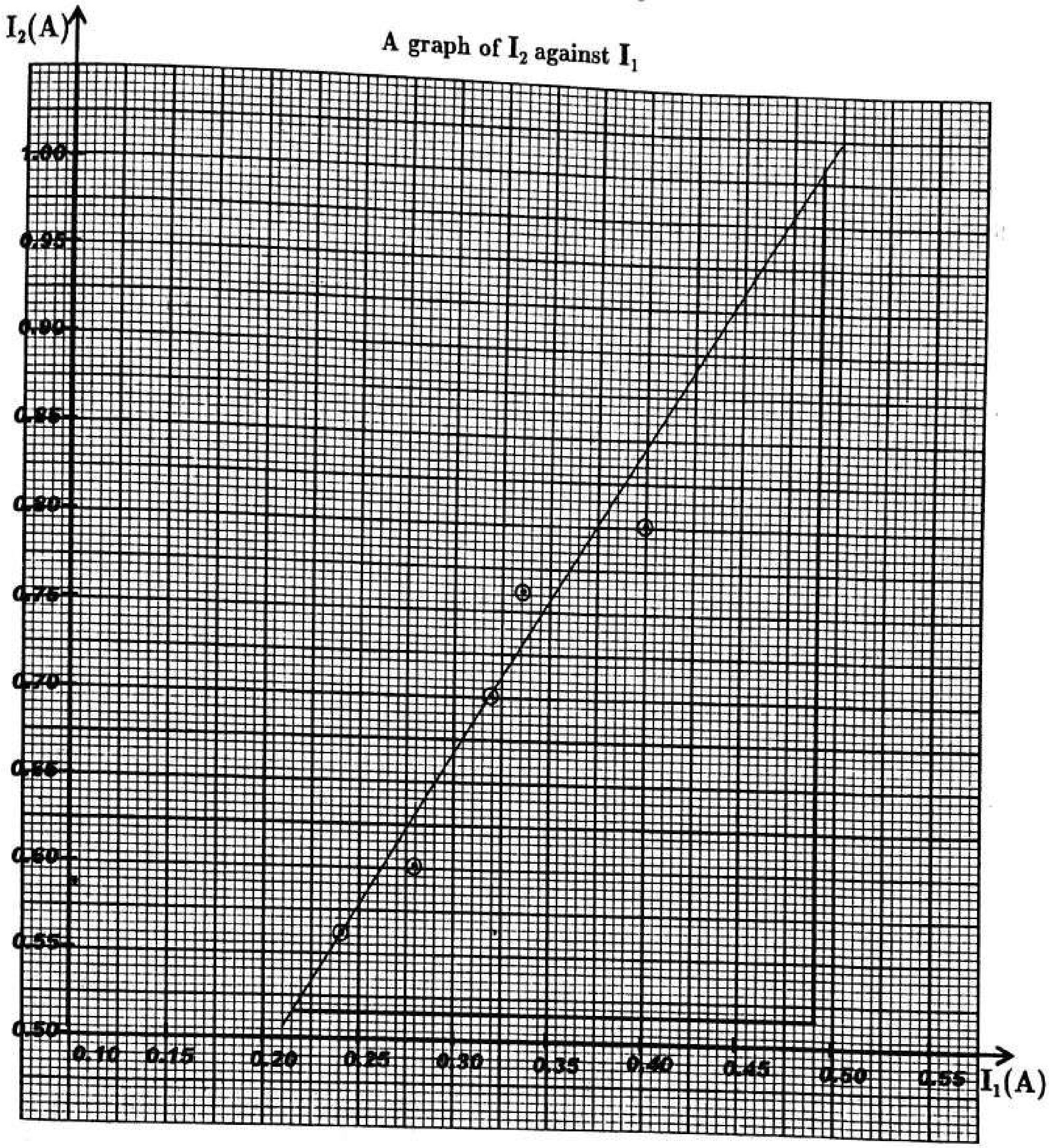
A graph of I_2 against I_1



From the graph,

$$\text{Slope, } S = \frac{\Delta I_2}{\Delta I_1}$$

$$= \frac{1.005 - 0.515}{0.49 - 0.215}$$

$$= \frac{0.49}{0.275}$$

$$\therefore \quad S = 1.78$$

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MARKING GUIDE

CODE	MARKS
R_1–Recording the value of I_1 to 1 or 2 d.p when $x = 0.200$m and unit {value = 1mrk ; unit (A) = $\frac{1}{2}$ mrk *Range (0.38 – 0.42)* (A)...	.= $1\frac{1}{2}$ mrks
R_1–Recording the value of I_2 to 1 or 2 d.p when $x = 0.200$m and unit {value = 1mrk ; unit (A) = $\frac{1}{2}$ mrk *Range (0.78 – 0.82)* (A)...	.= $1\frac{1}{2}$ mrks
Sub – total	= 03marks
T_1– Design of the table of results with 3 columns, x - column labelled with unit {x(m)}and all its values entered in the stated order in the paper..	= $\frac{1}{2}$ mrk
T_2 – Labelling the rest of the columns with unit; $\mathbf{I_1(A)}$ and $\mathbf{I_2(A)}$ {1mrk @}......................	= 1 mrks
T_3 – Recording 5 more values of $\mathbf{I_1}$ decreasing {(0.16-1.00),(0.15-0.94),(0.14-0.78),(0.13-0.65) & (0.12-0.57)(A)(No repeat)...($\frac{1}{2}$ mrk @)	= $2\frac{1}{2}$ mrks
– Recording 5 more values of $\mathbf{I_2}$ decreasing {(0.60-1.00),(0.55-0.96),(0.40-0.80),(0.30-0.75) & (0.20-0.66)(A)(No repeat)...($\frac{1}{2}$ mrk @)	= $2\frac{1}{2}$ mrks
Sub – total	= $06\frac{1}{2}$ marks
G_1 – Title of the graph, A graph of $\mathbf{I_2}$ and against $\mathbf{I_1}$ (No units)..	.= $\frac{1}{2}$ mrk
G_2 – drawing and labeling the axes with unit; $\mathbf{I_2(A)}$ and $\mathbf{I_1(A)}$(@ $\frac{1}{2}$ mrk)...........................	.=1mrk
G_3 – Suitable and convenient scales for the axes covering at least 50% of graph paper(@ $\frac{1}{2}$ *mrk*)	.=1 mrk
G_4 – Correctly plotting 5 points..(1mrk @)	= 5 mrks
G_5 – The line of best fit...	.= $\frac{1}{2}$ mrk
G_6 – The method of finding the slope. Big triangle covering all plotted points.......................	= $\frac{1}{2}$ mrk
Sub – total	=08 $\frac{1}{2}$ mrks
C_1 – Calculation of the slope, S. – Correct substitution... – Arithmetic... – Accuracy. *Range,* S = (1.40 - 2.40)...	 = $\frac{1}{2}$ mrk .= $\frac{1}{2}$ mrk = 1 mrk
Sub – total	=02marks
TOTAL	=20MARKS

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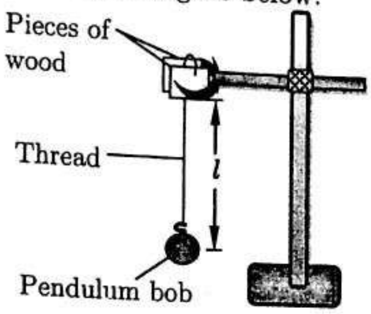
P535/3 -2015

Qn. 1 in this experiment, you will determine the constant, k, of the spring provided.

PART I

(a) Set up the apparatus as shown in the figure below.



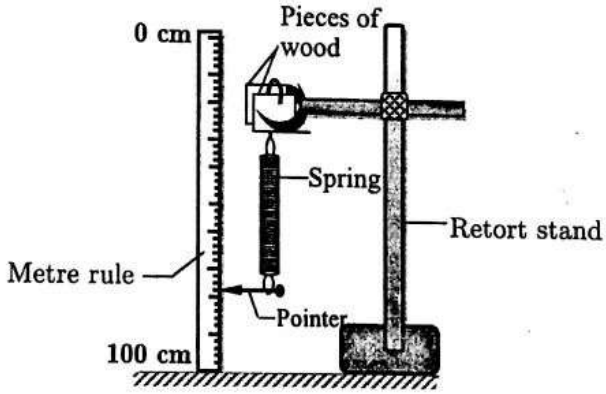
(b) Measure and record length l.

(c) Pull the bob slightly towards you and release it to oscillate.

(d) Measure and record the time, t, for 20 complete oscillations.

PART II

(a) Clamp one end of the spring in the retort stand as shown in the figure below.



(b) Read and record the initial position, Y_o, of the pointer on the vertical metre rule scale placed with the zero mark at the top.

(c) Suspend a mass, M = 0.10 kg from the lower hook of the spring.

(d) Read and record the new position, Y, of the pointer on the vertical metre rule as in (b).

(e) Repeat procedures (c) and (d) for M = 0.20, 0.30, 0.40, 0.50 and 0.60 kg.

(f) Record your results in a suitable table including values of $x = Y - Y_o$ in metres.

(g) Plot a graph of M (along the vertical axis) against x (along the horizontal axis).

(h) Determine the slope, S, of your graph.

(i) Calculate, k, from the expression; $k = 1.6 \times 10^3 \left(\frac{\pi}{t}\right)^2 \times l \times S$.

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Solution

PART I

Length, $l = 50.0$ cm

$= 0.500$ m

Time, $t = 29.0$ s

PART II

$Y_o = 60.0$ cm

$= 0.600$ m

$Y = 62.0$ cm

$= 0.620$ m

Table of results

M(kg)	Y(m)	x(m)
0.10	0.620	0.020
0.20	0.640	0.040
0.30	0.660	0.060
0.40	0.680	0.080
0.50	0.700	0.100
0.60	0.720	0.120

From the graph on the next page,

$$\text{Slope, } S = \frac{\Delta M}{\Delta x}$$

$$= \frac{0.80 - 0.05}{0.16 - 0.01}$$

$$= \frac{0.75}{0.15}$$

$$\therefore S = 5 \text{ kg m}^{-1}$$

$$\text{Constant, } k = 1.6 \times 10^3 \left(\frac{\pi}{t}\right)^2 \times l \times S$$

$$= 1.6 \times 10^3 \left(\frac{3.14}{29.0}\right)^2 \times 0.500 \times 5$$

$$\therefore k = 46.89 \text{ kg s}^{-1}$$

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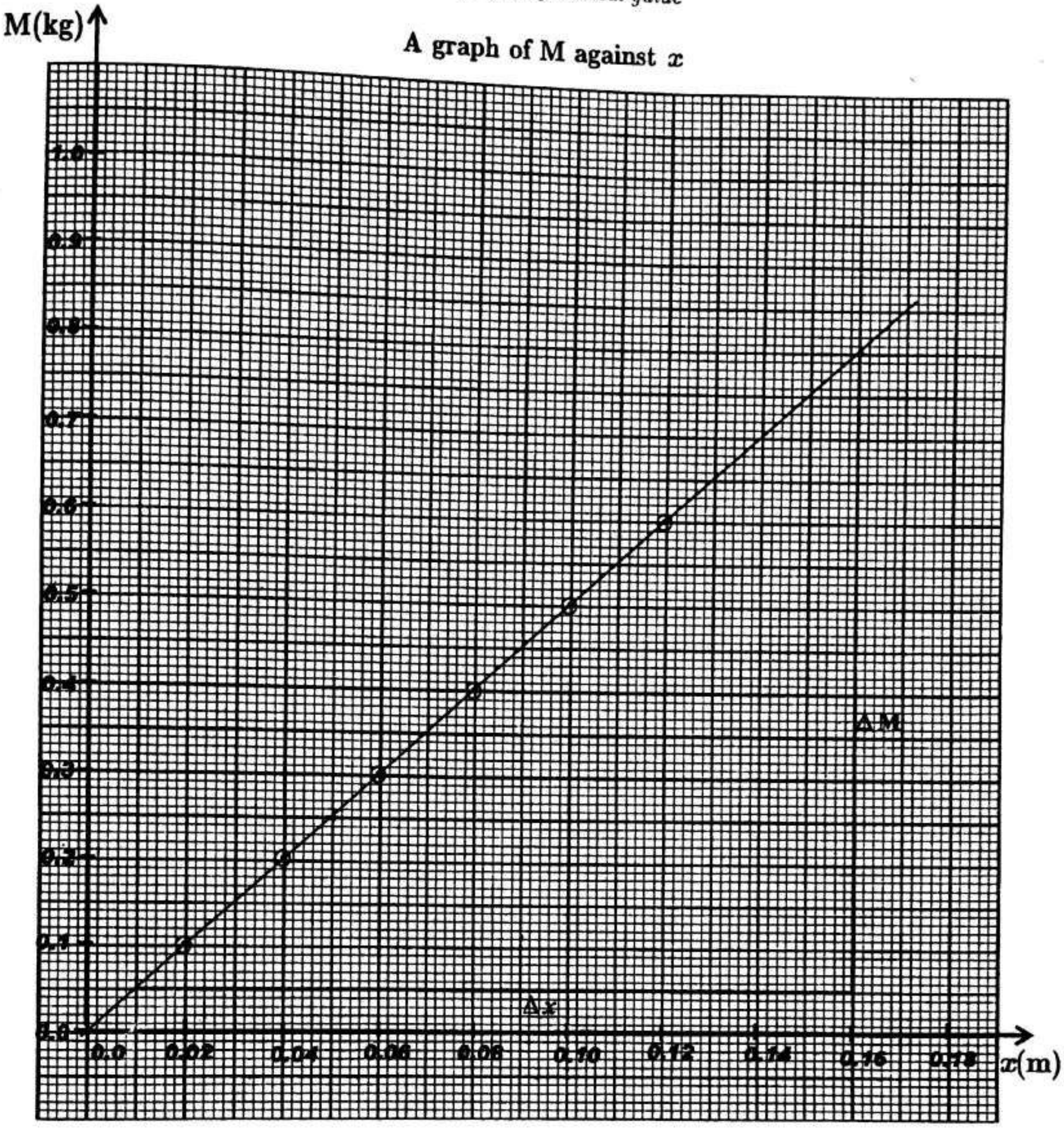
A graph of M against x



MARKING GUIDE

CODE	MARKS
R_1 – Recording the length, l, of the pendulum bob with unit to 1 dp in cm and 3 dps in metres , $l = (5.0 - 120.0)$ cm	$= \frac{1}{2}$ mrk
R_2 - Recording the time, t, for 20 oscillations and unit to 0 dp, 1dp or 2 dps, $t = (39.7\sqrt{l}) \pm 2$	= 1mrk
R_3 – Recording the initial position, Y_o of the pointer and unit. $Y_o = (0.0 - 80.0)$ cm; Value $= \frac{1}{2}$ mrk , unit $= \frac{1}{2}$ mrk	= 1 mrk
R_4 – Record the new position, Y of the pointer when M = 0.10 kg is suspended on the spring, (with unit)	= 1 mrk
Sub – total	$= 3\frac{1}{2}$ mrks

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CODE	MARKS
T_1 – Design of the table of results with at least 3-columns with M-column labelled with unit and all its values entered in stated order.	=0½mrk
T_2 – Label of the rest of the columns with units (each column = ½ mrk)	= 01mrk

M(kg)	Y(cm) or Y(m)	x(m)
0.10		
0.20		
0.30		
0.40		
0.50		
0.60		

T_3 – Recording 5 more values of Y increasing (to 1 dp in cm and 3 dps in metres, @ =1)	=05mrks
– Recording 6 values of x correctly calculated to 3 dps	=1½mrks
Sub – total	=08marks
G_1 – Title of the graph (without units)	=0½mrk
G_2 – Drawing and labelling the axes with units	=01mrk
G_3 – Choosing suitable and convenient scales (axes must be marked and origins shown on both axes)	=01mrk
G_4 – Correctly plotting 6 points (@ point = ½ mrk)	=03mrks
G_5 – Drawing the line of best fit	=0½mrk
G_1 – Method of finding the slope	=0½mrk
Sub – total	=6½ marks
C_1 – Calculation of the slope, S ✓ Substitution and arithmetic = ½ mrk ✓ Unit (kg m^{-1} or kg cm^{-1}) = ½ mrk	=01mrk
C_2 – Calculation of K ✓ Substitution, correct conversion and arithmetic = ½ mrk ✓ Unit (kg s^{-1} or N m^{-1}) = ½ mrk	= 01mrk
Sub – total	=02marks
TOTAL	**=20MRKS**

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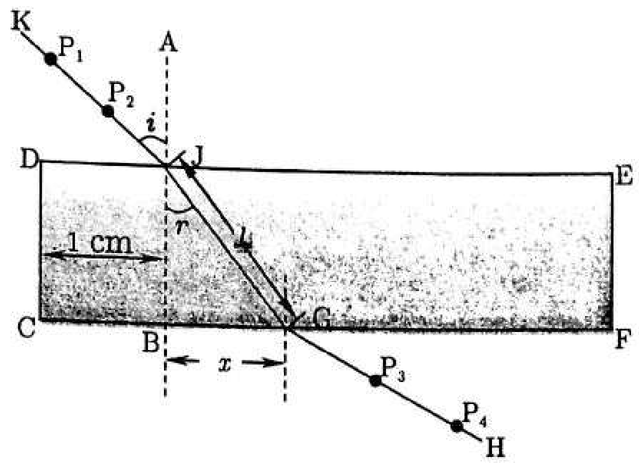
Question 2

In this experiment, you will determine the refractive index, n_g, of the glass block provided.

(a) Fix a white sheet of paper on the soft board.

(b) Place the broad face of the glass block to rest on the white paper and trace its outline.

(c) Remove the glass block and label its outline CDEF as shown in the figure below.



(d) Draw a normal AB to DE and CF at a distance of 1.0 cm from DC to meet DE at J and CF at B

(e) Measure angle $i = 10°$.

(f) Fix pins P_1 and P_2 on KJ.

(g) Replace the glass block onto its outline.

(h) Looking from side CF, fix pins P_3 and P_4 such that they are in line with the images of P_1 and P_2.

(i) Remove pins P_3 and P_4 and the glass block from its outline.

(j) Draw the line HG through P_4 and P_3 to meet CF at G.

(k) Measure and record the angle, r, and distances x and l.

(l) Repeat procedures (e) to (k) for $i = 20, 30, 40, 50$ and $60°$.

(m) Record your results in a suitable table including values of $x \cos r$ and $\sin i$.

(n) Plot a graph of $\sin i$ **(along the vertical axis)** against $x \cos r$ **(along the horizontal axis)**.

(o) Determine the slope, S, of the graph.

(p) Calculate, t, from the expression, $t = l \cos r$ using values of l and r at $i = 30°$.

(q) Calculate, n_g from $n_g = S \times t$.

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Solution

Angle, $r = 6^{\circ}$

Distance, $x = 0.8$ cm

Distance, $l = 7.0$ cm

Table of results

$i(^{\circ})$	$r(^{\circ})$	x(cm)	l(cm)	sin i	$x$cos r (cm)
10	6	0.8	7.0	0.174	0.8
20	14	1.6	7.2	0.342	1.6
30	20	2.4	7.4	0.500	2.3
40	28	3.5	7.8	0.643	3.1
50	30	4.0	8.1	0.766	3.5
60	35	4.8	8.5	0.866	3.9

From the graph on page 65,

$$\text{Slope, S} = \frac{\Delta \sin i}{\Delta x \cos r}$$

$$= \frac{0.98 - 0.05}{4.5 - 0.25}$$

$$= \frac{0.93}{4.25}$$

$$\therefore \text{S} = 0.2188 \text{ kg m}^{-1}$$

Expression, $t = l \cos r$

$$= 7.4 \cos 20$$

$$= 7.4 \times 0.9397$$

$$t = 6.95738$$

Now, $n_g = S \times t$

$$= 0.2188 \times 6.95738$$

$$= 1.515$$

$$\therefore \quad n_g \simeq 1.5$$

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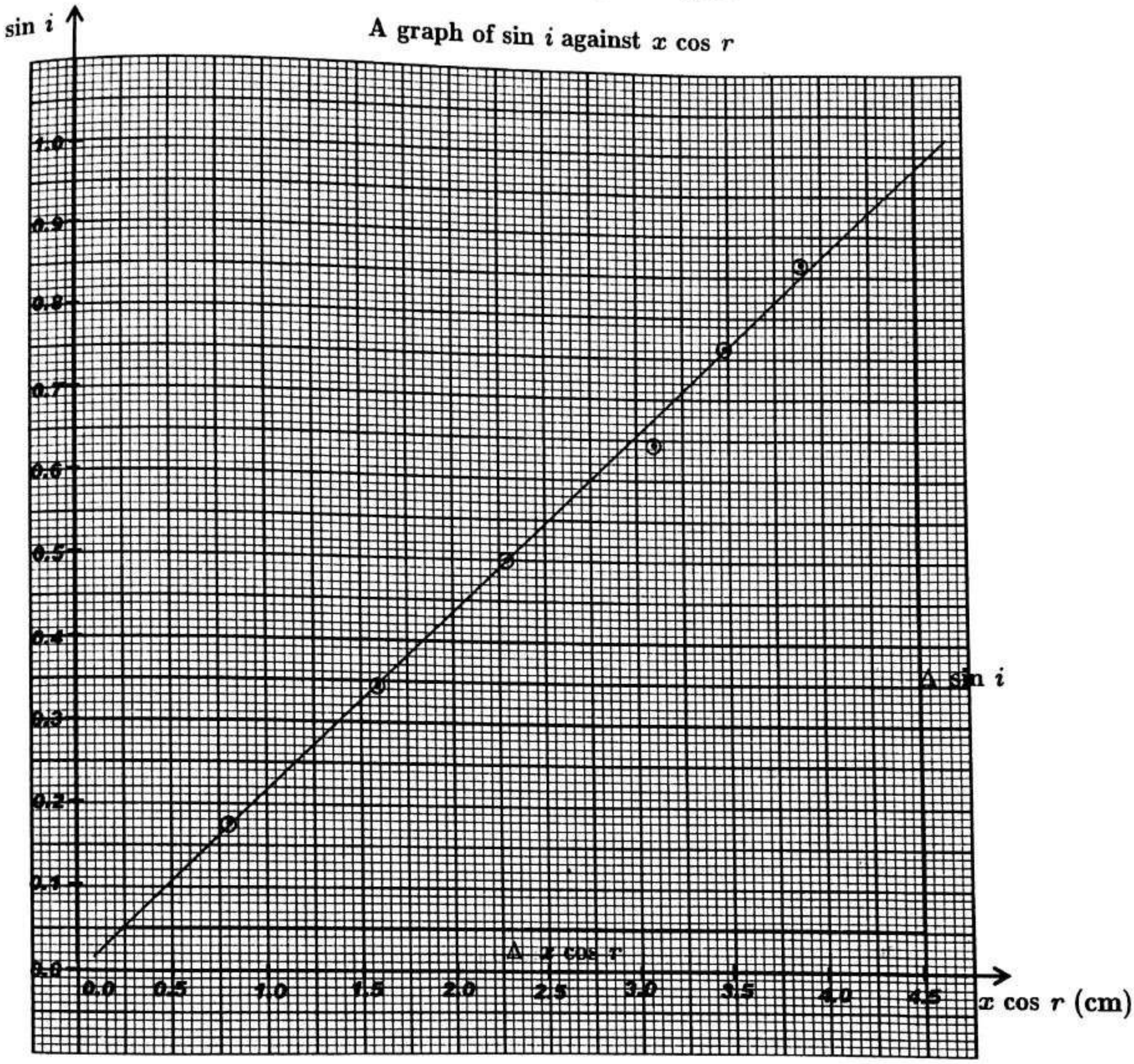
A graph of sin i against $x \cos r$



MARKING GUIDE

CODE		MARKS
D_1 - Tracing the outline CDEF of the glass block and drawing the normal AB at 1.0 cm from DC	$= \frac{1}{2}$ mrk	
- Drawing a line KJ at an angle $\theta = 10°$ to the normal and fixing pins P_1 and P_2 on it	$= \frac{1}{2}$ mrk	= 01 mrk
D_2 - Fixing pins P_3 and P_4 in line with images of P_1 and P_2; drawing a line HG through pin marks P_3 and P_4 to meet CF at G;	$= \frac{1}{2}$ mrk	
- Drawing a line joining G to J	$= \frac{1}{2}$ mrk	= 01 mrk
	Sub – total	= 02 mrks

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CODE	MARKS
R_1 – Recording the angle, r with or without unit to whole number or 0; dp, $r = (5 - 8)^{\circ}$	$= 0\frac{1}{2}$ mrk
R_2 – Recording the distance, x, when $i = 10^{\circ}$ with or without unit to 1 dp; $x = (0.5\text{-}0.9)$ cm	$=0\frac{1}{2}$ mrk
R_3 – Recording the distance, l, when $i = 10^{\circ}$ with or without unit to 1 dp; $l = (5.0\text{ -}7.1)$ cm	$=0\frac{1}{2}$ mrk
Sub – total	$=1\frac{1}{2}$ mrks
T_1 -Design of the table of results with at least 6 columns with i - column labelled with unit $\{i\ (^{\circ})\}$ and all its values entered in the stated order in the paper	$=\frac{1}{2}$ mrk
T_2- Labelling of the rest of the columns with units; sin i without unit (All five columns= 1 mrk ; any 3 or 4 $=\frac{1}{2}$ mrk)	$=01$ mrk

$i(^{\circ})$	$r(^{\circ})$	x(cm)	l(cm)	sin i	$x$cos r (cm)
10					
20					
30					
40					
50					
60					

CODE	MARKS
T_3 – Recording 5 more values of r increasing to 0 d.p	$=1\frac{1}{2}$ mrk
– Recording 5 more values of x increasing to 1 d.p	$=1\frac{1}{2}$ mrk
– Recording 5 more values of l increasing to 1 d.p	$=1\frac{1}{2}$ mrk
– Recording 6 values of sin i, correctly calculated to at least 3 dp (any 3 correct$=\frac{1}{2}$ *mrk*)	=1 mrk
– Recording 6 values of $x$cos r, correctly calculated to at least 1 dp (any 3 correct$=\frac{1}{2}$ *mrk*)	=1 mrk
Sub – total	**=08marks**
G_1 – Title of the graph, A graph of sin i against $x$cos r (without units)	$=\frac{1}{2}$ mrk
G_2 – Drawing and labeling the axes with units; sin i and $x$cos r (cm) ($\frac{1}{2}$ mrk @)	=1mrk
G_3 – Suitable and convenient scales(axes must be marked; arrows put at the ends and origins shown on both axes)($\frac{1}{2}$ *mrk* @)	=1 mrk
G_4 – Correctly plotting 6 points ($\frac{1}{2}$ mrk @)	=3 mrks
G_5 – The best straight line to fit the plotted points	$=\frac{1}{2}$ mrk
G_6 – The method of finding the slope. Big triangle covering all plotted points	$=\frac{1}{2}$ mrk
Sub – total	$=6\frac{1}{2}$ marks
C_1 – Calculation of the slope, **S**; Correct substitution and Arithmetic	$=\frac{1}{2}$ mrk
C_2 – Calculation of, t, from $t = l\cos\ r$; Correct substitution and Arithmetic	$=\frac{1}{2}$ mrk
C_3 – Calculation of $\mathbf{n_g}$ from $\mathbf{n_g} = \mathbf{S} \times t$ Substitution and arithmetic $= \frac{1}{2}$ mrk – Accuracy, *Range*, $\mathbf{n_g} = (\mathbf{1.4 - 1.7})$ $=\frac{1}{2}$ mrk	= 01 mrk
Sub – total	= 02 mrks
TOTAL	**=20MARKS**

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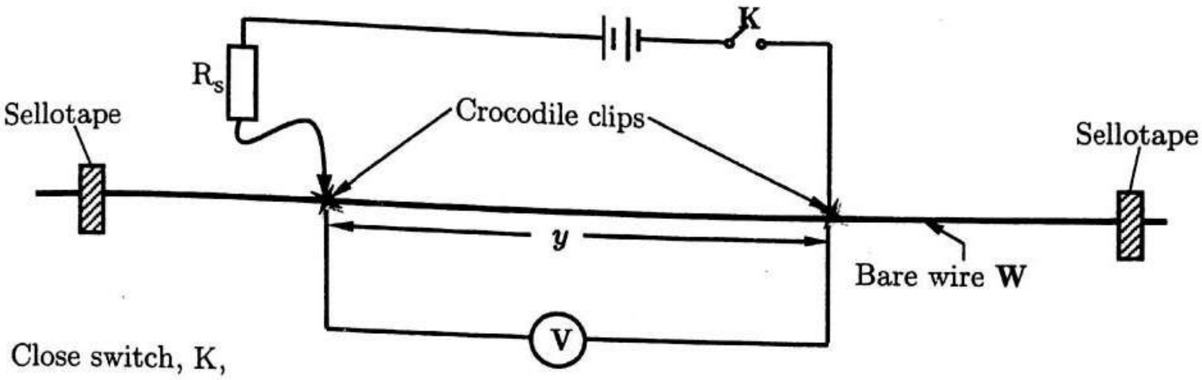
Qn. 3 *In this experiment, you will determine the internal resistance, r, of the cells provided.*

(a) Record the resistance, R_s, of the standard resistor provided.

(b) Connect the cells in series across the voltmeter and record the reading, E of the voltmeter.

(c) Fix the bare wire, W provided on the bench using sellotape.

(d) Connect the circuit shown in the figure below starting with length $y = 0.200$m.



(e) Close switch, K,

(f) Record the reading, V, of the voltmeter.

(g) Open switch, K.

(h) Repeat the procedure from (d) to (g) for values of $y = 0.300, 0.400, 0.500, 0.600$ and 0.700 m.

(i) Record your results in a suitable table including values of $\frac{1}{y}$ and $\frac{E}{V}$.

(j) Plot a graph of $\frac{E}{V}$ **(along the vertical axis)** against $\frac{1}{y}$ **(along the horizontal axis)**.

(k) Find the slope, S, of the graph.

(l) Calculate the internal resistance, r, from the expression $\mathbf{4.4\ S = r + R_S}$.

Solution:

Resistance, $R_s = 5.0\Omega$

Reading, $E = 3.00$ V

Reading, $V = 0.50$ V

Table of results

y(m)	V(V)	$\frac{1}{y}$(m^{-1})	$\frac{E}{V}$
0.200	0.50	5.0	6.0
0.300	0.60	3.3	5.0
0.400	0.70	2.5	4.3
0.500	0.90	2.0	3.3
0.600	1.00	1.7	3.0
0.700	1.10	1.4	2.7

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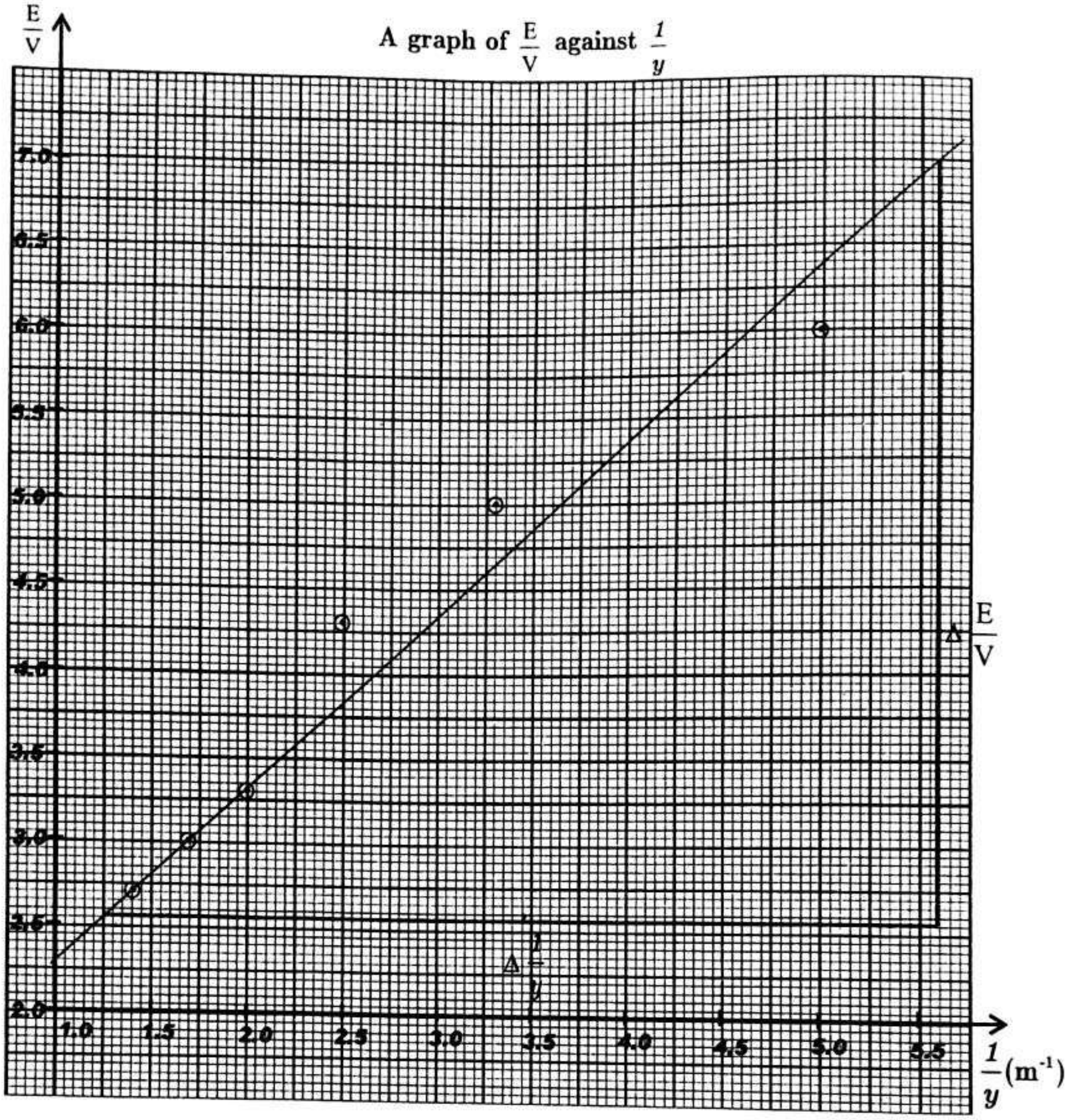
A graph of $\frac{E}{V}$ against $\frac{1}{y}$



$$\text{Slope, } S = \frac{\Delta \frac{E}{V}}{\Delta \frac{1}{y}}$$

$$= \frac{7.0 - 2.55}{5.6 - 1.25}$$

$$= \frac{4.45}{4.35}$$

$$\therefore \quad S = 1.02 \text{ m}$$

From, $4.4\,S = r + R_s$

Internal resistance, $r = 4.4 \times 1.02 - 5.0$

$= 5.42 - 5.0$

$\therefore \quad r = 0.42\ \Omega$

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MARKING GUIDE

CODE	MARKS
R_1 – Recording the resistance, R_S with unit to 0 dp or 1dp or 2 dp; $R_S = 5\Omega$ or 5.0Ω or 5.00Ω (ohms)	$=0\frac{1}{2}$ mrk
R_2 – Recording the reading, **E**, of the voltmeter and unit; $E = (2.40 - 3.40)V$; value = 1mrk, unit $=0\frac{1}{2}$ mrk	$=1\frac{1}{2}$ mrks
R_3 – Recording the voltmeter reading, **V**, with or without unit to 1 dp or 2dp; $\mathbf{V} = (0.30 - 0.80)V$	=01mrk
Sub – total	=03mrks
T_1 -Design of the table of results with at least 4 columns with y - column labelled with unit $\{y\ (m)\}$ and all its values entered in the stated order in the paper	$=0\frac{1}{2}$ mrk
T_2- Labelling of the rest of the columns with units; $\frac{E}{V}$ without unit.	=01mrk

y(m)	V(V)	$\frac{1}{y}$ (m^{-1})	l(cm)	$\frac{E}{V}$
0.200				
0.300				
0.400				
0.500				
0.600				
0.700				

T_3 – Recording 5 more values of **V** increasing to 2 d.p or 1 dp.(@ value = 1 mrk)	= 05mrks
– Recording 6 values of $\frac{1}{y}$ correctly calculated to at least to 1 d.p	=1 mrk
– Recording 6 values of $\frac{E}{V}$, correctly calculated to at least 1 dp	=01 mrk
Sub – total	$=08\frac{1}{2}$**marks**
G_1 – Title of the graph, A graph of $\frac{1}{y}$ against $\frac{E}{V}$ (without units)	$= 0\frac{1}{2}$ mrk
G_2 – Drawing and labeling the axes with units; $\frac{1}{y}$ (m^{-1}) and $\frac{E}{V}$ ($\frac{1}{2}$mrk @)	= 01mrk
G_3 – Suitable and convenient scales (axes must be marked; arrows put at the ends and origins shown on both axes)($\frac{1}{2}$mrk @)	= 01 mrk
G_4 – Correctly plotting 6 points ($\frac{1}{2}$mrk @)	= 03mrks
G_5 – The best straight line to fit the plotted points	$= 0\frac{1}{2}$ mrk
G_6 – The method of finding the slope. Big triangle covering all plotted points	$= 0\frac{1}{2}$ mrk
Sub – total	$=6\frac{1}{2}$**marks**
C_1 – Calculation of the slope, **S**; Correct substitution and Arithmetic $=\frac{1}{2}$mrk, unit $=\frac{1}{2}$mrk	=01mrk
C_2 – Calculation of internal resistance, r. Substitution and Arithmetic $=\frac{1}{2}$mrk, unit $=\frac{1}{2}$mrk	=01mrk
Sub – total	**=02marks**
TOTAL	**= 20MARKS**

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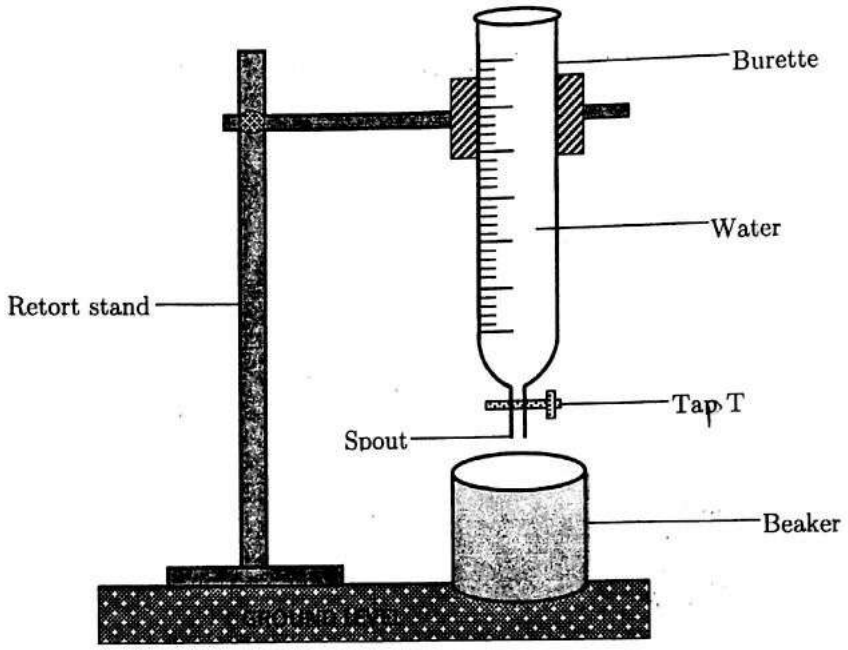
FURTHER PRACTICAL QUESTIONS WITH SAMPLE MARKING GUIDES

QUETION 1

In this experiment, you will determine the rate at which water flows out of a burette.

Apparatus:

1 burette with a tap or clip, 1 retort stand, 1 beaker, 100ml of water and 1 stop clock or watch.



a) Clamp the burette vertically as shown in the figure above.

b) Fill the burette with water up to the zero mark i.e. $V = 0.0 \text{ cm}^3$.

c) Place the beaker below the burette.

d) Close the spout of the burette with a finger.

e) Open tap, T, fully.

f) Remove the finger and simultaneously start the clock.

g) Read and record the time, t, taken for the water to stop flowing.

h) Repeat procedures (b) to (g) for values of V = 5.0, 10.0, 15.0, 20.0 and 25.0 cm^3 marks.

i) Record your results in a suitable table including values of (50 - V).

j) Plot a graph of (50 -V) (along the vertical) against t (along the horizontal axis).

k) Determine the slope, S, of the graph.

l) Find the intercept on the t - axis.

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MARKING GUIDE

CODE	MARKS
R_1- Recording the value of t when V = 0.0cm^3 and unit {value =1mrk ; unit (s) =$\frac{1}{2}$mrk } 0 or 1dp for stop clock and 2dp for stop watch: *Range (7.0 – 20.0)* (s)	=1$\frac{1}{2}$mrks
T_1- Design of the table of values with 3 columns, V - column labelled with unit {V(cm^3)} and All V- values entered	= $\frac{1}{2}$mrk
T_2-label of the rest of the columns with unit; t(s) and (50 - V)(cm^3){all 3 correct -1mrk, any 2 Correct - $\frac{1}{2}$*mrk* , 1 correct - 0}	=1mrk
T_3 - Recording 5 values of t decreasing to 0 or 1dp for stop clock and 2dp for stop watch *Range (4.0 - 20)* (s) (@1mrk)	= 5mrks
– Recording 6 values of (50 - V) correctly calculated to 0 or 1 dp ($\frac{1}{2}$mrk @)	= 3 mrks
Sub – Total	**= 11 marks**
G_1 – Title of the graph, A graph of (50 - V) against t.	=$\frac{1}{2}$mrk
G_2 – The label for each axis with unit; (50 - V)(cm^3)and t(s) (@$\frac{1}{2}$mrk)	=1mrk
G_3 - Suitable and convenient scales for the axes covering at least 50% of graph paper(@$\frac{1}{2}$ *mrk*)	=1 mrk
G_4 - 6 correctly plotted points ($\frac{1}{2}$mrk @)	=3mrks
G_5 – The best straight line to fit the plotted points.	=$\frac{1}{2}$mrk
G_6 – The method of finding the slope. Big triangle covering all plotted points.	=$\frac{1}{2}$mrk
C_1 – Calculation of the slope, S of the graph.	
– Correct substitution	=$\frac{1}{2}$mrk
– Arithmetic	=$\frac{1}{2}$mrk
– Accuracy and unit {value - $\frac{1}{2}$mrk , unit: cm^{3}s^{-1} - $\frac{1}{2}$mrk }	=1mrk
I_H – Correctly read value of the intercept on the horizontal axis with unit. Unit: (cm^3)	=$\frac{1}{2}$mrk
– Accuracy and unit g =(9.0 – 10.0)m s^{-2}{value - $\frac{1}{2}$mrk , unit: m s^{-2} - $\frac{1}{2}$mrk }	=1mrk
Sub – Total	**= 09 marks**
TOTAL	**=20MRKS**

NB: the big range set for values of t is because the spouts of the burettes vary greatly in sizes (diameter). Some burettes have very large spouts while others have very small spouts.

SAMPLE RESULTS

RESULT 1

V(cm^3)	t(s)	(50 - V)(cm^2)
0.0	17.12	
5.0	15.38	
10.0	14.76	
15.0	13.62	
20.0	13.03	
25.0	12.04	

RESULT 2

V(cm^3)	t(s)	(50 - V)(cm^2)
0.0	12.78	
5.0	12.00	
10.0	11.32	
15.0	10.47	
20.0	9.72	
25.0	8.91	

RESULT 3

V(cm^3)	t(s)	(50 - V)(cm^2)
0.0	7.78	
5.0	7.50	
10.0	6.97	
15.0	6.62	
20.0	6.25	
25.0	5.69	

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QUESTION 2

In this experiment, you will determine the refractive index 'n' of the glass block provided.

Apparatus:

1 glass block, 1 white sheet of paper, 4 optical pins, 4 drawing pins, 1 soft board and a complete geometry set.

Procedure:

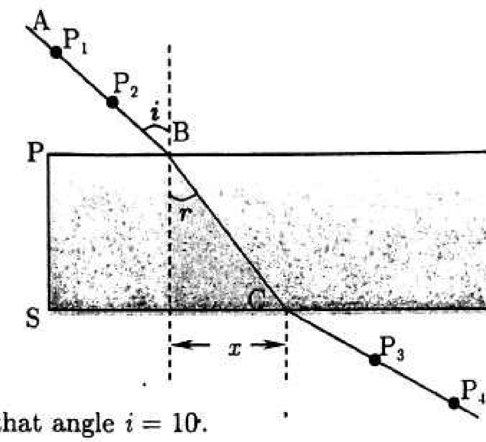
a) Measure and record the width w of the glass provided.

b) Using the drawing pins provided, fix the plane white sheet of paper on a soft board.

c) Place the glass of block in the middle of the white sheet of paper and using a pencil, mark the outline PQRS of the glass block.

d) Remove the glass block.

e) Draw a perpendicular to PQ at point A, 1.5 cm from P to meet SR at B.



f) Draw a line AB such that angle $i = 10^\circ$.

g) Replace the glass block onto the white sheet of paper on the soft board.

h) Stick two pins P and P along AB. Looking through the glass block from the opposite face SR, stick two other pins P and P such that they appear to be in line with the images of P and P as seen through the glass block.

i) Remove the glass block.

j) Draw a line through points P and P to meet SR at C.

k) Join C and B.

l) Measure and record the angle and the distance x.

m) Repeat procedures (f) to (l) for values for $i = 20^\circ, 30^\circ, 40^\circ, 50^\circ$ and 60°.

n) Enter your results in a suitable table including values of $\sin i$, $\cos r$ and $x\cos r$.

o) Plot a graph of $\sin i$ against $x\cos r$.

p) Find the slope, S, of your graph.

q) Calculate the value of the refractive index n from $S = \frac{n}{w}$

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MARKING GUIDE

CODE	MARKS
D_1 - Tracing the outline PQRS of the glass block	$=\frac{1}{2}$ mrk
D_2 - Drawing a perpendicular at point B, 1.5cm from P	$=\frac{1}{2}$ mrk
D_3 - Drawing a line AB such that angle $i = 10^\circ$ and sticking pins P_1 and P_2 along AB	$=\frac{1}{2}$ mrk
D_4 - Sticking pins P_3 and P_4 in line with the images of P_1 and P_2	$=\frac{1}{2}$ mrk
D_5 - Drawing a line through pin marks P_3 and P_4 to meet SR at C and joining C to B	$=\frac{1}{2}$ mrk
Sub – total	$=2\frac{1}{2}$ mrks
R_1- Recording the width of the glass block to 2dp with unit; *Range (5.00 – 7.00)* (cm) {value $=\frac{1}{2}$ mrk ; unit:(cm) $=\frac{1}{2}$ mrk }	$=1$mrks
R_2- Recording the value of r to 0dp when $i = 10^\circ$ with unit; *Range (6.4 – 6.8)* (cm) {value $=\frac{1}{2}$ mrk ; unit (cm) $=\frac{1}{2}$ mrk }	$=\frac{1}{2}$ mrk
T_1 -Design of the table of results with 5 columns, i - column labelled with unit $\{i(^\circ)\}$and all i values entered	$=\frac{1}{2}$ mrk
T_2- Label of the rest of the columns with unit; $r(^\circ)$, x(cm), sin$i$, cos$r$ and $x$cos$r$ { any 2 correct - $\frac{1}{2}$ *mrk* }	$=1$mrk
T_3 –Recording 5 values of r increasing to 0 dpl {(10 -14),(16 – 20),(22 – 27),(28 – 30) and (31 - 34)($^\circ$) (@$\frac{1}{2}$ mrk)	$=2\frac{1}{2}$ mrks
– Recording 6 values of x increasing to 1dp {(1.3 -1.7),(2.2 – 2.6),(3.0 – 3.4),(3.6 – 4.0) and (4.4 - 4.8)(cm) {any 3 correct - $\frac{1}{2}$ mrk }	$=1$ mrk
– Recording 6 values of sin$i$, correctly calculated to 3dp { any 3 correct - $\frac{1}{2}$ *mrk* }	$=1$mrk
– Recording 6 values of cos$r$, correctly calculated to 3dp { any 3 correct - $\frac{1}{2}$ *mrk* }	$=1$mrk
– Recording 6 values of $x$cos$r$, correctly calculated to 2dp { any 3 correct - $\frac{1}{2}$ *mrk* }	$=1$mrk
Sub – total	**$=9\frac{1}{2}$ marks**

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CODE	MARKS
G_1 – Title of the graph, A graph of $\sin i$ against $x\cos r$ (no units)	$=\frac{1}{2}$ mrk
G_2 – The label of the axes with units; $\sin i$ and $x\cos r$ (cm) (@ $\frac{1}{2}$ mrk)	$=1$mrk
G_3 – Suitable and convenient scales for the axes covering at least 50% of graph paper(@ $\frac{1}{2}$ *mrk*)	$=1$ mrk
G_4 – 6 correctly plotted points (any 2 correct - $\frac{1}{2}$ mrk @)	$=1\frac{1}{2}$ mrks
G_5 – The best straight line to fit the plotted points	$=\frac{1}{2}$ mrk
G_6 – The method of finding the slope. Big triangle covering all plotted points	$=\frac{1}{2}$ mrk
C_1 – Calculation of the slope, S	
– Correct substitution	$=\frac{1}{2}$ mrk
– Arithmetic	$=\frac{1}{2}$ mrk
– Accuracy	$=\frac{1}{2}$ mrk
C_2 – Correctly substituting the value of S into the formula for n	$=\frac{1}{2}$ mrk
C_3 – Correctly value of n;	
Accuracy	$=\frac{1}{2}$ mrk
Unit	$=\frac{1}{2}$ mrk
Sub – total	**= 08marks**
TOTAL	**=20MARKS**

SAMPLE RESULTS

$i(°)$	$r(°)$	x(cm)	Sin$i$	cos$r$	$x\cos r$(cm)
10	8	1.0	0.174	0.990	0.99
20	12	1.4	0.342	0.978	1.37
30	18	2.2	0.500	0.951	2.09
40	25	3.1	0.643	0.906	2.81
50	29	3.7	0.766	0.875	3.24
60	32	4.2	0.866	0.848	3.56

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QUESTION 3

In this experiment, you will determine the internal resistance r of the cells provided.

Apparatus:

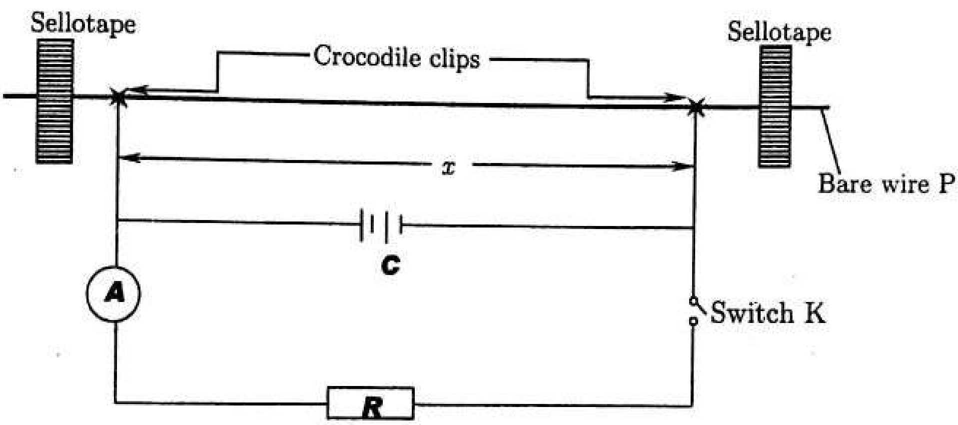
2 dry cells, 1 ammeter (0 – 1A), constantan wire SWG 26, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 2 crocodile clips, a double cell holder and a resistor R of known resistance.

Procedure:

a) Record the resistance R_0 of the resistor R.

b) Connect the two dry cells in series across the voltmeter and record the reading V_0 of the voltmeter.

c) Fix the bare wire P provided on the bench using sellotape.



d) Connect the circuit as shown in the figure above starting with a length $x = 0.200$ m.

e) Close switch K.

f) Record the reading I of the ammeter.

g) Open the switch K.

h) Repeat procedures (d) to (g) for values of $x = 0.300$, 0.400, 0.500, 0.600 and 0.700 m.

i) Record your results in a suitable table including values of $\frac{1}{I}$ and $\frac{1}{x}$.

j) Plot a graph of $\frac{1}{I}$ against $\frac{1}{x}$.

k) Find the intercept C on the $\frac{1}{I}$ - axis.

l) Calculate the internal resistance r from the expression: $r = V_0C - R_0$.

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MARKING GUIDE

CODE	MARKS
R_1 –Recording the value of R_S to 0dp and unit {value = $\frac{1}{2}$ mrk ; unit (Ω) = $\frac{1}{2}$ mrk }	= 1 mrk
R_1 –Recording the value of I when x = 0.200m with unit to 2dp; unit (A)	= $\frac{1}{2}$ mrk
T_1 –Design of the table of values with 4 columns, x - column labelled with unit {x(m)}and all x - values entered	= $\frac{1}{2}$ mrk
T_2 –label of the rest of the columns with unit; I(A), $\frac{1}{I}(A^{-1})$ and $\frac{1}{x}(m^{-1})$ ($\frac{1}{2}$ *mrk* @)	= $1\frac{1}{2}$ mrks
T_3 – Recording 5 values of I decreasing to 2dp ; Range(0.40 – 0.54) (A) (Accept constant difference between successive values) ($\frac{1}{2}$ *mrk* @)	= $2\frac{1}{2}$ mrks
– Recording 6 values of $\frac{1}{I}$ correctly calculated to 1dp(also accept 2 and 3dp) ($\frac{1}{2}$ *mrk* @)	= 3 mrks
– Recording 6 values of $\frac{1}{x}$ correctly calculated to 2dp ($\frac{1}{2}$ *mrk* @)	= 3 mrks
Sub – total	**= 12 marks**
G_1 – Title of the graph, A graph of $\frac{1}{I}$ against $\frac{1}{x}$.	= $\frac{1}{2}$ mrk
G_2 – The label for each axis with unit; $\frac{1}{I}(A^{-1})$ and $\frac{1}{x}(m^{-1})$. (@ $\frac{1}{2}$ mrk)	= 1mrk
G_3 – Suitable and convenient scales for the axes covering at least 50% of graph paper(@ $\frac{1}{2}$ *mrk*)	= 1 mrk
G_4 – 6 correctly plotted points ($\frac{1}{2}$ mrk @)	= 3mrks
G_5 – The best straight line to fit the plotted points.	= $\frac{1}{2}$ mrk
I_V – Correctly read value of the intercept on the vertical axis with unit. Unit : (A^{-1})	= $\frac{1}{2}$ mrk
C_1 – Calculation of internal resistance *r*.	
– Correct substitution	= $\frac{1}{2}$ mrk
– Accuracy and unit: Ω {value - $\frac{1}{2}$ mrk , unit - $\frac{1}{2}$ mrk }	= 1 mrk }
Sub – total	**= 08mrks**
TOTAL	**= 20MRKS**

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CHAPTER TWO

MECHANICS EXPERIMENTS

EXPERIMENT 1

In this experiment you will determine the mass, m, of the metre rule provided.

Apparatus:

6 masses each of 10g, 1 metre rule, 1 knife edge and 1 wooden rectangular block.

Procedure:

a) Label the ends of the metre rule provided A and B and balance the metre rule provided on a knife-edge with the graduated side facing upwards without the mass M.

b) Note the balance point P and record its distance from the end B and call it y.

c) Using a thread, hang a mass M of 10 g at the 10.0 cm mark of the metre rule and balance the arrangement as shown in the figure below.

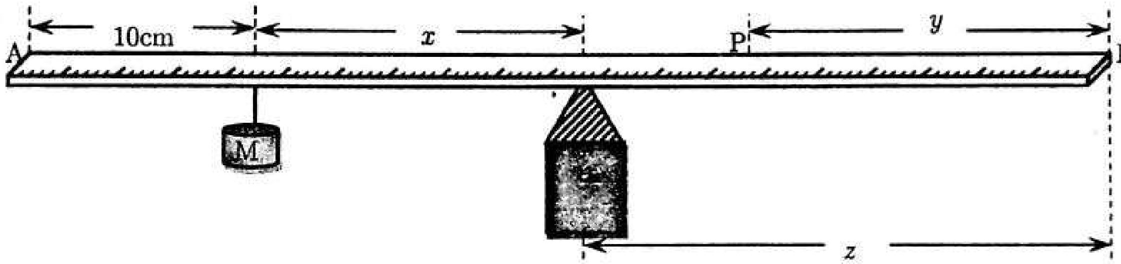

Fig. Expt. 1

d) Read and record distance x and z.

e) Repeat the procedures (c) and (d) for values of M = 20 g, 30 g, 40 g, 50 g, and 60 g.

f) Record your results in a suitable table including values of (z - y) and $\frac{(z-y)}{x}$

g) Plot a graph of M (along vertical axis) against $\frac{(z-y)}{x}$ (along horizontal axis)

h) Find the slope S of your graph.

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EXPERIMENT 2

In this experiment, you will determine the mass of the metre rule provided.

Apparatus:

1 mass of 100 g, 1 metre rule, 1 knife edge and 1 rectangular block of wood.

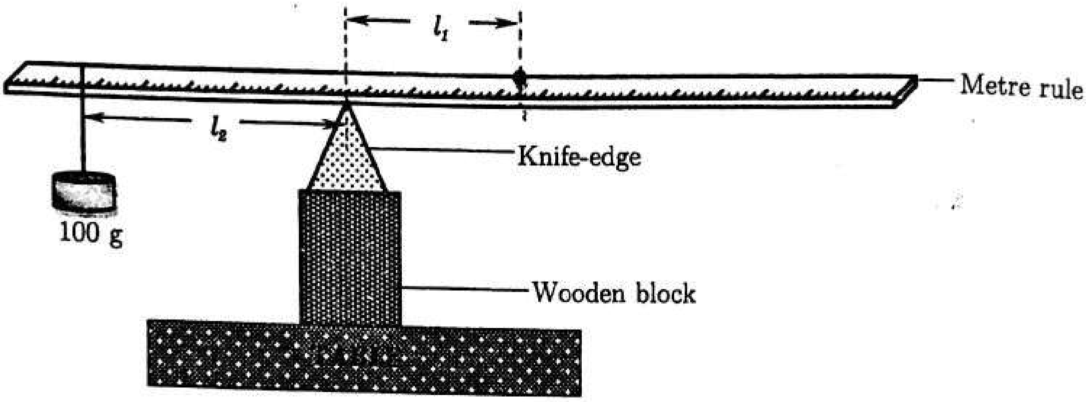

Fig.expt 2

Procedure:

a) Place the block of wood on the table so that it rests on its smallest cross-section area.

b) Place the knife-edge on top of the block.

c) Balance the metre rule provided on the knife-edge with its calibrated face upwards.

d) Record the position C at which the metre rule balances.

e) Suspend a mass of 100g at the 2.0cm mark and adjust the rule until it balances again.

f) Determine the distances l_1 and l_2 of C and the weight respectively from the knife-edge.

g) Repeat procedures (e) and (f) with the weight hanging from the 6.0, 10.0, 14.0, 18.0 and 22.0cm marks respectively.

h) Record your results in a suitable table.

i) Plot a graph of l_1 against l_2.

j) Find the slope s of the graph.

k) Calculate the mass M from the expression: $M = 100s$.

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EXPERIMENT 3

In this experiment you will determine the mass of the metre rule provided.

Apparatus:

1 metre rule, 1 knife edge, 1 wooden rectangular block and a mass, M of 100g.

Procedure:

a) Balance the metre rule on the knife-edge. Note the position G of the point at which it balances. Hence record the distance Z of G from the left end.

b) Attach a mass M at a distance x = 5.0cm from the left end and balance it on the knife edge.

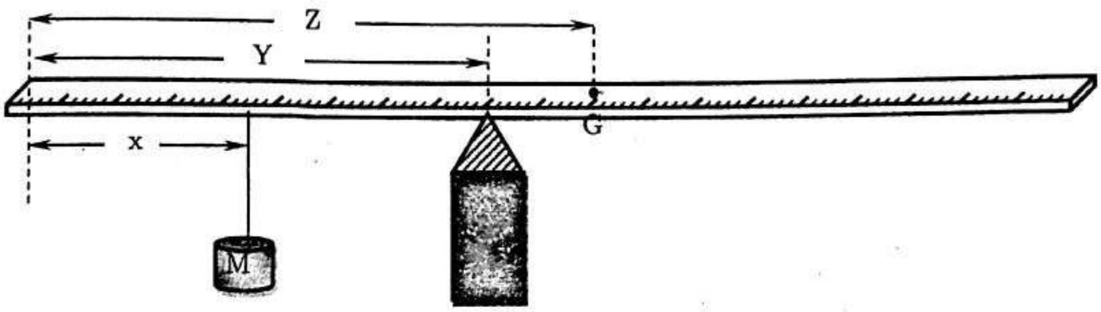

Fig. Expt. 3

c) Record the distance, Y, of the knife-edge from the left end of the rule.

d) Repeat procedures (b) and (c) for x = 10.0 cm, 15.0 cm, 20.0 cm, 25.0 and 30.0 cm.

e) Tabulate your results including values of (Y-x) and (Z –Y).

f) Plot a graph of (Z –Y) against (Y-x).

g) Find the slope, S of your graph.

h) Calculate the mass M_o from $M_o = \frac{M}{S}$.

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EXPERIMENT 4

In this experiment, you will determine the specific gravity of the solid provided.

Apparatus:

1 beaker(preferably a plastic beaker), a 100 g mass labelled W, rubber bung or sand of known mass labelled W_1, 1 metre rule, 1 knife edge, 1 rectangular block of wood and water.

Procedure:

a) Balance the metre rule provided on the knife edge. Mark and record the balancing point (the position of the centre of gravity) on the metre rule without the weight W_1 and the solid W.

b) Tie loops of the thread provided on solid W and weight W_1 provided.

c) Hang the solid W from the 10.0 cm mark of the metre rule. Put the weight W_1 on the other end and adjust its position until it balances horizontally while keeping the knife-edge at the balancing point of (a) (see figure below).

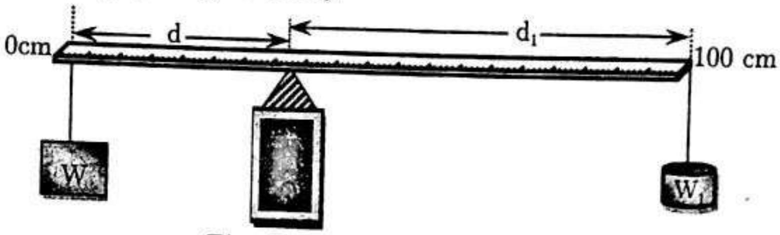

Fig. Expt. 4(a)

d) Read and record the position D where W_1 balances off W. Measure and record the distances d and d_1 of W and W_1 from the pivot respectively.

e) Repeat procedure (c) to (d) when the solid W is hanged from the 15.0 cm, 20.0 cm, 25.0 cm and 30.0 cm marks.

f) Repeat procedures (c) to (d) when the solid W is now fully immersed (dipped) in water as shown in the figure below. Find the new balance position d_2 of W_1 for each value of d.

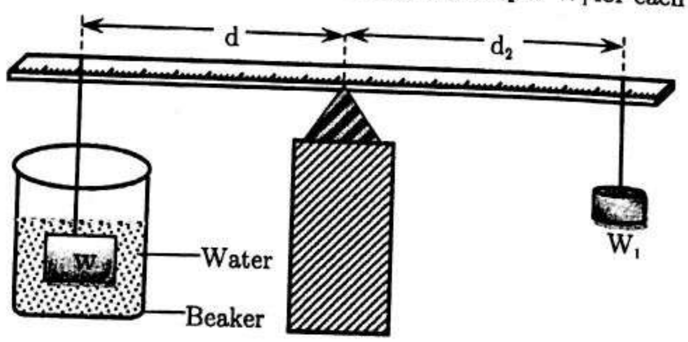

Fig. Expt. 4(b)

g) Tabulate your results including values of d, d_1, d_2 all in cm.

h) Plot a graph of d_1 (**along the vertical axis**) against $(d_1 - d_2)$ (**along the horizontal axis**).

i) Find the slope, n, of the graph.

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EXPERIMENT 5

In this experiment, you will determine the mass, m_2, of the sand provided.

Apparatus:

1 metre rule, 1 retort stand with a clamp, 6 masses each of 100g, sand (mass M_2), and a thread of length 1m.

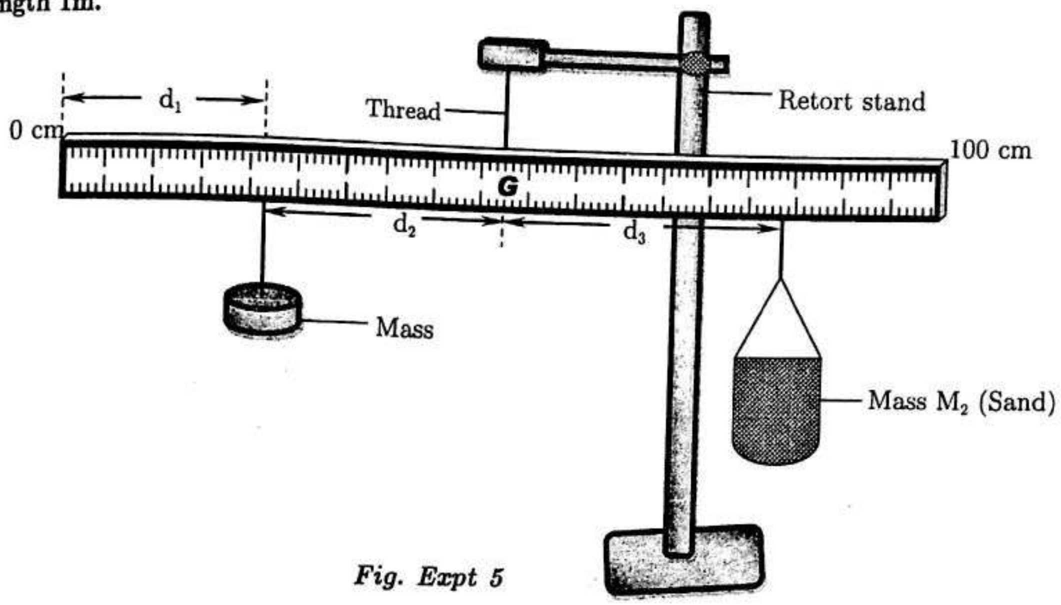

Fig. Expt 5

a) Suspend a metre rule from a retort stand using a piece of thread provided.

b) Adjust the position of the thread until the metre rule balances horizontally.

c) Read and record the position G of the thread on the metre rule at balance.

d) Suspend a mass M_1 = 100 g at a distance d_1 = 20.0 cm from one end of the metre rule.

e) Suspend the mass M_2 of the sand from the opposite side of the thread of suspension.

f) Adjust the position of the mass M_2 until the metre rule balances again as shown in the figure above.

g) Measure and record the distance d_3 of the point of suspension of mass M_2 from the point G.

h) Repeat procedures (d) to (g) for values of M_1 = 200, 300, 400, 500 and 600 g.

i) Determine the distance d_2 of M_1 from G.

j) Enter your results in a suitable table including values of M_1d_2.

k) Plot a graph of M_1d_2 against d_3

l) Determine the slope M_2 of the graph.

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EXPERIMENT 6

In this experiment, you will determine the relative density ρ of the material of solid X provided.

Apparatus:

1 metre rule, 1 retort stand with a clamp, 1 mass of 100g, a solid (rubber bung), a thread, 1 beaker and water.

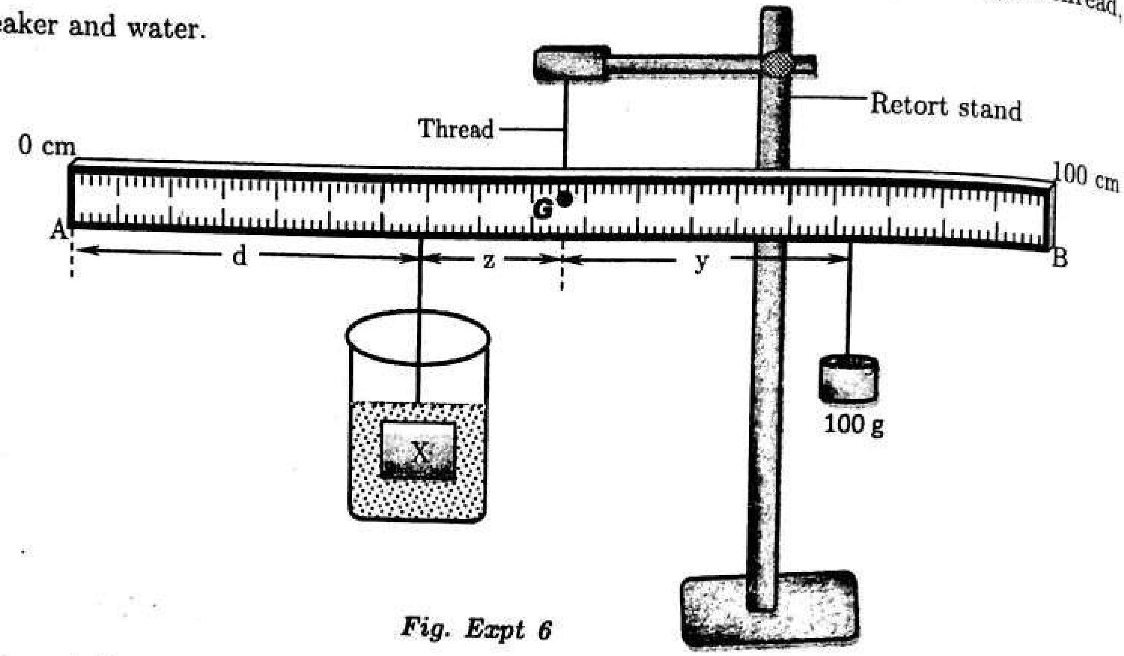

Fig. Expt 6

a) Record the mass M of the solid X provided.

b) Suspend a metre rule from a clamp using a piece of thread.

c) Adjust the metre rule until it balances horizontally.

d) Read and record the distance of the balance point P of the metre rule from end A.

e) Suspend the solid X at a distance d = 10.0 cm from end A of the metre rule.

f) Immerse solid X completely in water in the mug.

g) Suspend a 100 g mass from a point, Q between P and B.

h) Adjust the position of Q until the metre rule balances horizontally with X completely immersed and not touching the mug as shown in figure above.

i) Measure and record distances z and y.

j) Repeat procedures (e) to (i) for values of d = 15.0, 20.0, 25.0, 30.0 and 35.0 cm.

k) Enter your results in a suitable table.

l) Plot a graph of z against y.

m) Find the slope S of your graph. Calculate the relative density ρ of the material from the expression: $\rho = \dfrac{M}{M - 100S}$

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EXPERIMENT 7

In this experiment, you will determine the relative density of the solid provided using Archimedes' principle.

Apparatus:

1 metre rule, 1 spiral spring(Nuffield type), six 50g slotted masses, 1 beaker or mineral water bottle filled with water and a retort stand with a clamp.

Procedure:

(a) Clamp the spring provided and a metre rule as shown in the figure below.

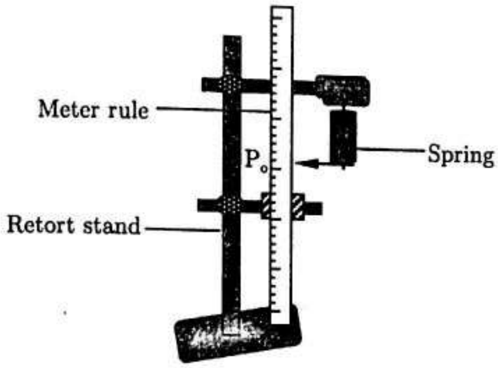

Fig. Expt 7(a)

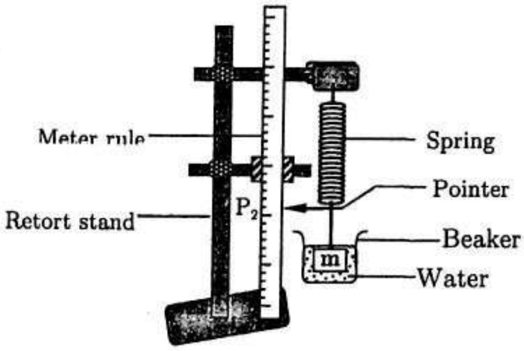

Fig. Expt 7(b)

(b) Record the initial position of the pointer P_o when the spring is unloaded.

(c) Using a thread, suspend a mass m = 50g to the spring and note the new position P_1 of the pointer.

(d) Find the extension $e_o = P_1 - P_o$.

(e) Suspend the mass in (c) above so that it is completely submerged into the water. Note the new position P_2 of the pointer.

(f) Find the extension, $e_1 = P_2 - P_o$.

(g) Repeat procedure (b) to (f) for m = 100, 150, 200, 250 and 300g

(h) Tabulate your results including values of $e_o - e_1$.

(i) Plot a graph of e_o against $e_o - e_1$.

(j) Find the slope, S, of your graph.

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EXPERIMENT 8

In this experiment, you will determine the acceleration due to gravity by means of a spring.

Apparatus:

3 masses of 100 g, 1 mass of 50g, 1 spring with a pointer, 1 metre rule and 1 retort stand with 2 clamps.

Procedure:

a) Clamp a metre rule provided on the retort stand so that it is vertical.

b) Suspend the spiral spring provided from the retort stand

c) Attach a pointer P to the spiral spring so that the pointer is horizontal as shown in the figure below.

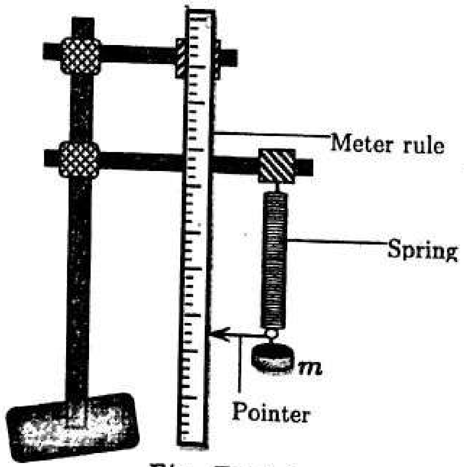

Fig. Expt. 8

d) Read and record the position of the pointer P_0 on the metre rule clamped vertically.

e) Suspend a mass m = 50 g from the free end of the spiral spring.

f) Read and record the new position, P_1, of the pointer.

g) Find the extension x cm of the spiral spring from $x = P_1 - P_0$.

h) Repeat the procedures (d) to (h) above for the mass m = 100 g, 150 g, 200 g, 250 g and 300 g.

i) Tabulate your results.

j) Plot a graph of extension x **(along the vertical axis)** against mass m kg **(along the horizontal axis)**.

k) Find the slope, k, of your graph.

l) Determine the acceleration due to gravity, g, from g = 35k.

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EXPERIMENT 9

In this experiment, you will determine the acceleration due to gravity by means of a spring.

Apparatus:

1 metre rule, 1 mass of 50 g, 5 masses of 100 g, 1 spring with a pointer, 1 retort stand with 2 clamps and 1 stop clock.

a) Clamp the spring provided and a metre rule as shown in the figure below.

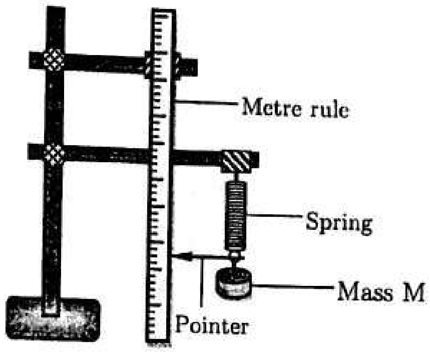

Fig. Expt. 9

b) Using the thread provided, suspend a mass M = 0.050 kg from the free end of the spiral spring.

c) Read and record the position, P_o, of the pointer on the metre rule.

d) Hang a mass M equal to 0.100 kg to the lower end of the spring (see figure above). Read and record the new position, P_1, of the pointer on the vertical metre rule.

e) Find the extension of the spring *e*.

f) Remove the 0.050 kg mass suspended from the spring and the vertical metre rule from the stand.

g) Pull the 0.100 kg mass slightly and release it.

h) Measure and record the time for 20 complete oscillations. Find the time T for one oscillation.

i) Repeat the procedures (h) and (i) for values of M = 0.200 kg, 0.300 kg, 0.400 kg and 0.500 kg.

j) Record your results in a suitable table including values of T and T^2.

k) Plot a graph of T^2 (along the vertical axis) against M (along the horizontal axis).

l) Find the slope S of the graph.

m) Calculate g, from the formula $g = \frac{40\pi^2 e}{S}$.

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EXPERIMENT 10

In this experiment, you will find the ratio of effective spring constant of two similar springs in series.

Apparatus:

1 meter rule, 2 helical springs, 1 retort stand with 2 clamps, 1 mass of 50g and 3 masses each of 100g.

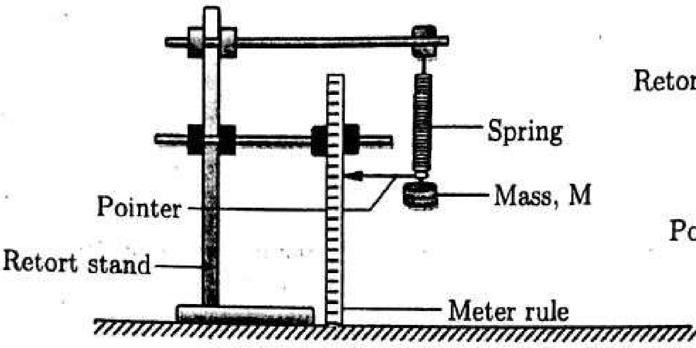

Fig. Expt 10(i)

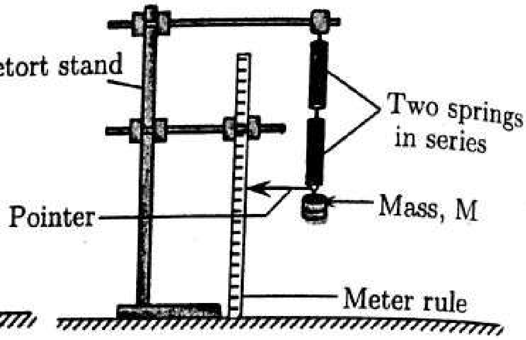

Fig. Expt 10(ii)

a) Arrange the apparatus as shown in the *fig.expt 10(i).*

b) With only the spring suspended, read and record the original position P_0 of the pointer.

c) Hang mass M = 100g on the spring

d) Read and record the new position P_1 of the pointer.

e) Calculate the extension X_1 in cm

f) Remove mass M.

g) Repeat the experiment using mass M = 200g and record the extension X_2

h) Calculate the spring constant K_1 for a single spring from the expression; $K_1 = 50\left(\frac{1}{X_1} + \frac{2}{X_2}\right)$

i) Re-arrange your apparatus with two similar springs in series as shown in *fig. expt 10(ii).*

j) With mass M removed, record the initial position P_0 of the pointer.

k) Hang mass M = 0.100kg on the springs

l) Read and record the new position P_1 of the Pointer.

m) Calculate the extension e.

n) Remove the mass M

o) Repeat procedure (k) to (m) with M = 0.150, 0.200, 0.250, 0.300 and 0.350kg

p) Tabulate your results including values of F = Mg. (Take g = $10ms^{-2}$)

q) Plot a graph of F against e and find the slope K_2

r) Find the ratio $K_1:K_2$

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EXPERIMENT 11

In this experiment, you will determine the effective mass, m_0, of the spring provided.

Apparatus:

1 metre rule, 1 retort stand with 2 clamps, 5 masses each of 100g, 1 spring with a pointer and 1 stop clock or watch.

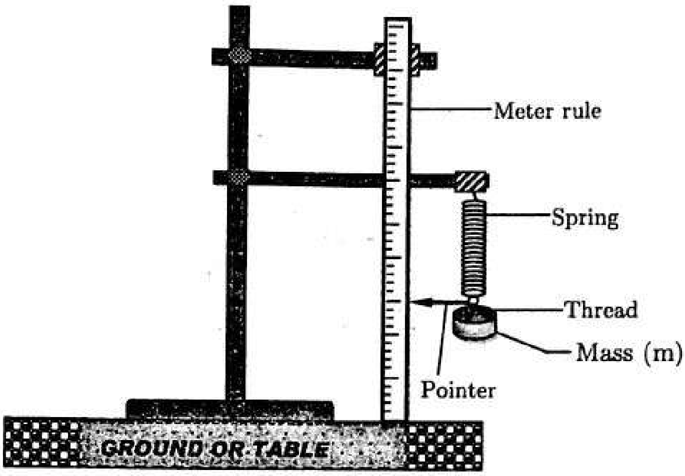

Fig.Expt 11

a) Attach an optical pin to one end of the spring to act as a pointer.
b) Clamp a metre rule vertically beside the spring with the zero mark up as
c) shown in fig. expt 11.
d) Read and record the position, P_0, of the pointer on the metre rule.
e) Suspend a mass, m = 0.100 kg from the free end of the spring.
f) Read and record the new position P_1 of the pointer.
g) Find the extension, $e = P_1 - P_0$ of the spring.
h) Remove the metre rule.
i) Displace the mass slightly downwards and release it to oscillate
j) Measure and record the time for 20 oscillations.
k) Determine the time T for one oscillation.
l) Repeat procedures (i) to (k) for values of m = 0.200, 0.300, 0.400 and 0.500 kg.
m) Record your results in a suitable table including values of T^2
n) Plot a graph of T^2 (along the vertical axis) against m (along the horizontal axis).
o) Find the intercept, C, on the T^2-axis.
p) Calculate the effective mass m_0, of the spring from the expression $m_0 = \frac{Cg}{40\pi^2 e}$

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EXPERIMENT 12

In this experiment, you will determine the relative density of a liquid.

Apparatus:

1 G-clamp, 2 metre rules, pointer, 7 masses of 50 g, 1 retort stand with a clamp and a thread.

Procedure:

a) Clamp the spring provided vertically and suspend the beaker from it as shown in the figure below.

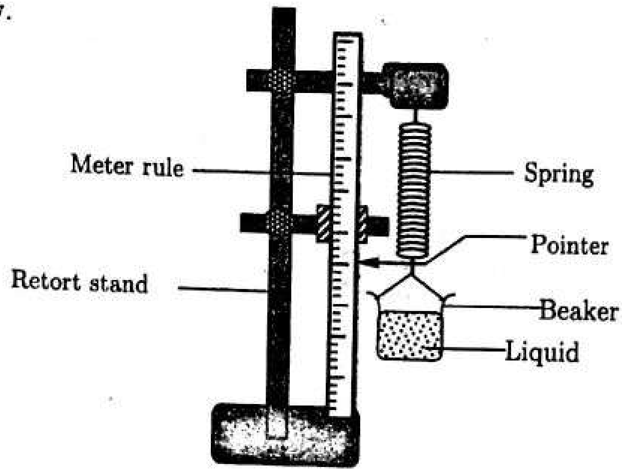

Fig. Expt 12

b) Record the initial position of the pointer on the metre rule.

c) Pour $50cm^3$ of water into the beaker and record the new position of the pointer.

d) Find the extension x.

e) Repeat procedures (c) and (d) for four more readings by adding 50 cm^3 of water each time.

f) Pour out the water and dry the beaker with a piece of tissue paper provided.

g) Repeat procedures (a) to (e) using liquid L and call the extension produced y.

h) Record your results in suitable tables.

i) Plot a graph of y (along the vertical axis) against x (along the horizontal axis).

j) Determine the slope, S, of the graph.

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EXPERIMENT 15

In this experiment, you will determine the acceleration due to gravity g_0.

Apparatu:

1 pendulum bob, 1 retort stand with a clamp and 1 stop clock/ stop watch

Procedure:

a) Suspend the pendulum bob from a retort stand as in the figure below.

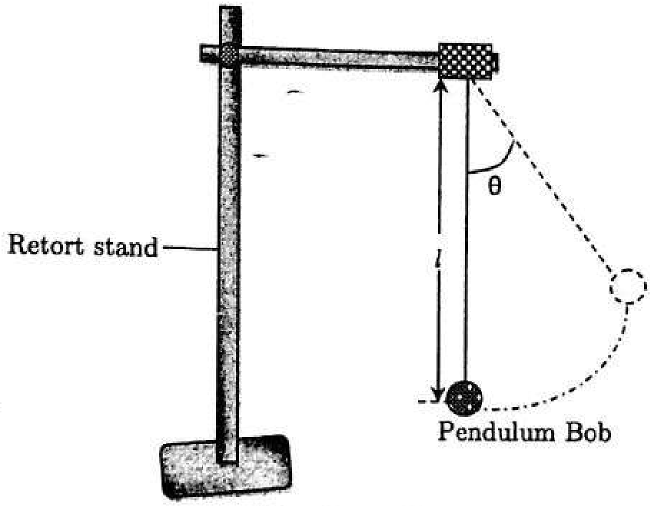

Fig. Expt 15

b) Adjust the thread such that the length l = 80.0 cm.

c) Displace the bob through a small angle θ as shown in the figure above.

d) Determine the time t for 20 oscillations. Hence find the frequency f of the oscillation using the expression; $f = \frac{20}{t}$.

e) Repeat procedures (b) and (d), for values of l = 60.0, 50.0, 40.0, 30.0, 20.0 and 10.0 cm.

f) Record your results in a suitable table including the values of log (10f) and log l.

g) Plot a graph of log(10f) against log$l$.

h) Find the slope S of your graph.

i) Read and record the value of log(10f) when log l =0. Call this value K_0.

j) Calculate the acceleration due to gravity g_0 from the expression: $K_0 = \log(g_0) - 1.6$.

k) Calculate the factor n from the expression: $n = \frac{1}{S}$.

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EXPERIMENT 16

In this experiment, you will to determine acceleration due to gravity using a pendulum bob.

Apparatus:

1 string (1.30m long), 1 pendulum bob, 1 retort stand with 1 clamp and 1 stop clock or stop watch.

a) Suspend the pendulum as shown in the figure below with the length l = 1.200m and height h from the ground level is equal to 0.100 m.

(N.B: A pendulum is a string with a mass hanging from its end)

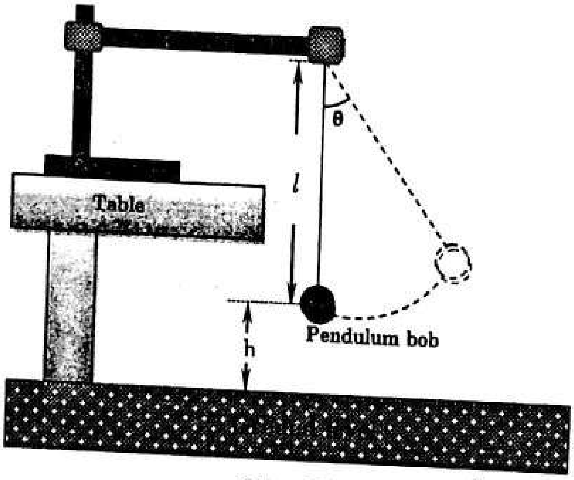

Fig. Expt 16

b) Displace the pendulum bob through a small angle θ.

c) Release it oscillation in a vertical plane and measure the time for 20 complete oscillations.

d) Find the time T for one oscillation.

e) Raise the pendulum bob (by reducing the length of the pendulum) by a distance h = 0.200, 0.300, 0.400, 0.500, 0.600 and 0.700m and in each case repeat procedures (b) to (d).

f) Record your results in a suitable table including values of T^2.

g) Plot a graph of h against T^2.

h) Find the slope S of the graph.

i) Calculate the acceleration due to gravity g from the expression. $S = \frac{-g}{4\pi^2}$.

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EXPERIMENT 17

In this experiment, you will be required to determine the length of the thread provided.

Apparatus:

1 string (130 cm long), 1 pendulum bob,1 retort stand with 1 clamp and 1 stop clock.

Procedure:

a) Setup the pendulum as shown in the figure below with the length $l = 120.0$cm and height h from the ground level equal to 40.0 cm.

(N.B: A pendulum is a string with a mass hanging from its end)

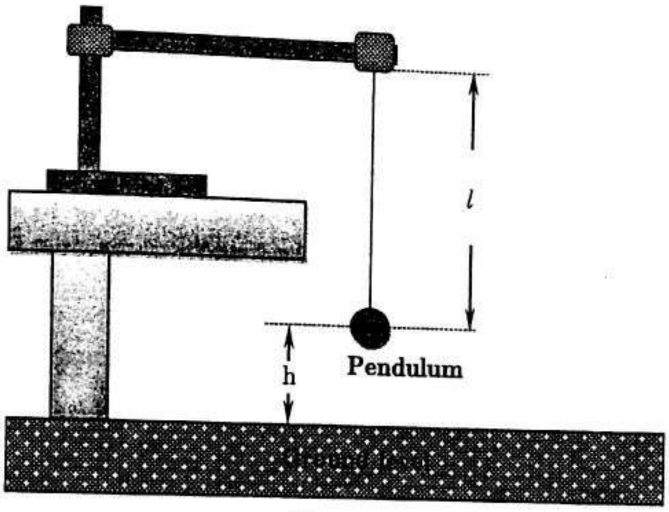

Fig. Expt 17

b) Set the pendulum bob in a small horizontal oscillation and measure the time for 20 complete oscillations.

c) Find the time T for one oscillation.

d) Repeat procedures (a) to (c) for values of h = 30.0 cm, 50.0 cm, 70.0 cm and 90.0 cm from the ground level.

e) Tabulate your results in a suitable table including values of T, T^2 and h.

f) Plot a graph of T^2 (along the vertical axis) against h (along the horizontal axis).

g) Find the value of T^2 when h = 0 and call it S_1.

h) Calculate l from $S_1 = 0.4\ \pi^2\ l$ (take $\pi = \frac{22}{7}$).

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EXPERIMENT 18

In this experiment, you will to determine the length of a pendulum using two methods.

Apparatus:

1 string (1.30m long), 1 pendulum bob, 1 retort stand with 1 clamp and 1 stop clock or stop watch.

Method 1

(a) Suspend the pendulum on a retort stand. Make sure that not more than 2cm of the free end is clamped.

(b) Displace the pendulum through a small distance and find the time for twenty oscillations.

(c) Find the period, T, of oscillations.

(d) Find the value of l_1 from the formula: $l_1 = \frac{T^2 g}{4\pi^2}$.

Method 2

(a) Displace the bob of a simple pendulum through a horizontal distance, $d = 10.0$cm.

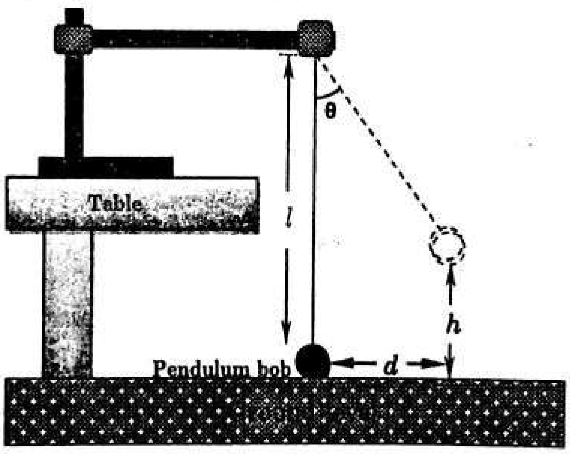

Fig. Expt 18

(b) Measure the vertical displacement, h, of the bob.

(c) Repeat procedure (a) and (b) for $d = 12.0$cm, 14.0cm, 16.0cm, 18.0cm, 20.0cm and 22.0cm.

(d) Tabulate your results including the values of $\frac{d^2}{h}$.

(e) Plot a graph of $\frac{d^2}{h}$ against h.

(f) Find the slope l_2 of your graph.

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EXPERIMENT 19

In this experiment, you will determine the coefficient of static friction, μ, between two surfaces.

Apparatus:

7 masses each of 100g, 1 spring with a pointer, 1 manila sheet with a centimetre scale attached (scale must be made from a graph paper), 1 wooden block of dimensions (10cm x 4cm x 3cm) labelled M_0 with its mass indicated on it and a piece of thread 30cm long.

Procedure:

(a) Fix the manila sheet (with a scale attached on) using pieces of cellotape on a table as shown below

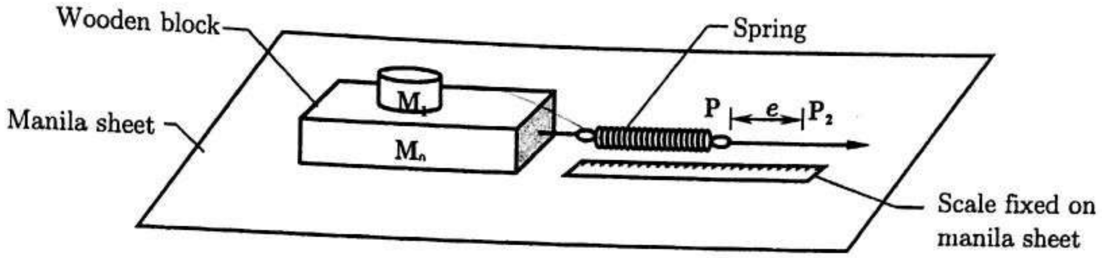

Fig.expt 19

(b) Record the mass, M_o of the wooden block

(c) Attach the spring on the block using a short piece of thread.

(d) Place the spring to the block on the manila sheet, such that the spring lies along the scale as shown in the figure above.

(e) Place a mass, $M_1 = 0.200$kg on the wooden block.

(f) Adjust the position of the spring such that the spring is taut.

(g) Read and record the position, P_1 of the pointer on the unstreched spring.

(h) Gently pull the spring while observing the block just moves over the manila sheet. (*Make sure the block does not come in contact with the scale*).

(i) Record the new position, P_2 of the pointer when the block just moves.

(j) Determine the extension, $e = P_2 - P_1$ (in metres) of the spring.

(k) Repeat procedures (e) to (j) for values of $M_1 = 0.300$, 0.400, 0.500, 0.600 and 0.700kg.

(l) Record your results in a suitable table including values of $(M_O + M_1)$.

(m) Plot a graph of e (along the vertical axis) against $(M_O + M_1)$ (along the horizontal axis)

(n) Determine the slope, S, of the graph.

(o) Find the coefficient of static friction, μ, from the expression; $\mathbf{S = 0.33\mu}$.

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EXPERIMENT 20

In this experiment, you will determine the coefficient of static friction, μ, between the surface of the metre rule and a soda bottle top.

Apparatus:

7 masses each of 100g, 1 spring with a pointer, 1 manila sheet with a centimetre scale attached (scale must be made from a graph paper), 1 wooden block of dimensions (10cm x 4cm x 3cm) labelled M_0 with its mass indicated on it and a piece of thread 30cm long.

Procedure:

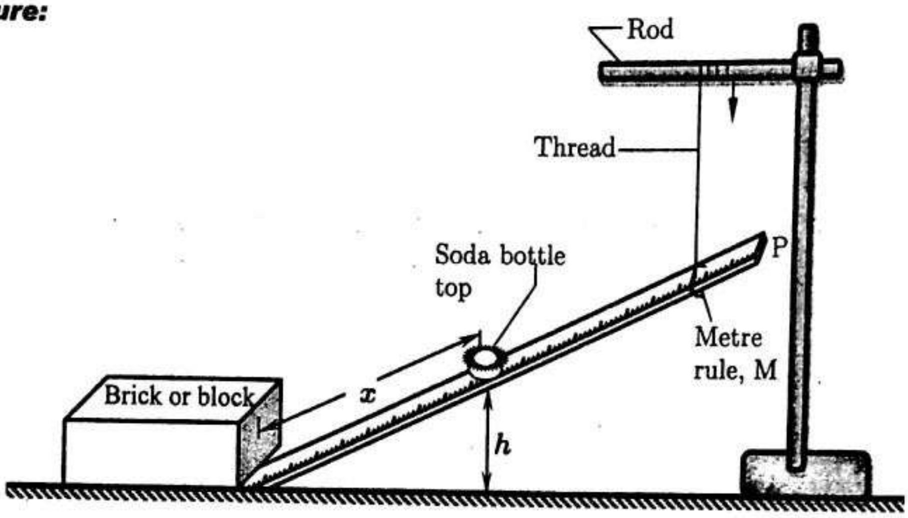

Fig.Exp 20

(a) Tie a loop of thread at one end of mere rule labelld, M.
(b) Place the other end of the metre rule against the base of the brick/block lying on the surface of the table
(c) Put the soda bottle top on the metre rule such that the distance, x, from base of the brick/block to the middle of the bottle top is 10cm.
(d) Pass the free end of the thread over the rod.
(e) Gently raise the end, P, of the metre rule by pulling the thread down wards until the bottle top just moves(*make sure the string is vertical at all times*) as shown in figure above.
(f) Tie the thread round the rod in order to keep the metre rule in position.
(g) Measure and record the vertical height, h, of the initial position of the bottle top from the table.
(h) Repeat procedures (b) to (g) for values of x = 20, 30, 40, 50 and 60cm.
(i) Record your results in a suitable table including values of $(x + h)$, $(x - h)$, $(x + h)(x - h)$ and $\sqrt{(x + h)(x - h)}$.
(j) Plot a graph of h against $\sqrt{(x + h)(x - h)}$.
(k) Find the slope, μ, of the graph.

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EXPERIMENT 21

In this experiment, you will determine how the depression of a clamped metre rule depends on its free length as shown in the figure below.

Apparatus:

1 G-clamp, 2 metre rules, 1 pointer (pin) and a mass M of 100g.

Proceure:

a) Clamp a metre rule firmly to the table with its graduated face upwards such that the free length y is equal to 40.0 cm as shown in the figure below.

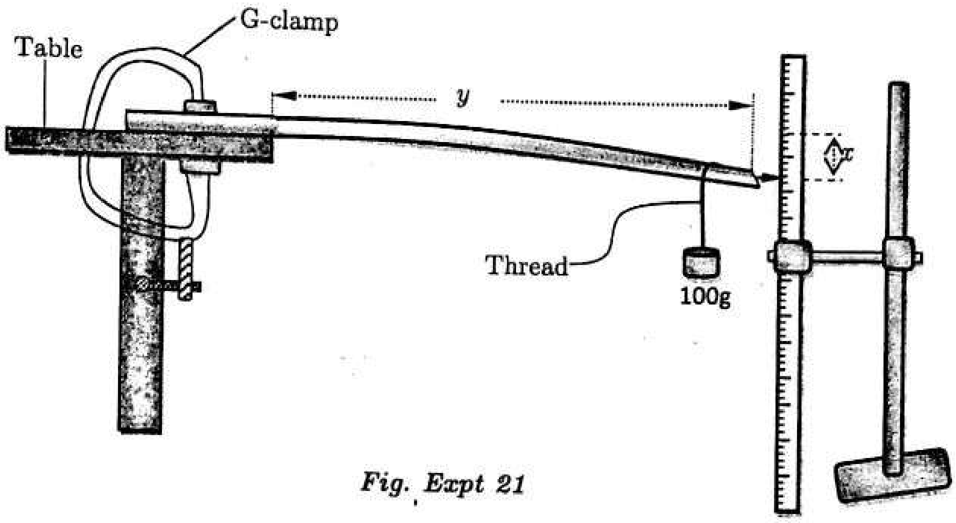

Fig. Expt 21

b) Read and record the position of the pointer (a pin fixed at the end of the metre rule), P_o on the vertical metre rule.

c) Hang a mass of 100 g at a distance of 5.0 cm from the free end of the horizontal metre rule.

d) Read and record the new position, P_1 of the pointer and find the depression x from $x = P_1 - P_0$.

e) Repeat procedures (a) to (d) for values of y = 50.0cm, 60.0cm, 70.0cm, 80.0cm and 90.0cm.

f) Record your results in a suitable table including the values of $10\log_{10}y$ and $10\log_{10}x$

g) Plot a graph of $10 \log_{10}y$ **(along the vertical axis)** against $10\log_{10}x$ **(along the horizontal axis).**

h) Find the slope, S, of your graph.

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EXPERIMENT 22

In this experiment, you will determine the time of the oscillation of the metre rule which is suspended horizontally.

Apparatus:

2 meter rules P and Q, 2 pieces of thread each of length 1.5m, knife edge, stop watch/stop clock and 1 retort stand with a clamp.

Procedure:

a) Balance the metre rule Q on a knife edge to determine the position of its centre of gravity (G).

b) Clamp the rod horizontally at least 30.0cm above the table.

c) Tie the thread around the metre rule firmly a points C and D, each a distance x from point G

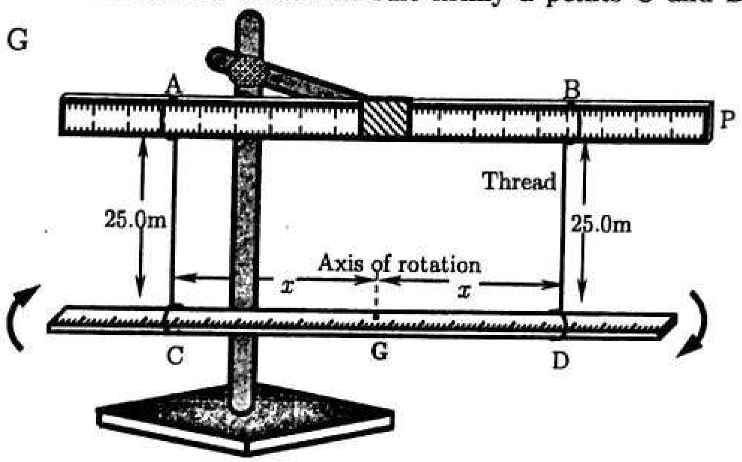

Fig. Expt 22

d) Adjust the length of the strings such that AC = BD = 25.0cm and $x = 10.0$cm.

e) Give the metre rule Q a small angular displacement and allow it to oscillate in the horizontal plane as shown above.

f) Measure and record the time for 20 oscillations.

g) Find the period of oscillation T

h) Repeat the above procedure (d) to (g) for values of $x = 15.0, 20.0, 25.0, 30.0$ and 35.0cm

i) Tabulate your results in a suitable table.

j) Plot a graph of T against x.

k) From your graph find x_1 the value of x, when T = 1.5s and x_2 the value of x, when T = 2.5s

l) Calculate the ratio; $x_1 : x_2$

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EXPERIMENT 23

In this experiment you will investigate the relationship between the depression of a load beam and the distance between the supports.

Apparatus:

1 metre rule, 1 half metre rule, 2 knife edges, a 500g mass and 1 retort stand with a clamp.

Procedure:

a) Attach a pointer at the 50.0 cm mark of the metre rule, using sellotape.

b) Place the metre rule so that it lies horizontally on the two knife-edges provided.

c) Clamp the half metre rule vertically and place it near the 50.0 cm mark of the horizontal metre rule as shown in the Figure below.

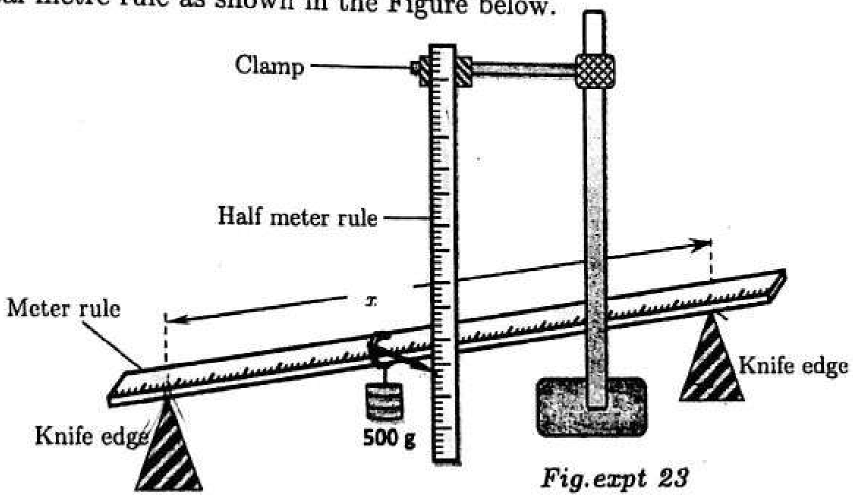

Fig.expt 23

d) Adjust the knife-edges such that the distance x between them is equal to 90.0 cm and they are equidistant from the 50.0 cm mark of the metre rule.

e) Read and record the position of the pointer on the scale.

f) Suspend a mass of 500 g at the 50.0 cm mark of the metre rule.

g) Read and record the position of the pointer on scale. Hence find the depression, d; of the metre rule.

h) Remove the mass from the metre rule.

i) Repeat procedures (d) to (h) for values of x = 80.0 cm, 70.0 cm, 60.0 cm, 50.0 cm, and 40.0cm.

j) Enter your results in a suitable table and include values of $\log_{10}d$ and $\log_{10}x$.

k) Plot a graph of $\log_{10}x$ (along the vertical axis) against $\log_{10}d$ (along the horizontal axis).

l) Find the slope, n, of the graph.

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EXPERIMENT 24

In this experiment, you will determine young's modulus for the wooden beam provided.

Apparatus:

1 metre rule, 1 half metre rule, 2 knife edges, 1 pointer (a pin), 6 masses each of 100g, 1 retort stand with a clamp, 1 vernier caliper and 1 micrometer screw gauge.

Procedure:

a) Measure and record the thickness, d, and the width, w, of the metre rule provided in metres.

b) Place the metre rule on the knife-edges such that each is 5.0 cm from each end as shown below.

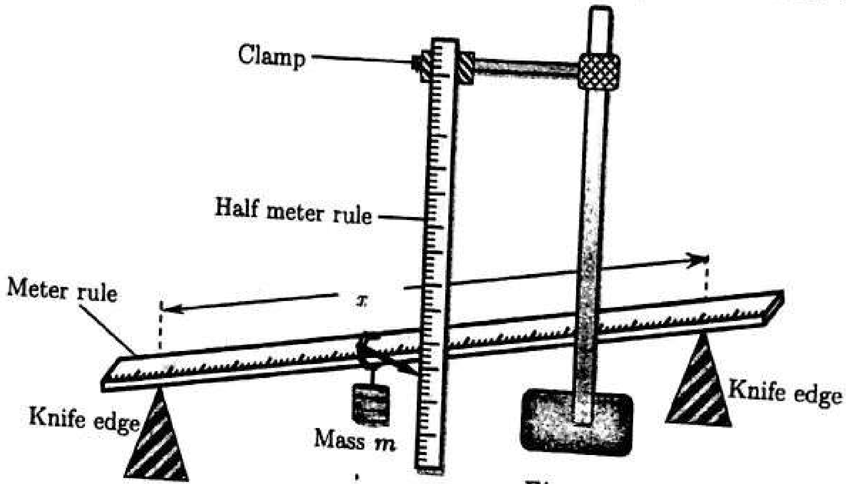

Fig. Expt 24

c) Tie a piece of thread provided from the centre of the metre rule.

d) Read and record the initial position x_0 of the pointer, on the scale of the half-metre rule.

e) Suspend a mass m = 0.100 kg on the thread.

f) Read and record the new position x of the pointer. Hence record the depression $(x - x_0)$ in metres of the centre of the metre rule.

g) Repeat the procedure (e) and (f) for values of m =0.200 kg, 0.300 kg, 0.400 kg, 0.500 kg and 0.600 kg.

h) Tabulate your results including values of $\frac{m}{w}$ and $4(x - x_0)$.

i) Plot a graph of $\frac{m}{w}$ against $4(x - x_0)$.

j) Find the slope, 'S' of your graph.

k) Determine Young's modulus 'E' from $E = 1000S\left(\frac{w}{d}\right)^3$

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EXPERIMENT 25

In this experiment you will determine Young's modulus of wood.

Apparatus:

1 G -clamp, a pointer(pin), 1 metre rule, 3 masses each of 100g, 1 mass of 50g, 1 retort stand with a clamp, 1 half metre rule, a micrometer screw gauge and a vernier caliper.

Procedure:

a) Read and record the breadth (width), W, and the thickness, d, of the metre rule in metres.

(b) Clamp the metre rule along the top of the bench with its graduated face upwards and with a length $l = 0.800$m projecting beyond the edge of the bench as shown below.

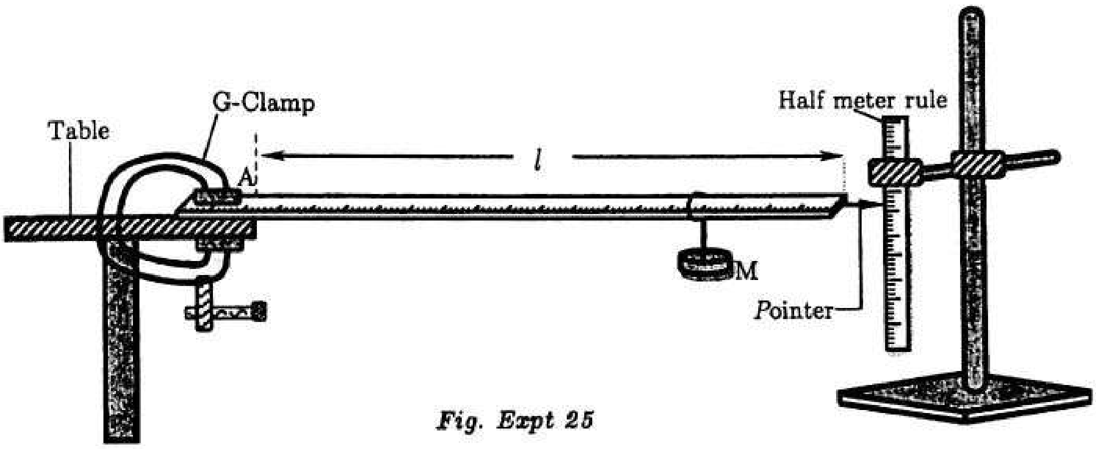

Fig. Expt 25

(c) Note and record position X_0 of the pointer on the metre rule clamped vertically on the retort stand.

(d) Suspend a mass M = 0.100 kg at a distance of 1 cm from the free end.

(e) Note the new position X of the pointer.

(f) Repeat the procedures (d) and (e) for values of M = 0.150 kg, 0.200kg, 0.250 kg, 0.300 kg and 0.350 kg.

(g) Tabulate your results including values of $(X-X_0)$.

(h) Plot a graph of $(X-X_0)$ against M.

(i) Determine the slope, S, of your graph.

(j) Calculate Young's modulus 'E' from $E = \frac{20}{Sd^3W}$

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EXPERIMENT 26

In this experiment, you will determine the Young's modulus for wood.

Apparatus:

1 metre rule, 1 retort stand with a clamp, pointer, 1 half metre rule, 2 masses each of 1 kg, a thread and 1 G - clamp.

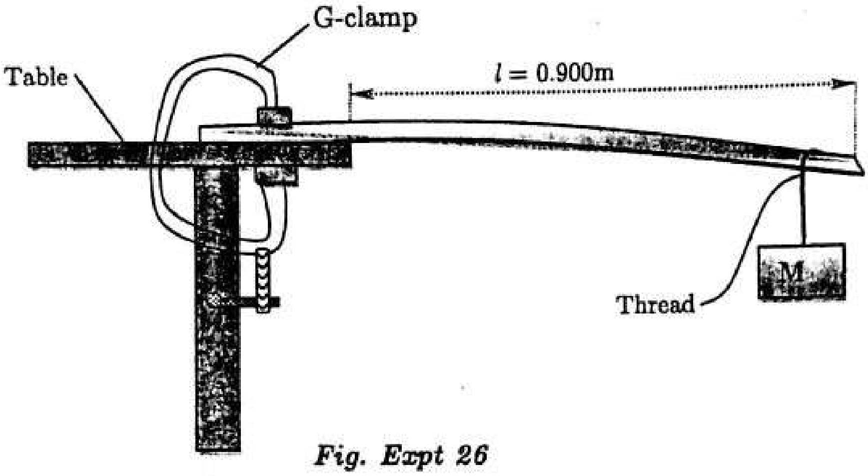

Fig. Expt 26

Procedure:

a) Record the thickness, *d*, of the metre rule provided.

b) Clamp the metre rule provided with the graduated face upwards such that the free length equals 80.0 cm as shown in the figure above.

c) Attach a mass, M equal to 0.050 kg at the end of the metre rule with a thread.

d) Depress the mass through a small vertical distance and release it to oscillate.

e) Measure and record the time for 20 oscillations. Find the time, T, for one oscillation.

f) Repeat procedures (c) to (e) for M equal to 0.100, 0.150, 0.200 and 0.250 kg.

g) Record your results in a suitable table including values of T^2.

h) Plot a graph of T^2 (along the vertical axis) against M (along the horizontal axis).

i) Find the slope, S, of the graph.

j) Calculate Young's modulus ,Y , for wood from: $Y = \frac{1590}{Sd^2}$

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EXPERIMENT 27

In this experiment, you will determine the constant, E, of the metre rule provided.

Apparatus:

2 masses of 100 g, 1 metre rule, pointer, 1 half metre rule, 2 knife edges, 1 retort stand with a clamp, 2 wooden rectangular blocks and a thread.

Procedure:

(a) Measure and record the mass M of the metre rule provided.

(b) Fix a pointer at the 50.0 cm mark of the metre rule provided.

(c) Place the two blocks of wood on the bench so that each stands on its square face.

(d) Place a knife edge on top of each block.

(e) Place the metre rule provided with its graduated face upwards on the knife-edges so that the knife edges are equidistant from the 50cm mark of the metre rule and the distance, d, between them is 70.0cm.

(f) Clamp a half metre rule vertically near the 50.0 cm mark of the metre rule.

(g) Read and record the position of the pointer on the half metre rule.

(h) Hang a 0.500kg mass at a distance 5.0 cm from each end of the metre rule as shown in figure below.

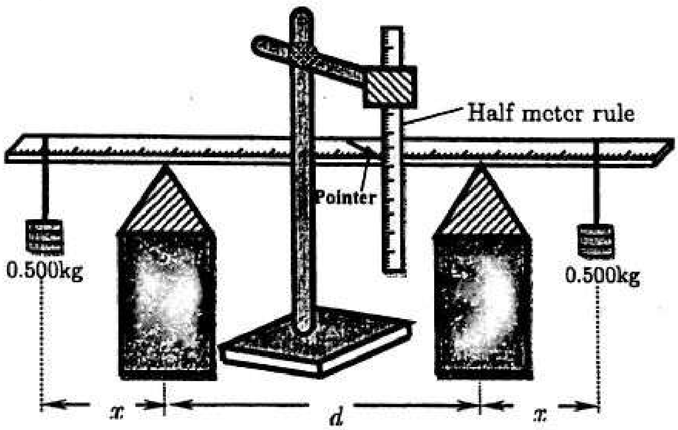

Fig. Expt 27

h) Read and record the position of the pointer. Find the elevation, *h*, produced at the centre of the metre rule.

i) Measure and record distance, x, of a knife-edge from the point of suspension of the mass.

j) Remove the masses.

k) Repeat procedures in (d) to (j) for values of d = 60.0, 50.0, 40.0, and 30.0 cm.

l) Tabulate your results in a suitable table including values of d^2 and $\frac{h}{x}$.

m) Plot a graph of d^2 (along the vertical axis) against $\frac{h}{x}$ (along the horizontal axis).

n) Find the slope, S, of the graph.

o) Calculate the constant, E, of the metre rule from, E $=10MS$.

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EXPERIMENT 28

In this experiment you will determine the density of water.

Apparatus:

1 large beaker (500ml), 1 small beaker (250ml) with a cm scale (made from a graph paper) attached to it using transparent sellotape, 15 bottle tops, a small amount of sand ($\frac{1}{4}$ kg), water , spatula(or a small spoon)and a vernier caliper.

Procedure:

(a) Record the radius r of the small beaker.

(b) Place the small beaker in the larger beaker containing water.

(c) Add a small quantity of sand using a spatula or a small spoon into the small beaker until it floats upright as shown in the figure below. Make sure the small beaker does not touch the sides of the large beaker.

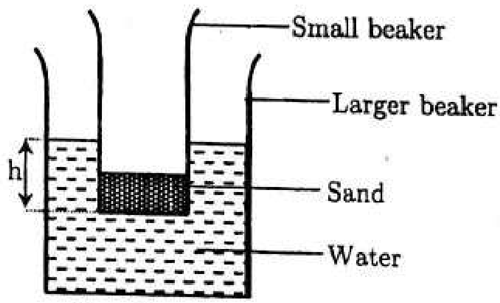

Fig. Expt. 28

(d) Place three bottle tops into the small beaker.

(e) Read and record the depth, h, by which the small beaker sinks into the water.

(f) Repeat procedures (d) and (e) for 6, 9, 12 and 15 bottle tops.

(g) Record your results in a suitable table.

(h) Plot a graph of the number of bottle tops (on the vertical axis) against h (on the horizontal axis).

(i) Find the slope, S, of the graph.

(j) Calculate the density of water, ρ, from the expression $2.5S=\rho\pi r^2$.

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EXPERIMENT 27

In this experiment, you will determine the constant, E, of the metre rule provided.

Apparatus:

2 masses of 100 g, 1 metre rule, pointer, 1 half metre rule, 2 knife edges, 1 retort stand with a clamp, 2 wooden rectangular blocks and a thread.

Procedure:

(a) Measure and record the mass M of the metre rule provided.

(b) Fix a pointer at the 50.0 cm mark of the metre rule provided.

(c) Place the two blocks of wood on the bench so that each stands on its square face.

(d) Place a knife edge on top of each block.

(e) Place the metre rule provided with its graduated face upwards on the knife-edges so that the knife edges are equidistant from the 50cm mark of the metre rule and the distance, d, between them is 70.0cm.

(f) Clamp a half metre rule vertically near the 50.0 cm mark of the metre rule.

(g) Read and record the position of the pointer on the half metre rule.

(h) Hang a 0.500kg mass at a distance 5.0 cm from each end of the metre rule as shown in figure below.

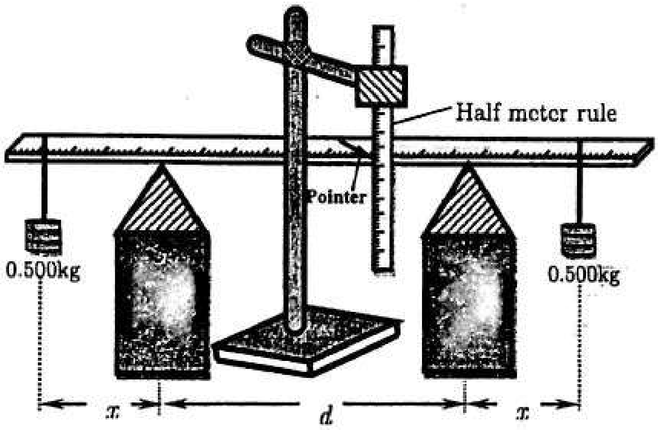

Fig. Expt 27

h) Read and record the position of the pointer. Find the elevation, *h*, produced at the centre of the metre rule.

i) Measure and record distance, *x*, of a knife-edge from the point of suspension of the mass.

j) Remove the masses.

k) Repeat procedures in (d) to (j) for values of d = 60.0, 50.0, 40.0, and 30.0 cm.

l) Tabulate your results in a suitable table including values of d^2 and $\frac{h}{x}$.

m) Plot a graph of d^2 (along the vertical axis) against $\frac{h}{x}$ (along the horizontal axis).

n) Find the slope, *S*, of the graph.

o) Calculate the constant, E, of the metre rule from, E =10M*S*.

Scanned by CamScanner

EXPERIMENT 28

In this experiment you will determine the density of water.

Apparatus:

1 large beaker (500ml), 1 small beaker (250ml) with a cm scale (made from a graph paper) attached to it using transparent sellotape, 15 bottle tops, a small amount of sand ($\frac{1}{4}$ kg), water , spatula(or a small spoon)and a vernier caliper.

Procedure:

(a) Record the radius r of the small beaker.

(b) Place the small beaker in the larger beaker containing water.

(c) Add a small quantity of sand using a spatula or a small spoon into the small beaker until it floats upright as shown in the figure below. Make sure the small beaker does not touch the sides of the large beaker.

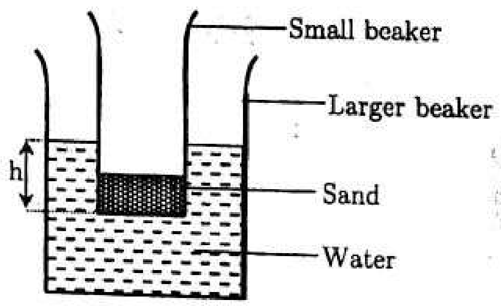

Fig. Expt. 28

(d) Place three bottle tops into the small beaker.

(e) Read and record the depth, h, by which the small beaker sinks into the water.

(f) Repeat procedures (d) and (e) for 6, 9, 12 and 15 bottle tops.

(g) Record your results in a suitable table.

(h) Plot a graph of the number of bottle tops (on the vertical axis) against h (on the horizontal axis).

(i) Find the slope, S, of the graph.

(j) Calculate the density of water, ρ, from the expression $2.5S = \rho\pi r^2$.

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EXPERIMENT 28

In this experiment, you will investigate the relationship between the number of images formed by two mirrors inclined to each other and the angle between them.

Apparatus:

2 plane mirror, 1 optical pins, 2 drawing pins, 1 plain white sheet of paper, 1 soft board and a complete geometry set.

Procedure:

(a) Fix a white sheet of paper on a soft board using drawing pins

(b) Draw a line AB, 10cm long and line BC about 10cm long such they make an angle of $\theta = 90^{\circ}$ at the point of intersection as shown in the figure below.

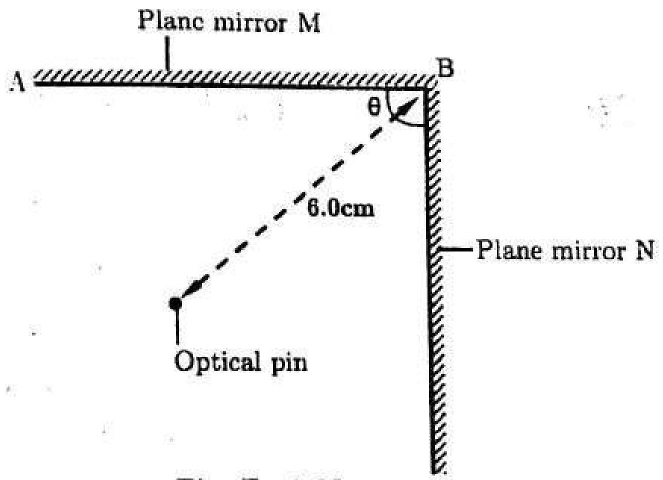

Fig. Expt 28

c) Place mirrors M and N on lines AB and BC respectively.

d) Put an optical pin a distance of about 6.0cm in front of point B.

e) While looking into the mirrors, position your eye a distance of not more than half a metre away from the mirrors. Count and record the number **n** of the images observed

f) Keeping the mirror M on the line AB, repeat procedures (b) to (c) for values of $\theta = 72^{\circ}, 60^{\circ}, 40^{\circ}$ and 30°.

g) Tabulate your results including values of $n\theta$ and $(n\theta + \theta)$

h) Suggest the equation relating n and θ, make **n** the subject.

NB: Staple your working sheet inside the work book

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EXPERIMENT 29

In this experiment, you will determine the focal length f of the concave mirror provided.

Apparatus:

2 dry cells, a double cell holder, 1 torch bulb, 1 bulb holder, 1 switch, 1 concave mirror, 1 screen with wire gauze, connecting wires, 1 metre rule and 1 screen.

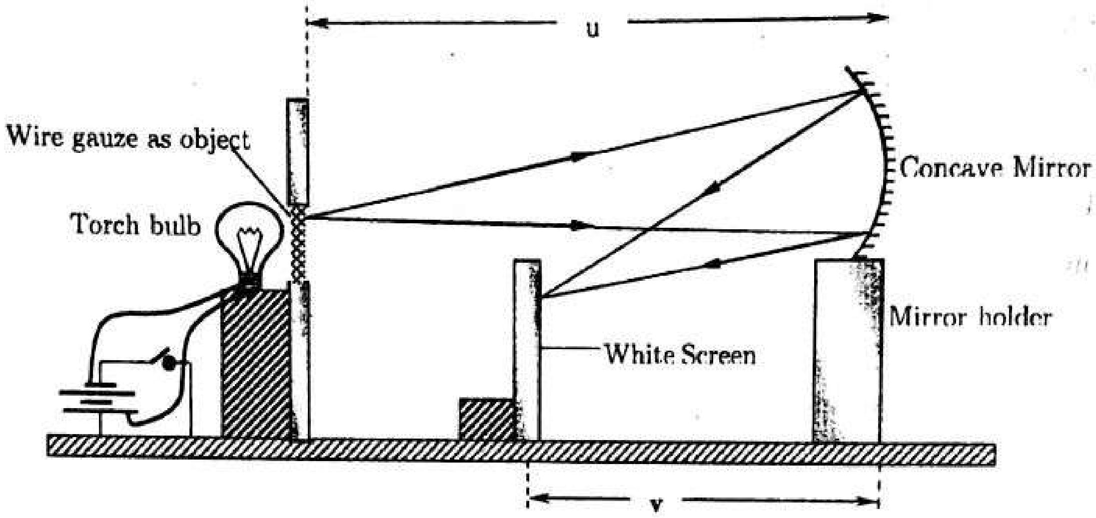

Fig. Expt 29

Procedure:

a) Connect the electrical circuit for lightning the bulb.

b) Arrange the illuminated wire gauze, the concave mirror and the white screen as shown in the figure above.

c) Move the concave mirror so that it is a distance u =15.0 cm from the object.

d) Adjust the position of the white screen until a sharply focused image I of the object appears on it.

e) Measure and record the image distance v.

f) Repeat procedures (c) to (e) for values of u = 20.0. 25.0. 30.0, 35.0 and 40.0cm.

g) Enter your results in a suitable table including values of uv and (u + v).

h) Plot a graph (u + v) (along the vertical axis) against uv (along the horizontal axis).

i) Find the slope S of the graph.

j) Calculate the focal length f from the expression: $f = \frac{1}{S}$.

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CHAPTER THREE

LIGHT EXPERIMENTS

EXPERIMENT 31

In this experiment, you will verify the first law of reflection of light.

Apparatus:

1 plane mirror, 1 soft board, 1 white sheet of paper, 4 optical pins, 4 drawing pins and a complete geometry set.

Procedure:

a) Fix the plain sheet of paper on the soft board provided.

b) Draw a line AB about 15.0 cm long on the plain sheet of paper.

c) Label the midpoint of AB as N and draw a normal PNQ.

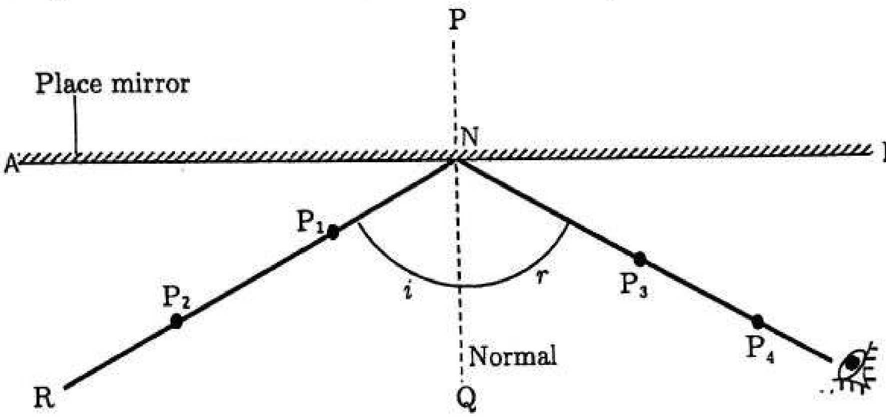

Fig. Expt 31

d) Draw a line RN at angle $i = 10°$

e) Fix pins P_1 and P_2 along the line RN at about 5.0cm apart.

f) Place the mirror along the mirror line AB as shown above.

g) View the images of P_1 and P_2 in the mirror from the opposite side of the normal.

h) Fix pins P_3 and P_4 such that they appear to be in a straight line with the images of P_1 and P_2

i) Remove the pins P_1, P_2, P_3, P_4 and the mirror from the white sheet of paper.

j) Draw a line SN passing through the mark of pins P_3 and P_4

k) Measure and record the angle r

l) Repeat procedures (e) to (l) for angle $i = 20°, 30°, 40°, 50°, 60°$ and $70°$

m) Record your values of i and r in a suitable table.

n) Draw a graph of i(along the vertical axis) against r (along the horizontal axis)

o) Find the slope S of your graph.

NB: Staple your working sheet inside the work book

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EXPERIMENT 32

In this experiment, you will verify the first law of reflection of light.

Apparatus:

1 plane mirror, 1 soft board, 1 white sheet of paper, 4 optical pins, 4 drawing pins and a complete geometry set.

Procedure:

a) Fix the plain sheet of paper on the soft board provided.

b) Draw a line XY on the white sheet of paper.

c) At the mid-point of line XY draw a normal AO as shown below.

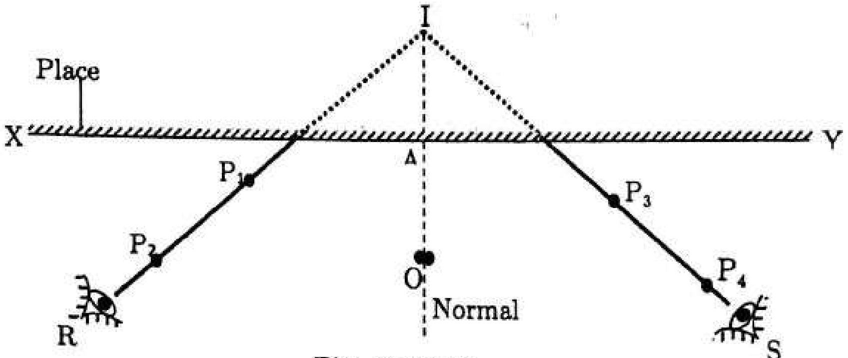

Fig. Expt 32

d) Fix a pin P at point O such that AO = 3.0cm.

e) Place the mirror provided vertically along XY as shown above.

f) View image I of the pin P at O from eye position R.

g) Stick pins P_1 and P_2 such that they are in line with the image I of pin P at O.

h) Remove pins P_1 and P_2.

i) From the eye position S, fix pins P_3 and P_4 such that they are in a straight line with the image I of pin P at O.

j) Remove the pins P_3 and P_4 and the mirror from the white sheet of paper.

k) Draw a line passing through the mark of pins P_1 and P_2 to meet the line through the mark of pins P_3 and P_4 at I.

l) Measure and record the distance AI.

m) Repeat procedures (d) to (l) for AO = 5.0cm, 6.0cm, 9.0cm and 10.0cm.

n) Tabulate your results in a suitable table.

o) Plot a graph of OA(along the vertical axis) against AI (along the horizontal axis)

p) Find the slope *d* of your graph.

NB: Staple your working sheet inside the work book

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EXPERIMENT 33

In this experiment, you will verify the second law of reflection of light.

Apparatus:

1 plane mirror, 1 soft board, 1 white sheet of paper, 3 optical pins, 4 drawing pins and a complete geometry set.

Procedure:

a) Fix the plain sheet of paper on the soft board provided.

b) Draw a line RS on the plain sheet of paper.

c) Label the midpoint of RS as N and draw a normal ANM.

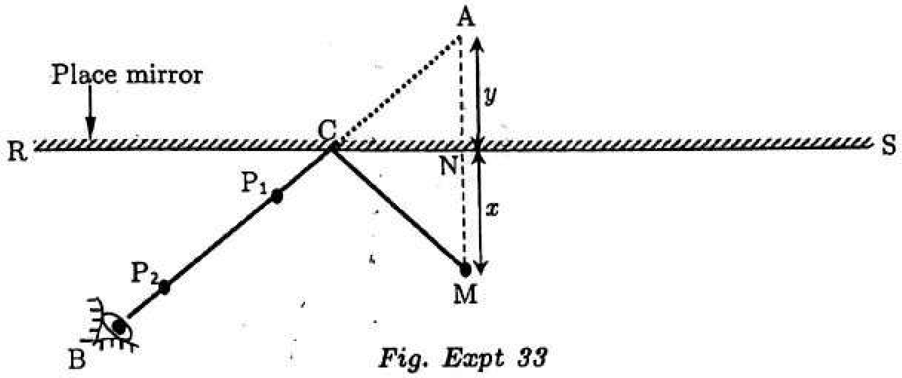

Fig. Expt 33

d) Measure the distance NM, $x = 1.5$cm and fix a pin at M.

e) Place the mirror along the mirror line RS as shown above.

f) View the image of the pin at M from the left hand side of the normal ANM and fix pins P_1 and P_2 such that they are in line with the image of the pin at M.

g) Remove the pins P_1, P_2 and the mirror from the white sheet of paper.

h) Draw a line BCA passing through the marks of pins P_1 and P_2 to meet the normal at A.

i) Measure and record the distance y between the points N and A.

j) Repeat procedures (d) to (i) for $x = 2.0$cm, 3.0cm, 4.0cm, 5.0cm, 6.0cm, 7.0cm and 8.0cm.

k) Record your results in a suitable table.

l) Plot a graph of x (along the vertical axis) against y (along the horizontal axis)

m) Find the slope S of your graph.

NB: Staple your working sheet inside the work book

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EXPERIMENT 34

In this experiment, you will investigate the relationship between the angle of rotation of a mirror and the angle of rotation of the reflected ray for a fixed point of incidence.

Apparatus:

1 plane mirror, 1 soft board, 1white sheet of paper, 4 optical pins, 4 drawing pins and a complete geometry set.

Procedure:

a) Fix the plain sheet of paper on the soft board provided.

b) Draw a line AB about 15 cm long on the plain sheet of paper.

c) Label the midpoint of AB as N.

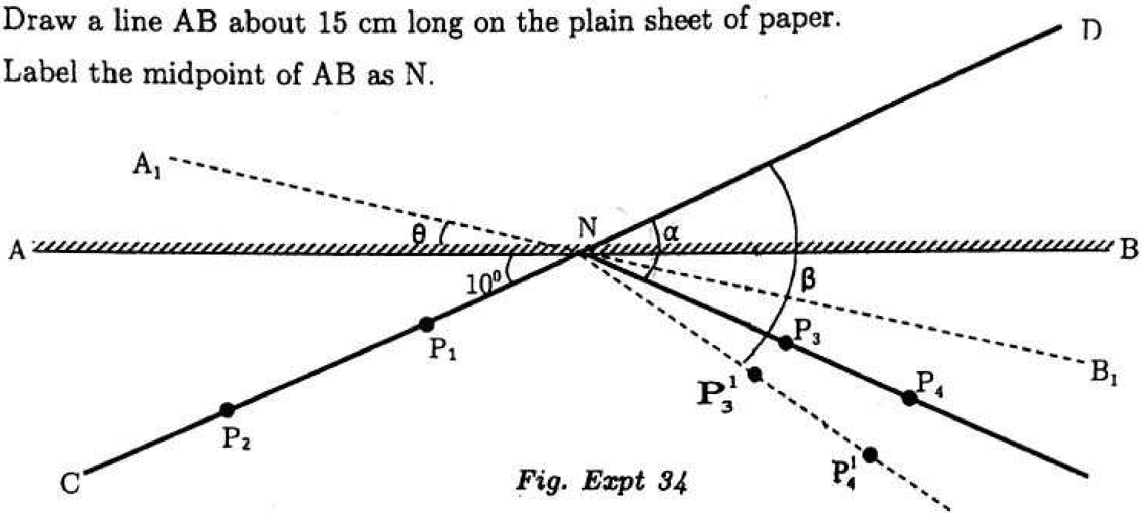

Fig. Expt 34

d) Draw a line CND at angle of 10^0 to AB.

e) Place the mirror provided along AB.

f) Stick pins P_1 and P_2 on the line CN.

g) Stick pins P_3 and P_4 such that they appear to be in line with the images of P_1 and P_2 formed by the mirror.

h) Remove the mirror. Join P_3P_4 to N.

i) Measure and record angle α.

j) Draw a line A_1NB_1 at an angle $\theta = 10^0$ to AB.

k) Place the mirror along A_1B_1. Repeat procedures (g) and (h).

l) Draw a line through points P_3^1 and P_4^1 to meet A_1B_1 at N.

m) Measure angle β.

n) Repeat procedures (j) to (m) for values of $\theta = 15^0$, 20^0, 25^0, 30^0 and 35^0.

o) Tabulate your results in a suitable table including values of (β-α).

p) Plot a graph of (β-α) (along the vertical axis) against θ (along the horizontal axis).

q) Find the slope S of your graph.

NB: Staple your working sheet inside the work book

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EXPERIMENT 35

In this experiment, you will determine the relationship between the angle of rotation of the mirror and supplement of the angle of deviation of the incident ray.

Apparatus:

1 plane mirror, plasticine, 1 white sheet of paper, 1 soft board, 3 optical pins, 4 drawing pins and a complete geometry set.

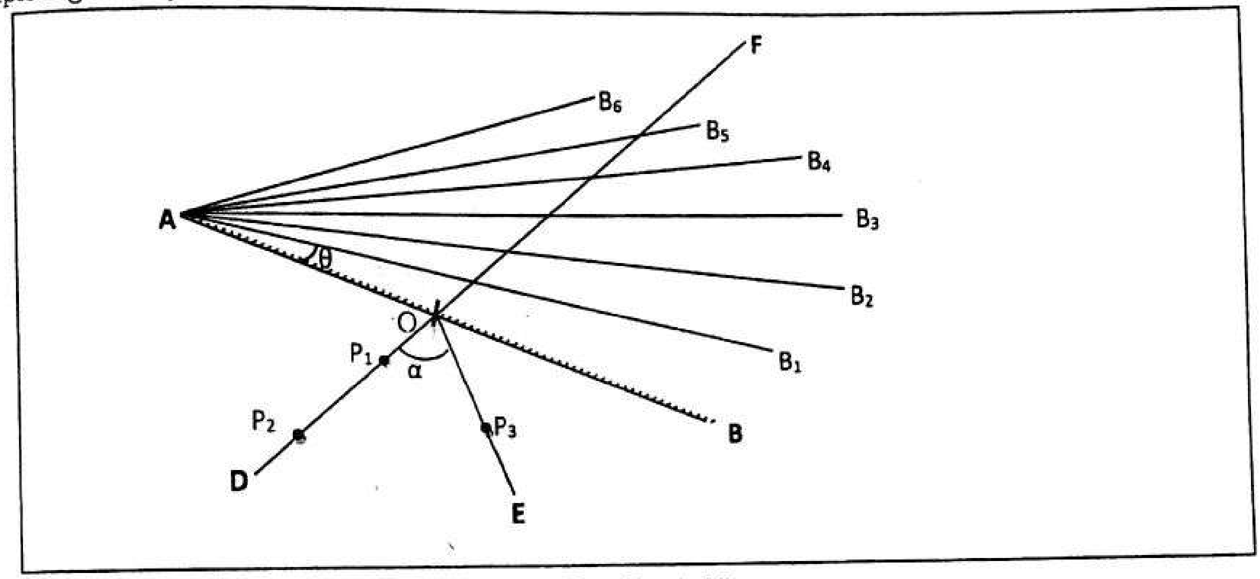

Fig. Expt 35

Procedure:

a) Fix a white sheet of paper on a board using drawing pins.

b) Draw a line AB, 10.0 cm long and about 6.0 cm from the bottom of the white sheet of paper.

c) Draw a line AB_1 making an angle $\theta = 10^0$ with AB.

d) Draw lines AB_2, AB_3, AB_4, AB_5 and AB_6 such that $\theta = 20^0, 30^0, 40^0, 50^0$ and 60^0 respectively.

e) Mark off point O on AB such that AO = 4.0 cm.

f) Draw a line DOF such that angle DOB is 100^0.

g) Place the mirror provided along AB and fix it in place using plasticine.

h) Fix pins at P_1 and P_2 on the line DO as shown in the figure above.

i) Fix a pin at P_3 such that it appears to be in line with images of the first two pins as seen through the mirror.

j) Remove the mirror.

k) Draw a line EO through P_3 to meet AB at O.

l) Measure and record angle α =DOE.

m) Repeat procedures (g) to (l) with the mirror placed along AB, AB_2, AB_3, AB_4, AB_5 and AB_6 respectively. Keep P_1 and P_2 fixed in their positions.

n) Measure and record the corresponding values of α.

o) Enter your results in a suitable table.

p) Plot a graph of θ against α.

q) Determine the slope, S, of your graph.

NB: Staple your working sheet inside the work book

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EXPERIMENT 36

In this experiment, you will investigate the relationship between the glancing angle and the angle of deviation for the ray of light incident on a plane mirror.

Apparatus:

1 plane mirror, 1 soft board, 1 white sheet of paper, 4 optical pins, 4 drawing pins and a complete geometry set.

Procedure:

a) Fix the plain sheet of paper on the soft board provided.

b) Draw a line AB about 15.0 cm long on the plain white sheet of paper.

c) Draw a line CD of length 12.0cm, perpendicular to AB such that CN is 6.0cm

d) Mark the point E on CD such that CE = h = 1.5cm

e) Join E to N and extend it backward as shown in the diagram with a dotted lines

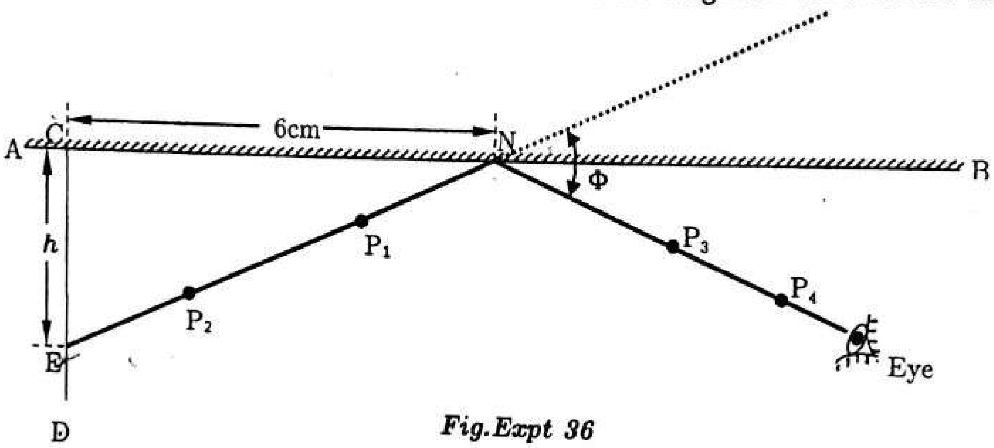

Fig.Expt 36

f) Place the mirror provided along AB.

g) Fix pins P_1 and P_2 on the line EN as shown in the diagram.

h) Stick pins P_3 and P_4 such that they appear to be in line with the images of P_1 and P_2 formed by the plane mirror.

i) Remove the mirror and draw a line through P_3 and P_4 to meet AB at N.

j) Measure and record angle Φ.

k) Repeat procedures (d) to (j) for values of h = 3.0, 4.5, 6.0, 7.5 and 9.0cm.

l) Tabulate your results in a suitable table including values of $\sin\Phi$, h^2 and x ; where $x = \dfrac{6h}{36+h^2}$.

m) Plot a graph of $\sin\Phi$ against x.

n) Find the slope S of your graph.

NB: Staple your working sheet inside the work book

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EXPERIMENT 37

In this experiment, you will verify one of the laws of reflection of light.

Apparatus:

1 plane mirror, 3 optical pins, 4 drawing pins, 1 plain white sheet of paper, 1 soft board and a complete geometry set.

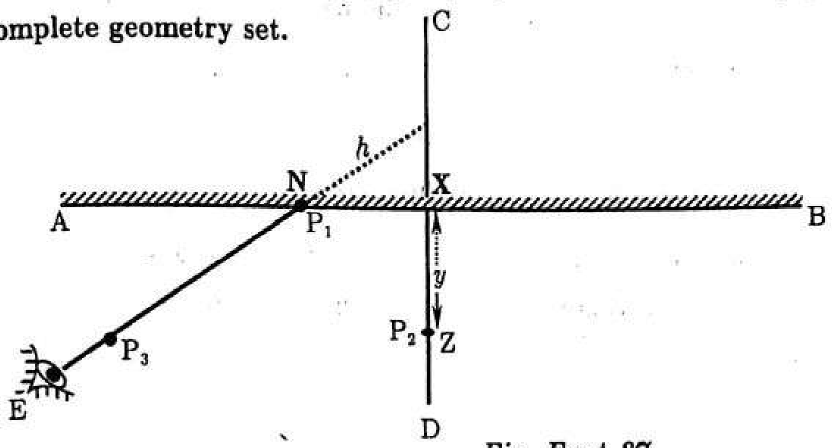

Fig. Expt 37

Procedure:

a) Draw lines AB and CD close to the center of your paper so that they are perpendicular to each other, with X as the point of intersection.

b) Mark a point N along AB so that NX is 2.0cm

c) Fix pin P_1 at N and pin P_2 at Z where $y = 1.0$cm

d) Place a mirror along AB so that it is in contact with pin P_1

e) With your eye at E, fix pins P_3 so that P_3 and P_1 appear to be in line with the image of P_2

f) Remove pins P_3, P_1 and the plane mirror

g) Draw a line through positions P_3 and P_1 to meet XC

h) Measure the length h

i) Return pin P_1 to its position N

j) Repeat procedure (c) to (h) fixing P_2 at $y = 2.0$, 3.0, 4.0, 5.0 and 6.0cm

k) Tabulate your results including values of $(h^2 - 4)^{\frac{1}{2}}$

l) Plot a graph of y against $(h^2 - 4)^{\frac{1}{2}}$

m) Find the slope of your graph.

NB: Staple your working sheet inside the work book

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EXPERIMENT 38

In this experiment, you will investigate the relationship between the number of images formed by two mirrors inclined to each other and the angle between them.

Apparatus:

2 plane mirror, 1 optical pins, 2 drawing pins, 1 plain white sheet of paper, 1 soft board and a complete geometry set.

Procedure:

(a) Fix a white sheet of paper on a soft board using drawing pins

(b) Draw a line AB, 10cm long and line BC about 10cm long such they make an angle of $\theta = 90°$ at the point of intersection as shown in the figure below.

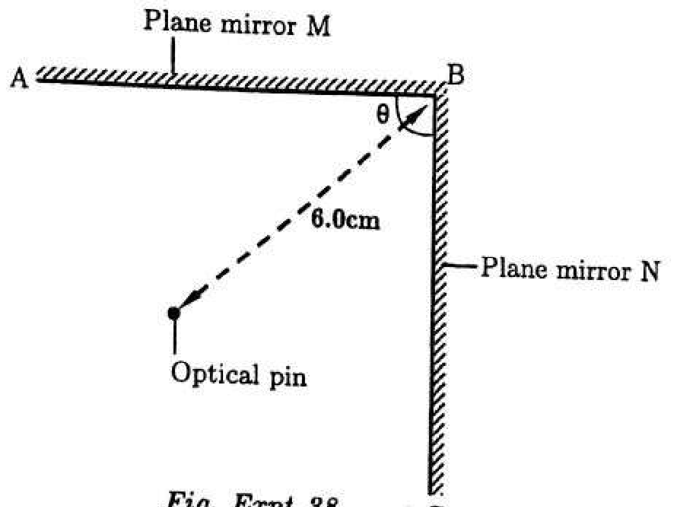

Fig. Expt 38

c) Place mirrors M and N on lines AB and BC respectively.

d) Put an optical pin a distance of about 6.0cm in front of point B.

e) While looking into the mirrors, position your eye a distance of not more than half a metre away from the mirrors. Count and record the number **n** of the images observed

f) Keeping the mirror M on the line AB, repeat procedures (b) to (e) for values of $\theta = 72°, 60°, 40°$ and $30°$.

g) Tabulate your results including values of $n\theta$ and $(n\theta + \theta)$

h) Suggest the equation relating **n** and θ, make **n** the subject.

NB: Staple your working sheet inside the work book

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EXPERIMENT 39

In this experiment, you will determine the focal length f of the concave mirror provided.

Apparatus:

2 dry cells, a double cell holder, 1 torch bulb, 1 bulb holder, 1 switch, 1 concave mirror, 1 screen with wire gauze, connecting wires, 1 metre rule and 1 screen.

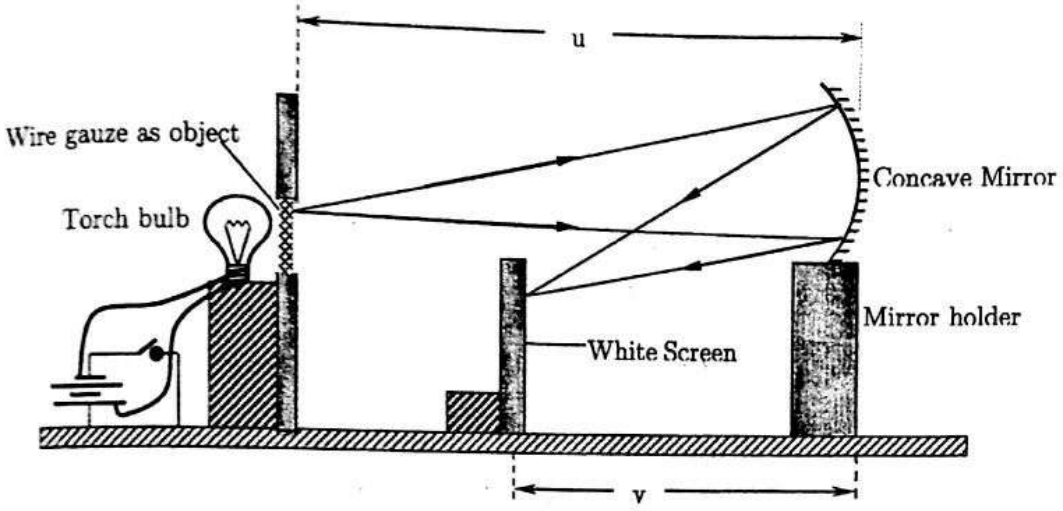

Fig. Expt 39

Procedure:

a) Connect the electrical circuit for lightning the bulb.

b) Arrange the illuminated wire gauze, the concave mirror and the white screen as shown in the figure above.

c) Move the concave mirror so that it is a distance u =15.0 cm from the object.

d) Adjust the position of the white screen until a sharply focused image I of the object appears on it.

e) Measure and record the image distance v.

f) Repeat procedures (c) to (e) for values of u = 20.0, 25.0, 30.0, 35.0 and 40.0cm.

g) Enter your results in a suitable table including values of uv and (u + v).

h) Plot a graph (u + v) (along the vertical axis) against uv (along the horizontal axis).

i) Find the slope S of the graph.

j) Calculate the focal length f from the expression: $f = \frac{1}{S}$.

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EXPERIMENT 40

In this experiment, you will determine the focal length of a concave mirror.

Apparatus:

2 dry cells, 1 double cell holder, 1 torch bulb, 1 concave mirror, 1 mirror/lens holder, 1 screen, 1 switch, connecting wires and 1 metre rule.

Procedure:

a) Arrange the touch bulb, the concave mirror and the screen as shown in the figure below.

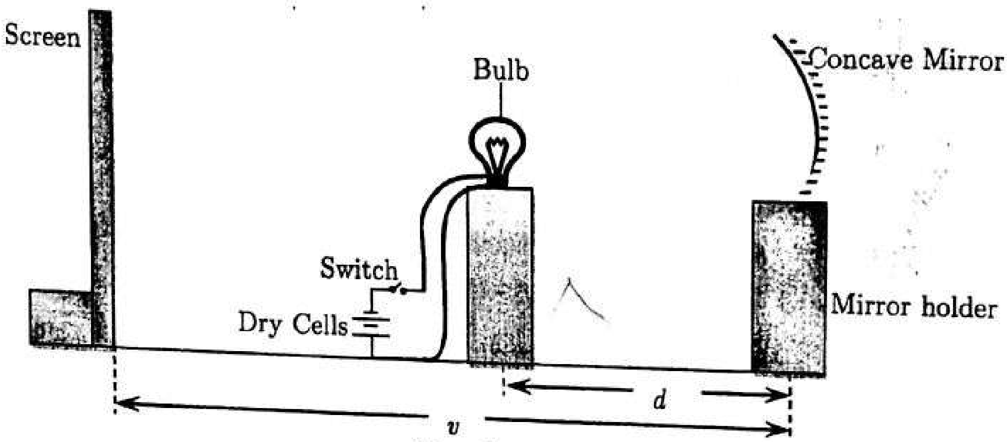

Fig. Expt 40

b) Adjust the distance d to 15.0 cm.

c) Close switch K.

d) Adjust the position of the screen to obtain a sharp image of the filament of the bulb on the screen.

e) Measure and record the distance v of the screen from the mirror.

f) Repeat the procedures (b) to (f) for values of $d = 20.0$, 25.0, 30.0, 35.0 and 40.0 cm.

g) Record your results in a suitable table including values of $\frac{v}{d}$.

h) Plot a graph of $\frac{v}{d}$ (along the vertical axis) against v (along the horizontal).

i) Find the slope S of the graph.

j) Calculate the focal length f from the expression $f = \frac{1}{S}$.

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EXPERIMENT 41

In this experiment, you will be required to determine the refractive index of glass inform of a glass block.

Apparatus:

1 glass block, 1 white sheet of paper, 4 optical pins, 4 drawing pins, 1 soft board and a complete geometry set.

Procedure:

a) Place the glass block on a plain paper on the soft board and draw its outline.

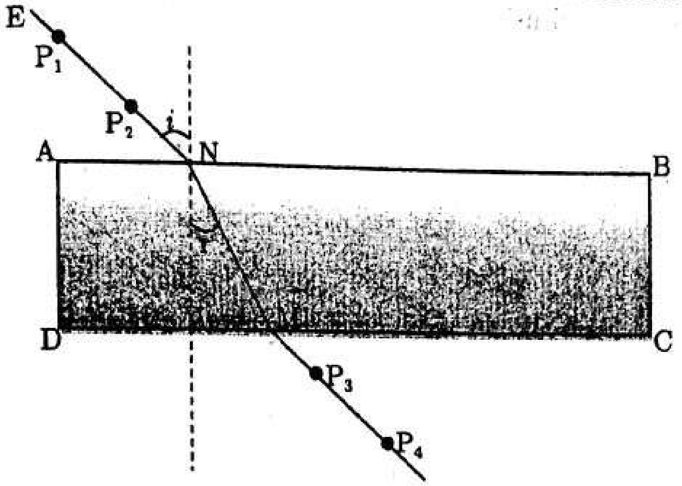

Fig. Expt 41

b) At point N, draw a normal to the face AB, 3.0 cm from A.

c) Draw a line EN at angle of incidence $i = 30^0$.

d) Stick pins P_1 and P_2 along EN such that their separation is about 5.0cm.

e) View the images of pins P_1 and P_2 from side DC of the glass block.

f) Stick pins P_3 and P_4 such that they are in line with the image of P_1 and P_2 as seen through the glass block.

g) Remove the glass block and pins. Join the positions of P_3 and P_4 to meet face DC at point M.

h) Joint point M to N. Measure and record the angle of refraction r.

i) Repeat procedures (c) to (h) for angles of incidence $i = 40^0, 50^0, 60^0$ and 70^0.

j) Tabulate your results including values of sin i and sin r.

k) Plot a graph of sin i against sin r.

l) Find the slope n of the graph which is the refractive index.

NB: Staple the tracing paper inside your work book

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EXPERIMENT 42

In this experiment you will be required to determine the width of a glass block provided.

Apparatus:

1 glass block, 1 white sheet of paper, 3 optical pins, 4 drawing pins, 1soft board and a complete geometry set.

Procedure:

a) Measure and record the width RS of the glass block.

b) Fix a plain sheet of paper on a soft board using the round bottom pins.

c) Place the glass block on a plain sheet of paper and trace its outline QRST.

d) Remove the glass block.

e) Mark a point N on QR such that QN is about 3.0 cm.

f) Draw a line NM perpendicular to QR and TS as shown in the figure below.

g) Place the glass block exactly on its outline on the plain sheet of paper on the soft board.

h) Stick a pin P_1 very close to the glass block as shown in figure below (almost at N).

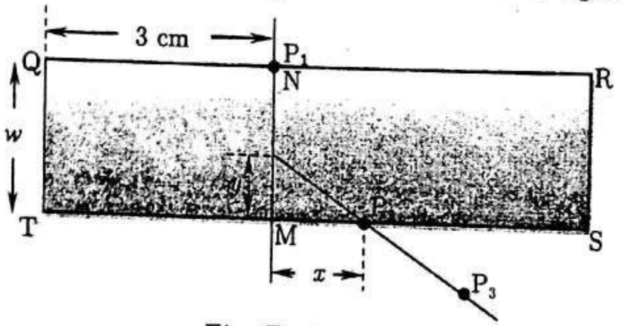

Fig. Expt 42

i) Stick another pin P_2 against the glass block on side TS at a distance $x = 2.0$cm from M.

j) Looking through side TS, stick another pin P_3 such that all the three pins appear to be in line.

k) Remove the glass block.

l) Draw a straight line through points P_2 and P_3 so that it meets the line NM.

m) Measure the distance y, from M to the point where the line through points P_3 and P_2 meets the line NM.

n) Repeat procedures (i) to (m) for values of $x = 2.5$ cm, 3.0 cm, 3.5 cm and 4.0 cm.

o) Record your results in a suitable table including values of x^2 and y^2.

p) Plot a graph of x^2 against y^2.

q) Read the value of x^2 when $y^2 = 0$ and call it x_o.

r) Calculate the width of the glass block w from the expression, $x_o = \frac{w^2}{1.25}$

NB: Staple the tracing paper inside your work book

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EXPERIMENT 43

In this experiment, you will determine the refractive index n of the material of the glass block provided.

Apparatus:

1 glass block, 1 white sheet of paper, 4 optical pins, 4 drawing pins, 1 soft board and a complete geometry set.

Procedure:

a) Fix the plain sheet of paper on a soft board using drawing pins.

b) Place the glass block on the sheet of paper so that it rests on the broader face and trace its outline ABCD.

c) Remove the glass block.

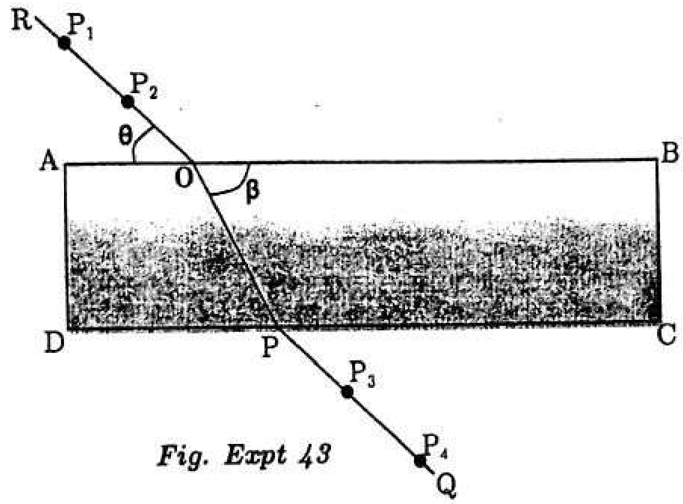

Fig. Expt 43

d) At point O about 2.0 cm from A, draw a line RO at an angle $\theta = 80^0$ to AB.

e) Fix pins P_1 and P_2 along RO and then replace the glass block onto its outline.

f) Looking through side DC, fix pins P_3 and P_4 such that they appear to be in a straight line with images of P_1 and P_2 as shown in the figure above.

g) Remove the pins and the glass block and draw a line through P_3 and P_4 to meet DC at P.

h) Join P to O.

i) Measure angle β.

j) Repeat procedures (d) to (i) for $\theta = 70^0, 60^0, 50^0, 40^0$ and 30^0.

k) Record your results in a suitable table including values of $\cos\theta$ and $\cos\beta$.

l) Plot a graph of $\cos\theta$ (along the vertical axis) against $\cos\beta$ (along the horizontal axis).

m) Find the slope 'n' of the graph.

NB: Staple the tracing paper inside your work book

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EXPERIMENT 44

In this experiment, you will determine the refractive index 'n' of the glass block provided.

Apparatus:

1 glass block, 1 white sheet of paper, 4 optical pins, 4 drawing pins, 1 soft board and a complete geometry set.

Procedure:

a) Using the drawing pins provided, fix the plain white sheet of paper on the soft board.

b) Place the glass block in the middle of the white sheet of paper and using a pencil, mark the outline PQRS of the glass block.

c) Remove the glass block. Draw a perpendicular to PQ at point B, 1.5 cm from P.

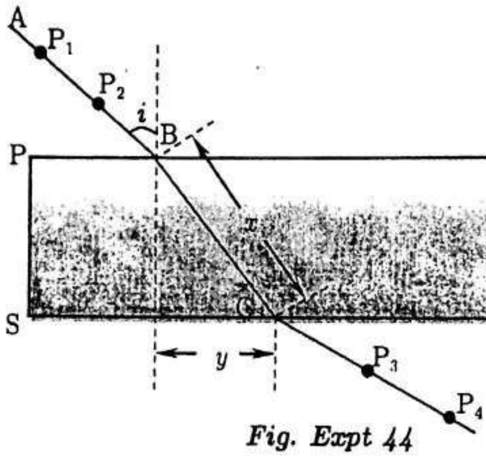

Fig. Expt 44

d) Draw a line AB such that angle $i = 10^0$.

e) Replace the glass block onto the white sheet of paper on the soft board.

f) Stick two pins P_1 and P_2 along AB. Looking through the glass block from the opposite face SR, stick two other pins P_3 and P_4 such that they appear to be in line with the images of P_1 and P_2 as seen through the glass block.

g) Remove the glass block.

h) Draw a line through P_3 and P_4 to meet SR at C.

i) Join C and B.

j) Measure and record the distance x and y.

k) Repeat procedures (d) to (j) for values for $i = 20^0, 30^0, 40^0, 50^0, 60^0$ and 70^0.

l) Enter your results in a suitable table including values of $\sin i$ and $\frac{y}{x}$.

m) Plot a graph of $\sin i$ against $\frac{y}{x}$.

n) Find the slope, n, of your graph.

NB: Staple the tracing paper inside your work book

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EXPERIMENT 45

In this experiment, you will determine the refractive index n of the material of the glass block provided.

Apparatus:

1 glass block, 1 white sheet of paper, 4 optical pins, 4 drawing pins, 1 soft board, and a complete geometry set.

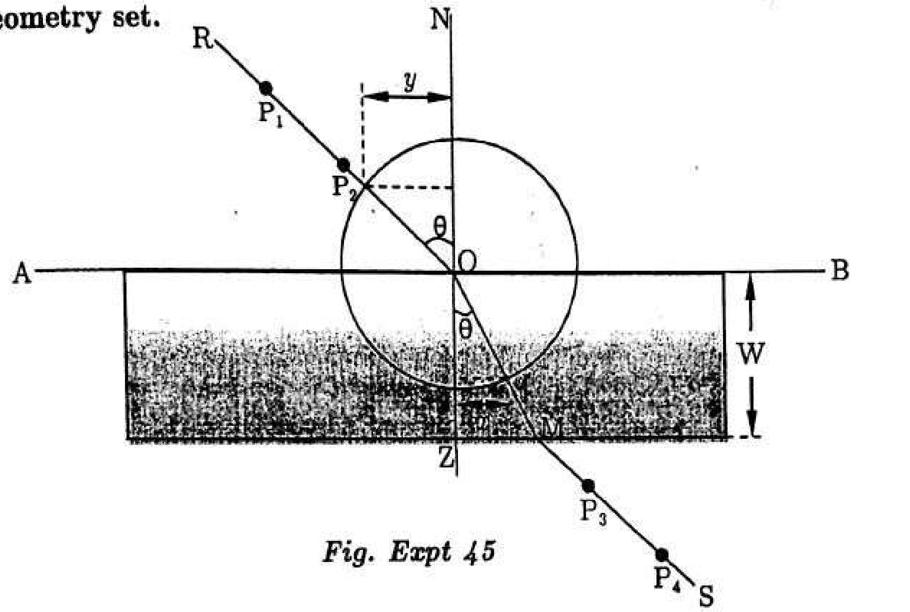

Fig. Expt 45

a) Fix the white sheet of paper on a soft board using drawing pins.

b) Draw the lines AB and NZ intersecting at right angles at O as shown above.

c) Draw a circle of radius 3.0cm having O as its centre.

d) Draw a line OA making an angle $\theta = 20^\circ$ with NZ. Fix two optical pins P_1 and P_2 along line AO.

e) Place the glass block in the middle of the paper with its longest edge along RS and trace out its outline.

f) Looking through the opposite face of the glass block, stick two other pins P_3 and P_4 such that they appear to be in line with images of pins P_1 and P_2 as seen through the glass block.

g) Remove the glass block and draw lines OM and MS.

h) Draw perpendiculars from the points where the lines RO and OM intersect the circle to the line POQ.

i) Measure and record the distances x and y.

j) Repeat procedures (d) to (i) for values of $\theta = 30^0$, 40^0, 50^0 and 60^0.

k) Enter your results in a suitable table.

l) Plot a graph of y against x.

m) Find the slope, S, of the graph.

NB: Staple the tracing paper inside your work book

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EXPERIMENT 46

In this experiment, you will determine the refractive index n of the material of the glass block provided.

Apparatus:

1 glass block, 1 white sheet of paper, 4 optical pins, 4 drawing pins, 1 soft board, and a complete geometry set.

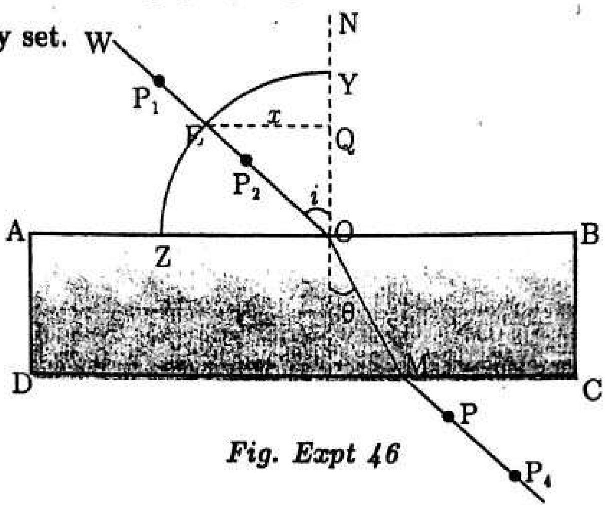

Fig. Expt 46

Procedure:

a) Fix the white sheet of paper on a soft board using drawing pins.
b) Place the glass block in the middle of the paper.
c) Trace the outline ABCD of the glass block.
d) Remove the glass block and draw the normal NO to AB.
e) With O as the centre, draw arc ZY of a circle of radius, $r = 4.0$ cm extending from the line NO to AO.
f) Draw a line WO making an angle, $i = 10^0$ with NO.
g) Replace the glass block.
h) Stick two pins P_1 and P_2 on line WO.
i) Looking through the glass block from side CD, stick two pins P_3 and P_4 such that they appear to be in line with images of pins P_1 and P_2 as seen through the glass block.
j) Remove the glass block and the pins. Draw a line through points P_3 and P_4 to meet CD at M.
k) Join O to M.
l) Measure and record angle θ.
m) Draw a line EQ normal to NO and measure its length x.
n) Repeat procedures (f) to (m) for values of $i = 20^0, 30^0, 40^0, 50^0$ and 60^0.
o) Enter your results in a suitable table including values of $\frac{x}{4}$ and $\sin\theta$.
p) Plot a graph of $\frac{x}{4}$ (along the vertical axis) against $\sin\theta$ (along the horizontal axis).
q) Find the slope n of the graph.

NB: Staple the tracing paper inside your work book

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EXPERIMENT 47

In this experiment, you will determine the refractive index n of the material of the glass block provided.

Apparatus:

1 glass block, 1 white sheet of paper, 4 optical pins, 4 drawing pins, 1 soft board, and a complete geometry set.

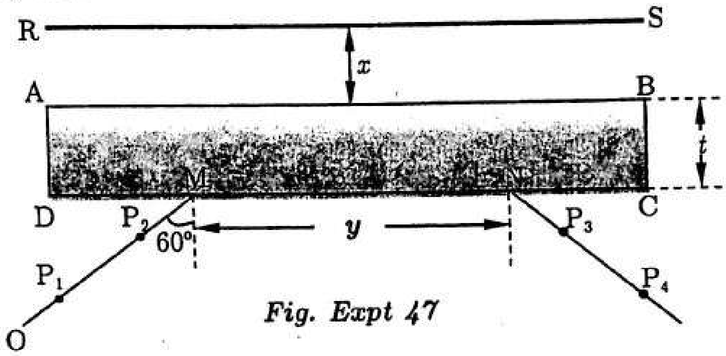

Fig. Expt 47

Procedure:

a) Fix the white sheet of paper on a soft board using drawing pins.

b) Place the slab on the piece of paper with its largest glass face facing you.

c) Trace the outline ABCD of the slab and then remove it.

d) Draw a line OM (M marked about 2cm from D) making an angle of 60^0 with the normal to DC.

e) Fix two pins P_1 and P_2 vertically on OM.

f) Draw a line RS parallel to AB at a distance $x = 1.0$.

g) Replace the slab and place a plain mirror with its reflecting face facing AB on RS as shown.

h) Looking through the face DC of the slab, fix two pins P_3 and P_4 so that they are in line with the images of P_1 and P_2.

i) Remove the slab and the mirror and draw a line through P_3 and P_4 to meet DC at N.

j) Measure the length, y, of MN.

k) Repeat procedures (f) and (j) for values of x =1.5, 2.0, 3.0, 3.5 and 4.0cm.

l) Tabulate your results including values of xy and $l = 12x^2 + y^2$

m) Plot a graph of l against xy.

n) Find the l-intercept, c, of the graph.

o) Measure the thickness, t, of the slab.

p) Calculate the refractive index, n, of the material of the slab from the expression;

$$n = \sqrt{\left(\frac{3t^2}{c} + \frac{3}{4}\right)}$$

NB: Staple the tracing paper inside your work book

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EXPERIMENT 48

In this experiment you will width, W, of the glass block provided.

Apparatus:

1 soft board, 1 white sheet of paper, 4 optical pins, 4 drawing pins, a mathematical set and 1 glass block.

Procedure:

(a) Using drawing pins fix the plain white sheet of paper provided on the soft board.

(b) Place the glass block on the sheet of paper, and trace out its outline ABCD.

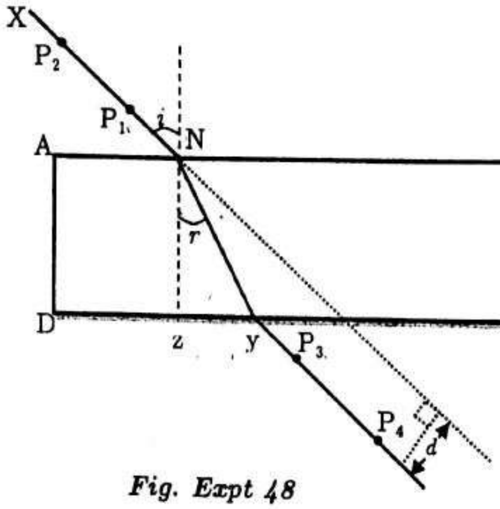

Fig. Expt 48

(c) Remove the glass block and draw the normal at N.

(d) Fix two pins, P_1 and P_2 on line XN at an angle $i = 15^0$.

(e) By using two other pins P_3 and P_4, trace the path of a ray through the glass block.

(f) Remove the glass block

(g) Measure and record the angles r and the lateral displacement d.

(h) Repeat procedure (e) to (h) for values of $i = 20^0$, 30^0, 40^0, 50^0 and 60^0.

(i) Tabulate your results including values of sin $(i\text{-}r)$ and $d\cos r$.

(j) Plot a graph of $d\cos r$ against sin $(i\text{-}r)$

(k) Find the slope, W, of your graph.

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EXPERIMENT 49

In this experiment, you will determine the refractive index 'n' of the glass block provided.

Apparatus:

1 glass block, 1 white sheet of paper, 4 optical pins, 4 drawing pins, 1 soft board and a complete geometry set.

Procedure:

a) Using the drawing pins provided, fix the plane white sheet of paper on a soft board.

b) Place the glass of block in the middle of the white sheet of paper and using a pencil, mark the outline PQRS of the glass block.

c) Remove the glass block. Draw a perpendicular to PQ at point A, 1.5 cm from P to meet SR at B.

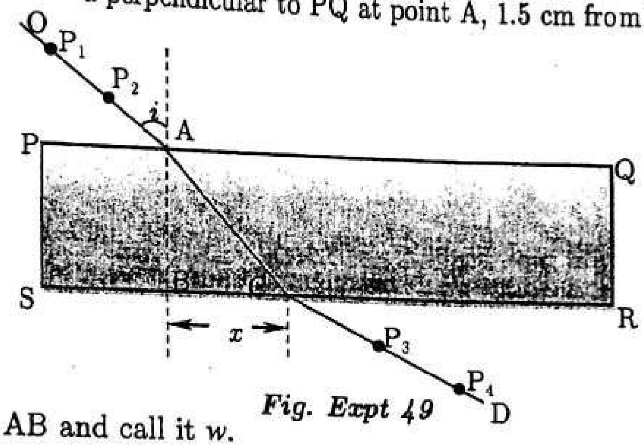

Fig. Expt 49

d) Measure the distance AB and call it w.

e) Draw a line OA such that angle $i = 10^0$.

f) Replace the glass block onto the white sheet of paper on the soft board.

g) Stick two pins P_1 and P_2 along OA and looking through the glass block from the opposite face SR, stick two other pins P_3 and P_4 such that they appear to be in line with the images of P_1 and P_2. Remove the glass block and the four pins from the soft board.

h) Draw a line DC through points P_3 and P_4 to meet SR at D.

i) Measure and record the distance x.

j) Repeat procedures (e) to (i) for values for $i = 20^0, 25^0, 30^0, 35^0, 40^0$ and 45^0.

k) Enter your results in a suitable table including values of $\frac{1}{\sin^2 i}$ and $\frac{1}{x^2}$.

l) Plot a graph of $\frac{1}{\sin^2 i}$ against $\frac{1}{x^2}$.

m) Find the slope, S, of your graph.

n) Calculate the refractive index, n, of the glass block from the relation $n = \left(\frac{w^2}{S}\right)^{\frac{1}{2}}$;

where w is the width of the glass block.

NB: Staple the tracing paper inside your work book

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EXPERIMENT 50

In this experiment, you will determine the constant, *W*, of the glass block provided.

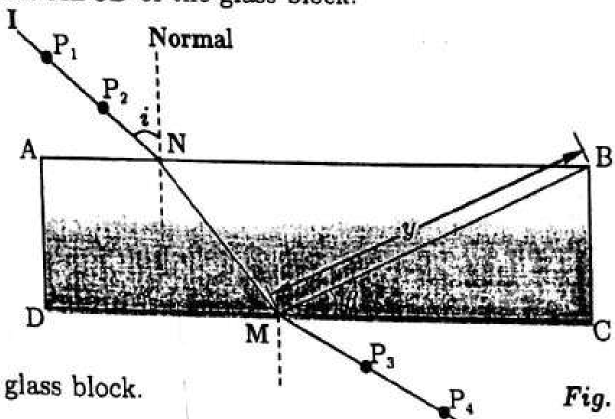
Apparatus:

1 glass block, 1 white sheet of paper, 4 optical pins, 4 drawing pins, 1 soft board and a complete geometry set.

(a) Fix a white sheet of paper on the soft board using drawing pins.

(b) Place the glass block with its broad face upper most on the white paper.

(c) Trace the outline ABCD of the glass block.



(d) Remove the glass block.

Fig. expt 50

(e) Draw a normal at N, on AB such that AN = 2.0 cm.

(f) Draw line IN such that angle $i = 10°$.

(g) Fix pins P_1 and P_2 vertically along IN.

(h) Replace the glass block onto its outline.

(i) Looking through the glass block on side DC, stick two other pins P_3 and P_4 such that they are in line with the images of P_1 and P_2.

(j) Remove the glass block.

(k) Draw a line through P_3 and P_4 to meet DC at M.

(l) Join M and B.

(m) Measure and record length, y and angle β as shown in the figure above.

(n) Repeat procedures (f) to (m) for $i = 20, 30, 40, 50$ and $60°$.

(o) Record your results in a suitable table including values of $\sin \beta$ and $\frac{1}{y}$.

(p) Plot a graph of **$\sin \beta$ (along the vertical axis)** against $\frac{1}{y}$ **(along the horizontal axis)**.

(q) Find the slope, ***W***, of the graph.

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EXPERIMENT 51

In this experiment, you will determine the refractive index 'n' of the glass block provided.

Apparatus:

1 glass block, 1 plain white sheet of paper, 4 optical pins, 4 drawing pins, 1 soft board and a complete geometry set.

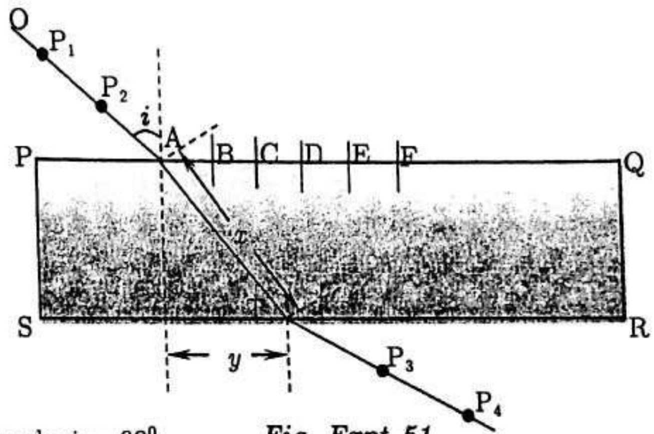
Procedure:

a) Using the drawing pins provided, fix the plain white sheet of paper on a soft board.

b) Place the glass block in the middle of the white sheet of paper and using a pencil, draw its outline PQRS.

c) Remove the glass block and mark 6 points A, B, C, D, E and F such that they are 1.0cm from each other and with A, 2.0cm from P.

d) Draw a normal at A.



e) Draw a line OA such that angle $i = 60^0$.

Fig. Expt 51

f) Replace the glass block on its outline PQRS.

g) Stick two pins P_1 and P_2 along OA.

h) Looking through the glass block from the opposite face SR, stick two other pins P_3 and P_4 such that they appear to be in line with the images of P_1 and P_2 as seen through the glass block. Remove the glass block and the pins.

i) Draw a line through P_3 and P_4 to meet SR at T. Join A and T.

j) Measure and record the distances x and y.

k) Repeat procedures (d) to (j) for values of $i = 50^0, 40^0, 30^0, 20^0$ and 10^0 respectively at B, C, D, E and F each time drawing a normal at the respective point.(each angle should be measured at the respective point)

l) Enter your results in a suitable table including values of $\sin i$ and $\frac{y}{x}$.

m) Plot a graph of $\sin i$ against $\frac{y}{x}$.

n) Find the slope, n, of your graph.

NB: Staple the tracing paper inside your work book

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EXPERIMENT 52

In this experiment, you will determine the refractive index 'n' of the glass block provided.

Apparatus:

1 glass block, 1 plain white sheet of paper, 4 optical pins, 4 drawing pins, 1 soft board and a complete geometry set.

Procedure:

a) Fix the plain white sheet of paper on a soft board using the drawing pins provided.

b) Place the glass block in the middle of the white sheet of paper and trace its outline ABCD as shown below

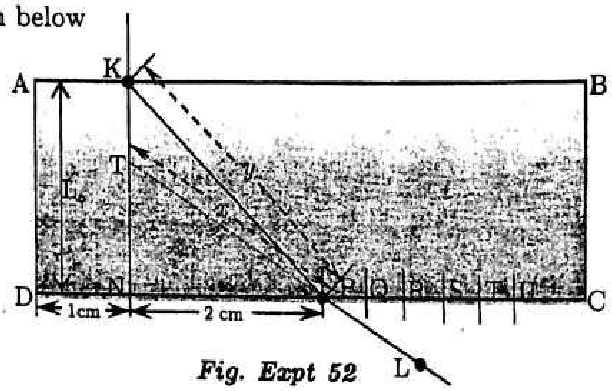

Fig. Expt 52

c) Remove the glass block and mark a point K on AB such that AK = 1.0cm.

d) Draw a normal at K to cut DC at N. Measure and record L_o, the length of KN.

e) Mark a point P on DC such that DP = 3.0cm. Mark also points Q, R, S, T and U at equal intervals of 1.0cm. Replace the glass block.

f) Fix a pin vertically at point K in contact with the edge of the glass block.

g) Fix a second pin vertically at P. looking through the glass block on side CD, fix a third pin L such that pins L and P appear to be in line with the image of pin K as seen through the glass block.

h) Remove the glass block and the pins. Join L to P and produce LP to cut line KN at T.

i) Join K to P.

j) Measure and record the lengths x and y.

k) Keeping the first pin fixed at K, repeat the experiment with the second pin at the positions Q, R, S, T and U.

l) Record your results in a suitable table.

m) Plot a graph of y against x.

n) Find the slope S of your graph.

o) From your graph find the value of x when $y = L_o$.

NB: Staple the tracing paper inside your work book

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EXPERIMENT 53

In this experiment, you will use a cylindrical vessel (e.g beaker) filled with water as a lens to compare its radius with the effective focal length.

Apparatus:

2 dry cells, 1 double cell holder, 1 torch bulb, a bulb holder, 1 switch, 1 beaker, water (about 300ml), plasticine, connecting wires, 1 metre rule and 1 screen.

Procedure:

a) Add 250ml of water to the vessel and obtain h, the height in cm of water above the base of the vessel.

b) Calculate an approximate value of R the internal radius in cm, from the formula; $R = \sqrt{\frac{80}{h}}$.

c) Fill the vessel with water and stand it on the metre rule using plasticine as shown in the figure below

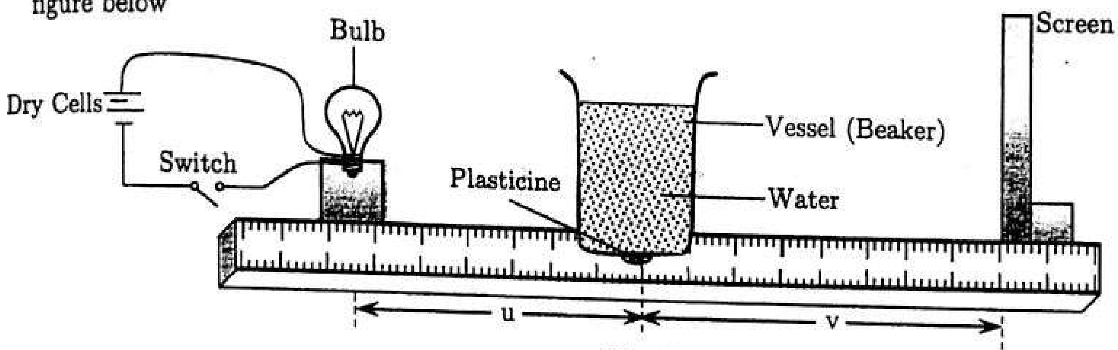

Fig. Expt 53

d) Place the lamp/bulb which acts as an object, about 10R cm away from the center of the lens.

e) Adjust the position of the beaker until a clear image is formed on the screen as shown in the figure above. The image formed is a sharp vertical line.

f) Measure the object distance, u, and the corresponding object distance v, both measured from the center of the vessel.

g) Record your results in a suitable table.

h) Repeat procedures (d) to (f) for u = 8R, 6R, 5R, and 3R.

i) Plot a graph of u against v.

j) From the graph, determine v^{l} the value of v for which v = u and u^{l} the value of u for which u = 2v.

k) Calculate, f, the effective focal length of the lens from the formula; $f = \frac{u^{l} + v^{l}}{5}$.

l) Find the approximate value of $\frac{R}{f}$

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EXPERIMENT 54

In this experiment, you will determine the relationship between the image distance and the diameter of the beaker provided.

Apparatus:

2 dry cells, 1 double cell holder, 1 torch bulb, a bulb holder, 1 switch, 1 beaker, water, 1 screen with wire gauze, connecting wires, 1 metre rule and 1 screen.

Procedure:

a) Measure and record the external diameter, D, of the beaker provided.

b) Place the screen and the object (wire gauze illuminated with a lamp) at a distance X = 8D.

c) Place the beaker containing water between the screen and the illuminated object as shown in the figure below.

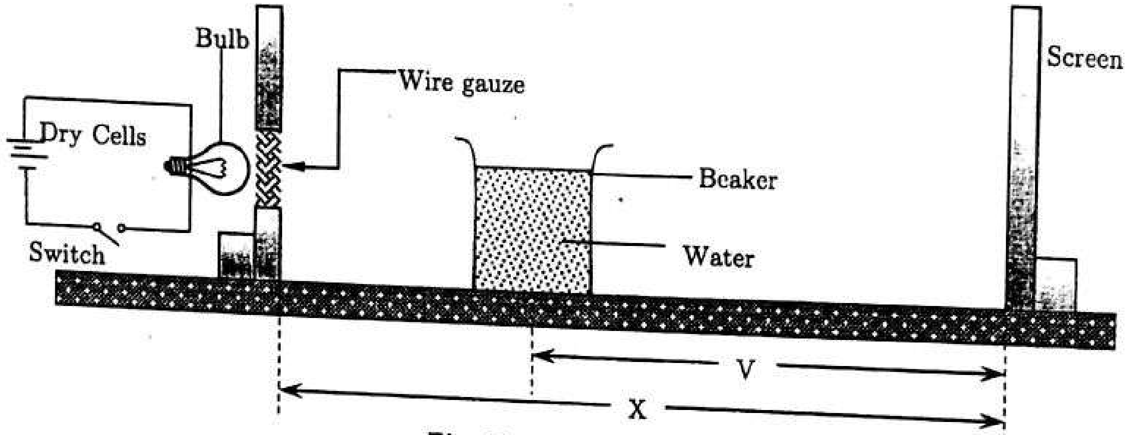

Fig. Expt 54

d) Adjust the position of the beaker to obtain a clear diminished image.

e) Measure and record the distance, V, of the centre of the beaker from the screen.

f) Repeat procedures (b) to (e) for X = 7.5D, 7.0D, 6.5D, 6.0D and 5.5D.

g) Record your results in a suitable table, including values of $\frac{V^2}{X}$

h) Plot a graph of $\frac{V^2}{X}$ against V.

i) Read and record the value V_0 when $\frac{V^2}{X} = 0$

j) Determine the value of $\frac{V_0}{D}$.

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EXPERIMENT 55

In this experiment, you will determine the focal length of a diverging lens using a converging lens.

Apparatus:

2 dry cells, 1 double cell holder, 1 torch bulb, a bulb holder, 1 switch, 1 lens, water, 1 screen with wire gauze, connecting wires, 1 metre rule and 1 screen.

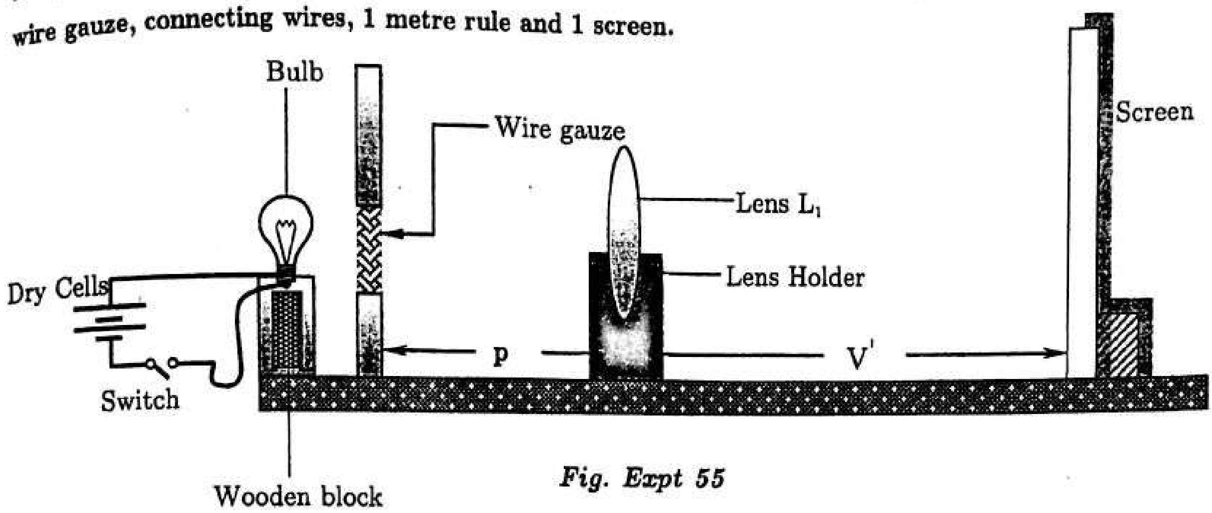

Fig. Expt 55

(a) Align the screen, lens L_1, and the illuminated wire gauze such that the centres of the lens and the gauze are at the same height above the bench and lie in a straight line as shown above.

(b) Place the illuminated wire gauze at a distance **p** = 20cm from lens, L_1.

(c) Close switch, K.

(d) Adjust the position of the white screen to obtain a sharp image of the wire gauze on it.

(e) Measure and record the distance, V' of the screen from lens, L_1.

(f) Place the diverging lens, L_2 (between L_1 and the screen) at a distance x = 8cm from lens, L_1, ensuring that its centre is in line with that of L_1.

(g) Keeping the distance, **p**, the same, adjust the position of the white screen until a sharp image is again formed on it.

(h) Measure ad record the distance, V, of the white screen from lens, L_2.

(i) Repeat procedure (f) to (h) for values of x = 9, 10, 11, 12 and 13cm.

(j) Tabulate your results including values of $U = (V' - x)$, VU and (V - U).

(k) Plot a graph of (V - U) **(along the vertical axis)** against UV **(along the horizontal axis)**

(l) Find the slope, S, of the graph.

(m) Calculate the focal length , f, of the diverging lens L_2 from $f = \frac{1}{S}$

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EXPERIMENT 56

In this experiment, you will determine the refractive index of glass.

Apparatus:

2 dry cells, 1 double cell holder, 1 torch bulb, 1 bulb holder, 1 switch, 1 lens, 1 glass block, 1 screen with wire gauze, connecting wires, 1 metre rule and 1 screen.

Procedure:

a) Measure and record the width of the glass block.

b) Read and the focal length, f, of the lens provided.

c) Arrange the bulb, the wire gauze, the lens and the screen as shown in the figure below such that $u = 1.5f$.

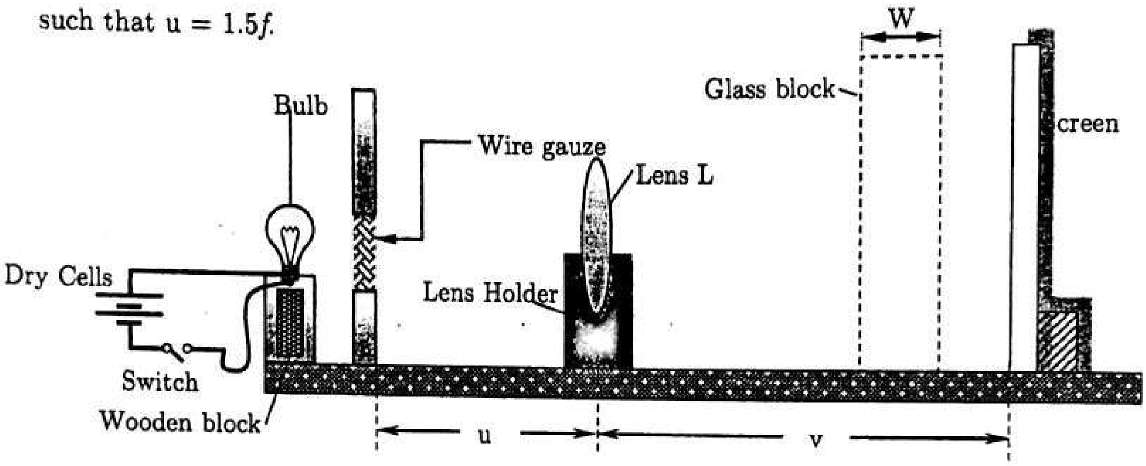

Fig. Expt 56

d) Close switch, K, and adjust the position of the screen until a sharp image of the cross wires is formed on it.

e) Measure and record the distance v between the screen and the lens.

f) Place the glass block between the lens and the screen as shown in the figure above. Close the switch.

g) Move the screen until another clear image of the gauze is obtained. Open the switch.

h) Measure and record the new distance V^{l} between the lens and the screen. Remove the glass block.

i) Repeat procedures (d) to (h) for values of $u = 2.0f$, $2.5f$, 3.0 and $4.0f$.

j) Enter your results in a suitable table.

k) Plot a graph of V against V^{l}.

l) Use your graph to find the value of V when V^{l} is equal to $2f$. Call this value P.

m) Calculate the refractive index n of the glass from the equation; $n = \frac{W}{W+P-2f}$.

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EXPERIMENT 57

In this experiment, you will determine the focal length f of the converging lens provided.

Apparatus:

2 dry cells, 1 double cell holder, 1 torch bulb, a bulb holder, 1 switch, 1 lens, water, 1 screen with wire gauze, connecting wires, 1 metre rule and 1 screen.

Procedure:

a) Mount the lens provided in a lens holder and place it to face a window.

b) Place the screen behind the lens and adjust it until a clear image of a distant object is obtained.

c) Measure and record the distance x between the lens and the screen.

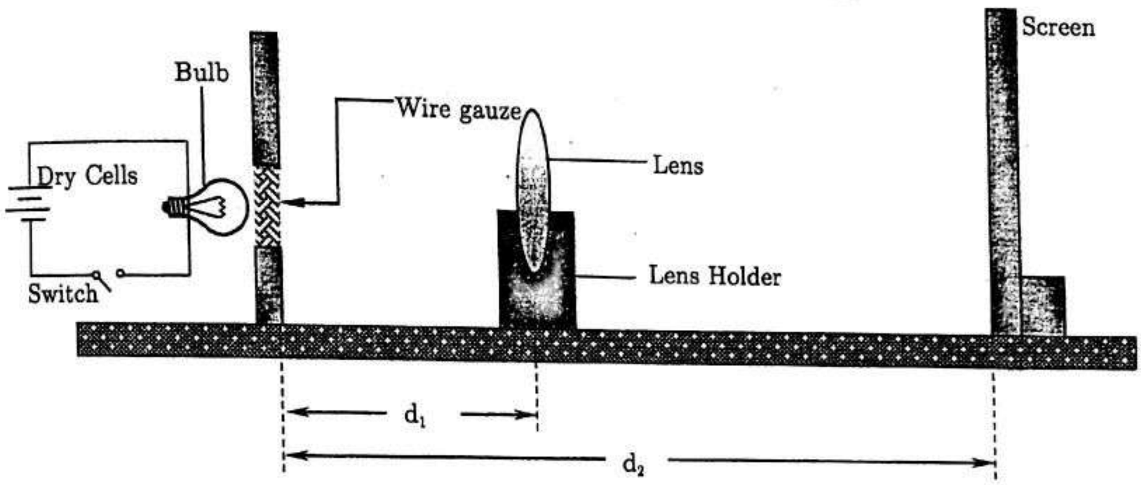

Fig. Expt 57

d) Arrange the bulb, wire gauze, lens and screen as shown in the figure above.

e) Adjust the lens so that the distance d_1 between the wire gauze and the lens is equal to $4.5x$.

f) Close the switch and move the screen until a clear image of the wire gauze is obtained on the screen.

g) Measure and record the distance d_2 between the wire gauze and the screen.

h) Repeat procedures (e) to (g) for values of $d_1 = 4.0x$, $3.5x$, $3.0x$ and $2.5x$.

i) Record your results in a suitable table including values of $(d_2 - d_1)$.

j) Plot a graph of d_1 against $(d_2 - d_1)$

k) From your graph find the minimum value of d_2 and call it d.

l) Calculate f from the formula, $f = \frac{d}{4}$.

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EXPERIMENT 58

In this experiment, you will determine the focal length of the converging lens L provided.

Apparatus:

2 dry cells, 1 double cell holder, 1 torch bulb, 1 bulb holder, 1 switch, 1 lens, and water, 1 screen with wire gauze, connecting wires, 1 metre rule and 1 screen.

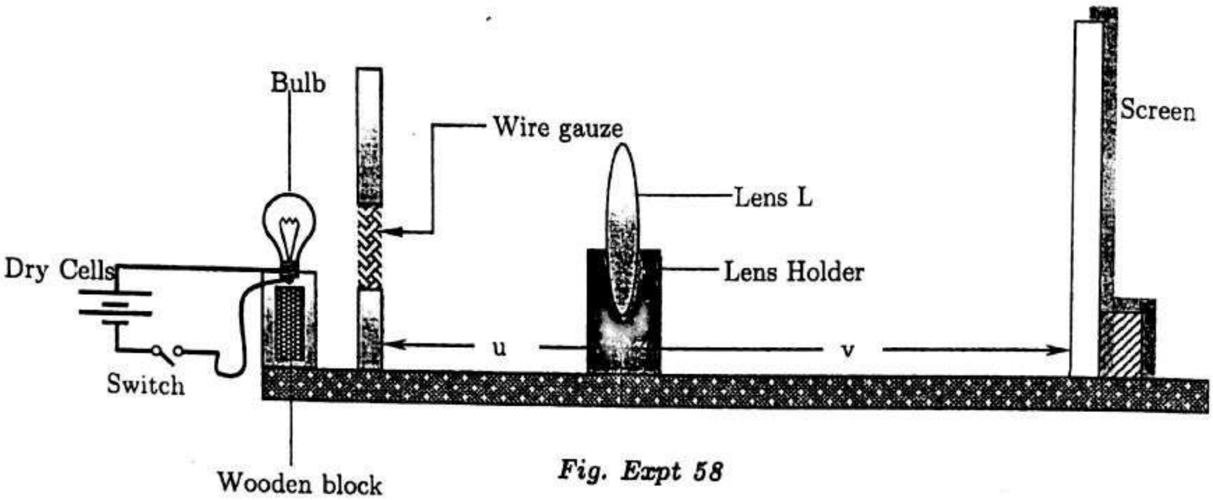

Fig. Expt 58

Procedure:

a) Connect the bulb, the dry cells and the switch K in series.

b) Arrange the bulb, the lens and the screen as shown in the figure above.

c) Adjust the distance u between the wire gauze and the lens L to 70 cm.

d) Close switch K.

e) Adjust the position of the screen to obtain a sharp image of the cross wires on it.

f) Measure and record the distance v between the screen and the lens.

g) Open the switch.

h) Repeat procedures (c) to (g) for values of u = 60, 50, 40, 30 and 20 cm.

i) Enter your results in a suitable table including values of $\frac{u}{v}$.

j) Plot a graph of $\frac{u}{v}$ against u.

k) Read and record the intercept C on the u-axis.

l) Find the slope S of the graph.

m) Calculate the focal length f of the lens from the expression: $f = \frac{1}{S}$.

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EXPERIMENT 59

In this experiment, you will determine the focal length of the converging lens provided.

Apparatus:

2 dry cells, a double cell holder, 1 torch bulb, 1 bulb holder, 1 switch, 1 lens, 1 screen with wire gauze, connecting wires 1 metre rule and 1 screen.

Procedure:

a) Fix the lens in the lens holder provided.

b) Switch on the bulb to illuminate the wire gauze.

c) Adjust the position of the screen so that it is at a distance $y = 90.0$cm from the gauze.

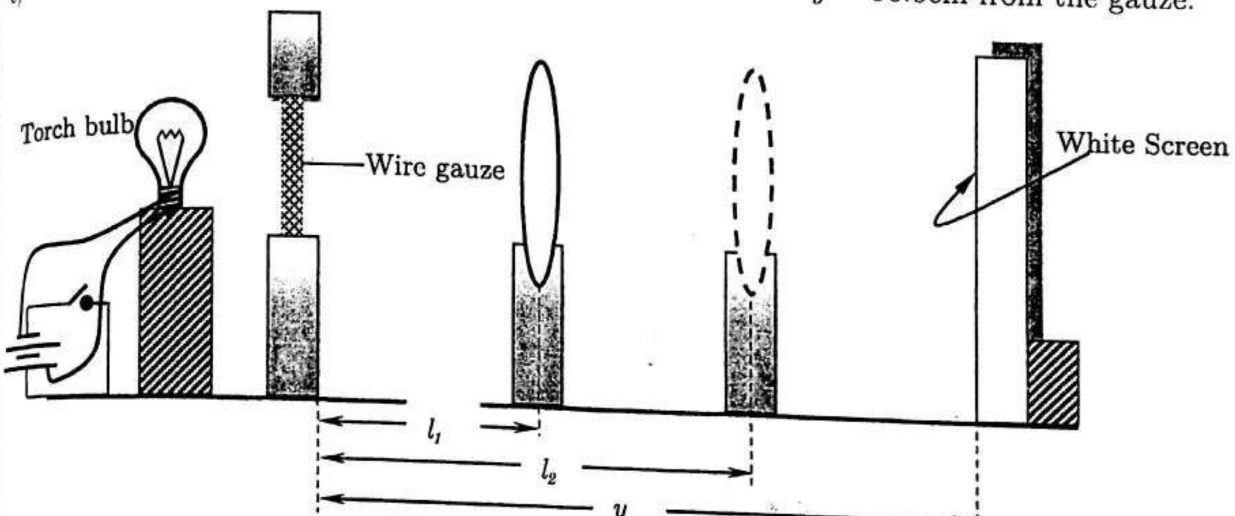

Fig. Expt 59

d) Place the lens between the gauze and the screen such that it's near the gauze.

e) Adjust the position of the lens to obtain a clear image of the wire gauze on the screen as shown in the figure above.

f) Measure and record the distance l_1 of the lens from the gauze.

g) Keeping the gauze and screen fixed, move the lens toward the screen to obtain a diminished image on the screen.

h) Measure and record the distance l_2 of the lens from the wire gauze.

i) Find the distance $x = l_2 - l_1$.

j) Repeat procedures (c) to (i) for values of $y = 85.0, 80.0, 75.0, 70.0$ and 65.0 cm.

k) Record your results in a suitable table including values of $\frac{x^2}{y}$.

l) Plot a graph of y against $\frac{x^2}{y}$.

m) Find the intercept, c, on the y-axis of the graph.

n) Calculate the focal length, f from the expression, $f = \frac{c}{4}$.

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EXPERIMENT 60

In this experiment you will determine the focal length of the lens provided.

Apparatus:

1 convex lens, 1 white screen, 2 dry cells in a cell holder, 1 torch bulb in bulb holder and wire gauge fixed in a vertical board with a hole.

Procedure:

a) Focus a distant object onto the screen.

b) Measure and record the distance, F, between the lens and the screen.

c) Arrange the apparatus as shown in the figure below.

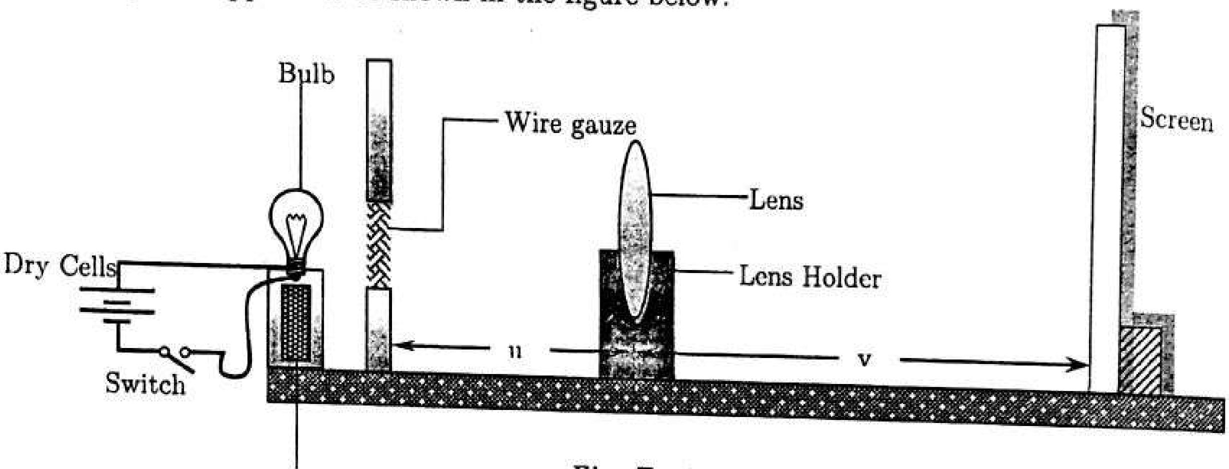

Fig. Expt 60

d) Starting with u = 1.5F adjust the position of screen to obtain a sharp image of wire gauze on the screen.

e) Measure and record the image distance v.

f) Repeat procedures (d) and (e) for values of u = 2.0F, 2.5F, 3.0F, 3.5F, 4.0F and 4.5F.

g) Tabulate your results in a suitable table including values (u+v).

h) Plot a graph of (u+v) against u.

i) Find the minimum value W of (u+v).

j) Find the focal length f of the lens from the expression, $W = 4f$.

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EXPERIMENT 61

In this experiment, you will determine the focal length, f, of the lens provided.

Apparatus:

1 convex lens (f =10cm), 1 white screen, 1 manila card, 4 pieces of sellotape, 1 metre rule, 2 dry cells in a cell holder, 1 torch bulb in bulb holder and wire gauge fixed in a vertical board with a hole.

Procedure:

(a) Fix the manila card provided on the table using sellotape.

(b) Fix the base of the lens holder exactly on the line passing through the mid-point of the manila card as shown in the figure below.

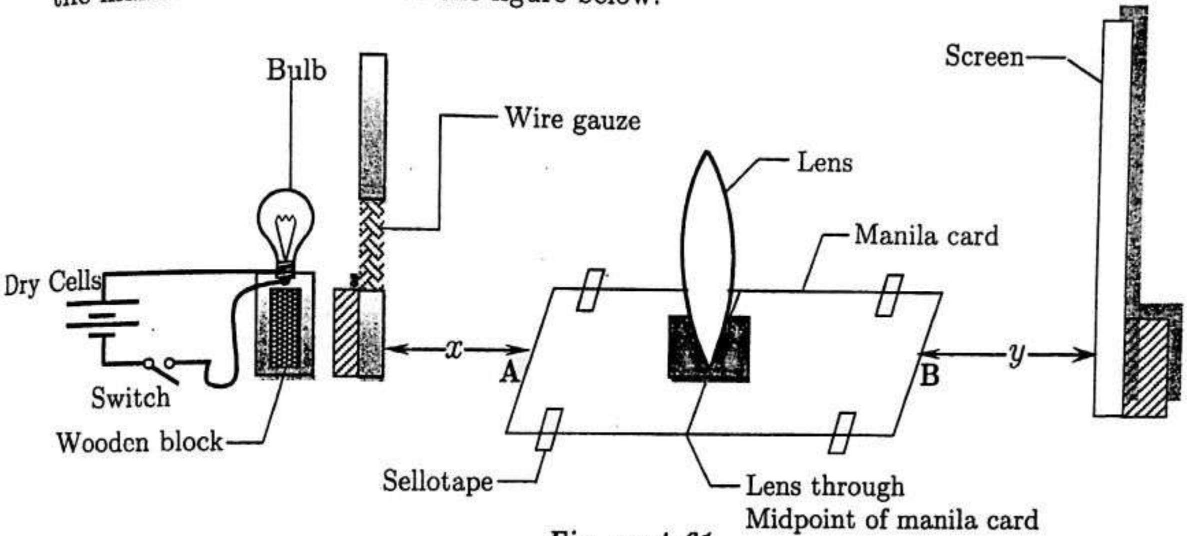

Fig. expt 61

(c) Align the screen, lens and illuminated wire gauze such that the centres of the lens and the gauze are the same height above the table and in a straight line.

(d) Place the wire gauze object at a distance x = **2.5 cm** from the edge A of the manila card.

(e) Move the screen to obtain a clear image of the object on the screen.

(f) Record the distance, y, of the screen from edge, B, of the manila card.

(g) Repeat procedures (d) to (f) for values of x = 5.0, 7.5, 10.0, 12.5 and 15.0 cm.

(h) record your results in a suitable table including values of $\frac{1}{y}$.

(i) Plot a graph of $\frac{1}{y}$ **(along the vertical axis)** against x **(along the horizontal axis)**

(j) Find the slope, S, of the graph

(k) Find the focal length, f, from the expression $S = \frac{1}{f^2}$.

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EXPERIMENT 62

In this experiment, you will determine the refractive index 'n' of the material of glass using a glass prism.

Apparatus:

1 equilateral glass prism, 1 soft board, 1 white sheet of paper, 4 optical pins, 4 drawing pins and a complete geometry set.

Procedure:

a) Place the glass prism on a white sheet of paper on the soft board and draw its outline. Label the vertices A, B and C as shown in the diagram below.

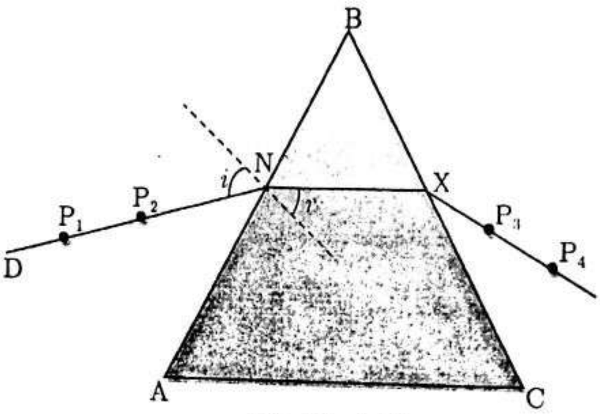

Fig. Expt 62

b) At point N, 2.0 cm from the vertex B, draw its normal to the line AB.
c) Draw a line DN at an angle of incidence $i = 30^0$.
d) Stick pins P_1 and P_2 about 5.0 cm apart on the line DN.
e) Place the prism back onto the the white sheet of paper with its faces exactly matching with lines and the vertex as in (a) above. View images of pins P_1 and P_2 along the face BC.
f) Stick pins P_3 and P_4 about 5.0 cm apart such that pins P_3 and P_4 are collinear with the images of pins P_1 and P_2.
g) Remove the pins and the prism. Draw a line through the marks of pins P_3 and P_4 and join point X to point N. Measure and record angle r.
h) Repeat procedure (c) to (g) for values of angle $i = 40^0, 50^0, 60^0$ and 70^0.
i) Tabulate your results in a suitable table including values of $\sin i$ and $\sin r$.
j) Plot a graph of $\sin i$ against $\sin r$
k) Find the slope n of the graph.

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EXPERIMENT 63

In this experiment, you will determine the refractive index, n, of the material of a glass prism.

Apparatus:

1 equilateral glass prism, 1 soft board, 1 white sheet of paper, 4 optical pins, 4 drawing pins and a complete geometry set.

Procedure:

a) Place the glass prism on a white sheet of paper on the soft board and draw its outline.

b) Remove the glass prism and label the outline ABC as shown in the diagram below.

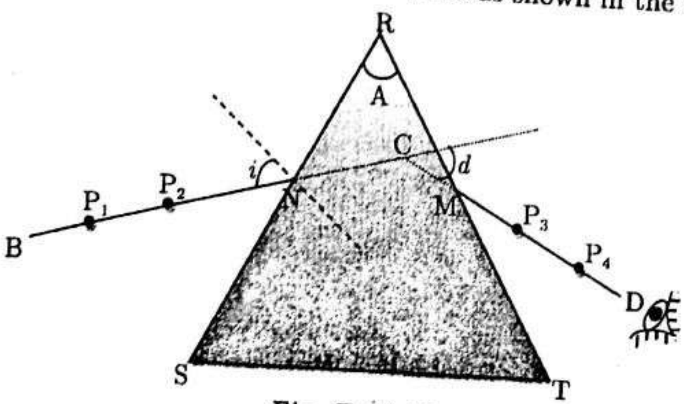

Fig. Expt 63

c) Draw a normal at point N, 2.0cm from the vertex R.

d) Draw a line BN such that the angle of incidence, $i = 30^0$.

e) Stick pins P_1 and P_2 about 3.0cm apart on the line BN and replace the glass prism.

f) Looking through side RT of the prism, fix pins P_3 and P_4 such that they appear to be in line with the images of pins P_1 and P_2 as seen through the glass prism.

g) Remove the pins and prism and draw a line DM through the marks of pins P_3 and P_4 to meet RT at M.

h) Produce lines BN and DM to meet at C.

i) Measure and record angle *d*.

j) Repeat procedure (d) to (i) for values of angle $i = 40^0, 50^0, 60^0, 65^0$ and 70^0.

k) Tabulate your results in a suitable table.

l) Plot a graph of *d* against *i*.

m) From your graph find the minimum value of *d* (call it d_{min}) and the corresponding value of *i*.

n) Measure and record the angle A from your tracing paper.

o) Calculate the refractive index of the material of glass from the expression; $n = \frac{sin\left(\frac{D+A}{2}\right)}{sin\left(\frac{A}{2}\right)}$

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EXPERIMENT 64

In this experiment, you will determine the refractive angle A of a triangular glass prism.

Apparatus:

1 Soft board, a white sheet of paper, 4 optical pins, 4 drawing pins, 1 equilateral prism and a mathematical set.

Procedure:

(a) Fix a plane sheet of paper on a soft board using drawing pins or sellotape.

(b) Place the glass prism on the sheet of paper and trace out its outline as shown in the figure below.

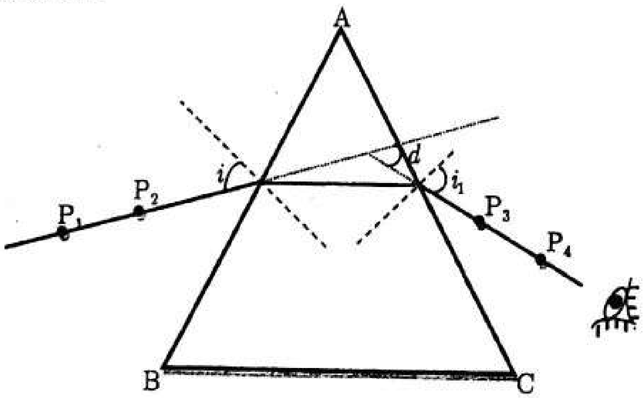

Fig. Expt 64

(c) Place the optical pin P_1 and P_2 such that the angle i is 30°

(d) Observe pins P_1 and P_2 through face AC and place pins P_3 and P_4 such that they appear to be in line with the images of pins P_1 and P_2.

(e) Remove the prism and the pins and trace the ray through the prism,

(f) Measure the angle of deviation, d and the angle of emergence i_1. Replace the prism.

(g) Repeat the procedures (c) to (f) for angles of incidence $i = 35^\circ, 40^\circ, 45^\circ, 50^\circ, 55^\circ, 60^\circ, 65^\circ, 70^\circ$ and 75°

(h) Tabulate your results including values of $(d - i_1)$

(i) Plot a graph of $(d - i_1)$ against i,

(j) Obtain the intercept A on the i-axis.

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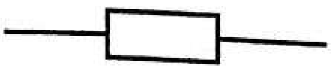
CHAPTER FOUR

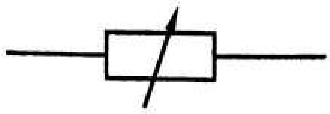
ELECTRICITY

COMMON ELECTRIC CIRCIUT SYMBOLS

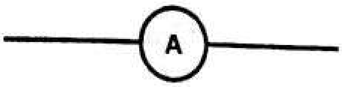
1. Fixed resistor



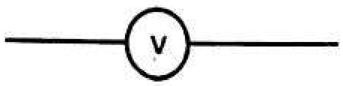
2. Variable



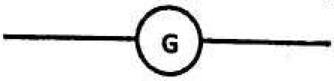
3. Ammeter



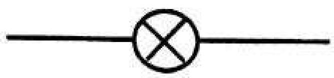
4. Voltmeter



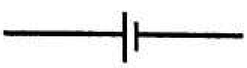
5. Galvanometer



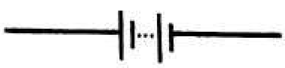
6. Lamp



7. Cell

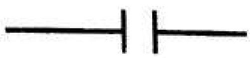


8. Battery

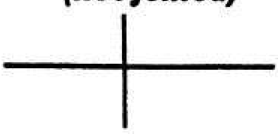


9. Switch

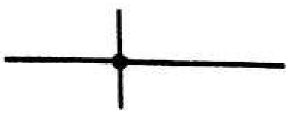
10. Capacitor



11. Wires crossing (not joined)



12. Wires joined



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EXPERIMENT 65

In this experiment, you will determine the ratio of internal resistance of a dry cell to the resistance per metre of the wire provideu.

Apparatus:

1 dry cell, 1 voltmeter(0 – 3V), constantan wire SWG 28, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape and a single cell holder.

Procedure:

a) Connect the dry cell, the switch K and set a voltmeter V across a length l of a Constantine wire as shown below.

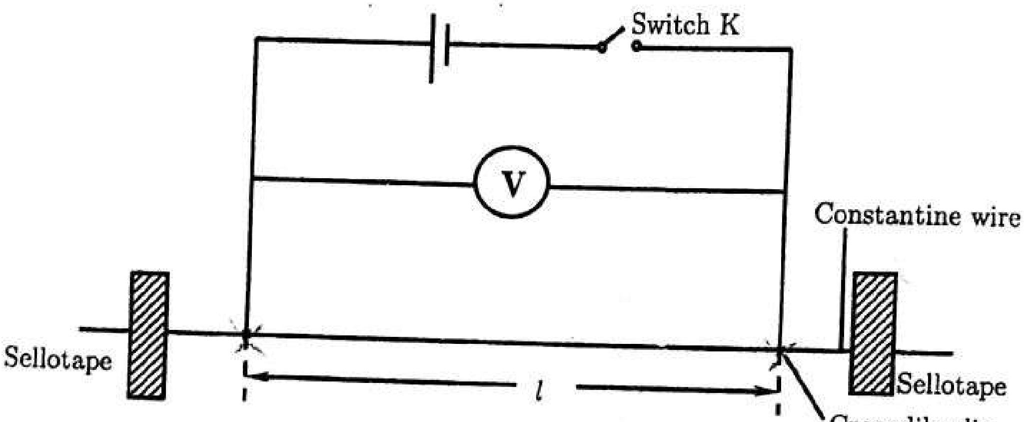

Fig. Expt 65

b) Starting with $l = 0.200$ m, close switch K. Read and record the value of V on the voltmeter.

c) Repeat procedure (b) above for values of $l = 0.300, 0.400, 0.500, 0.600, 0.700$ and 0.800 m.

d) Tabulate your results including values of $\frac{1}{V}$ and $\frac{1}{l}$.

e) Plot a graph of $\frac{1}{V}$ against $\frac{1}{l}$

f) Determine the intercept 'C' on the $\frac{1}{V}$.

g) Determine the slope S of your graph.

h. Find the value $\frac{100C}{S}$.

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EXPERIMENT 66

In this experiment, you will determine the internal resistance of a dry cell.

Apparatus:

1 dry cell, 1 voltmeter(0 – 3V), constantan wire SWG 28, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape and a single cell holder.

Apparatus:

a) Connect the circuit as shown in the diagram below with $l_o = 50.0$ cm. Start with $l = 10.0$ cm.

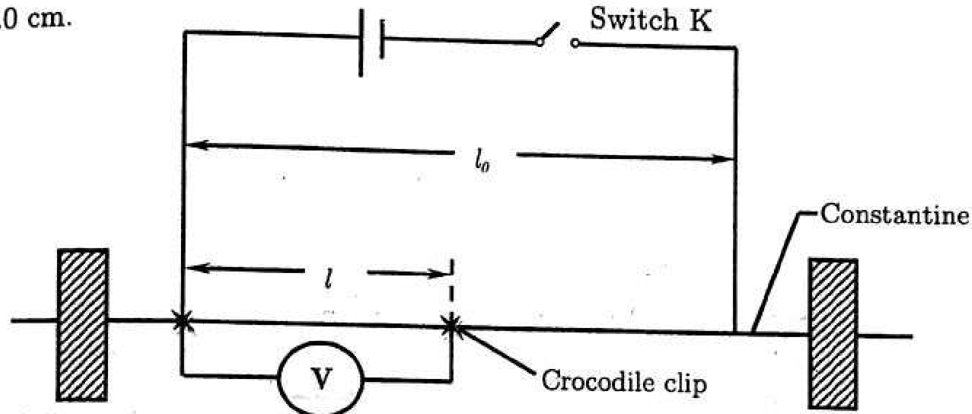

Fig. Expt 66

b) Close switch K.

c) Read and record the reading V of the voltmeter.

d) Open switch K.

e) Repeat procedures (b) to (d) for values of $l = 20.0, 30.0, 40.0, 50.0$ and 60.0cm.

f) Record your results in a suitable table.

g) Plot a graph of V against l.

h) Find the slope S of your graph.

i) Calculate the internal resistance r of the cell from the expression.

$r = 0.042\left[\frac{1.5}{S} - 50\right]$ where S is the slope of your graph.

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EXPERIMENT 67

In this experiment, you will determine the e.m.f, *E*, and internal resistance, *r*, of the dry cell provided.

Apparatus:

1 fresh dry cell, 1 ammeter(0 – 1A), 105cm of constantan wire SWG 28 labelled, Q , connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 1 voltmeter (0 - 3V), 2 crocodile clips, 1 switch labelled K and 1 single cell holder.

PART I

(a) Connect the circuit shown below in the figure below.

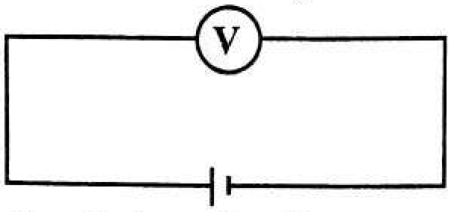

Fig. expt 67(i)

(b) Read and record the voltmeter reading, V_o .

(c) Disconnect the circuit.

PART II

(d) Connect the circuit shown in the figure below.

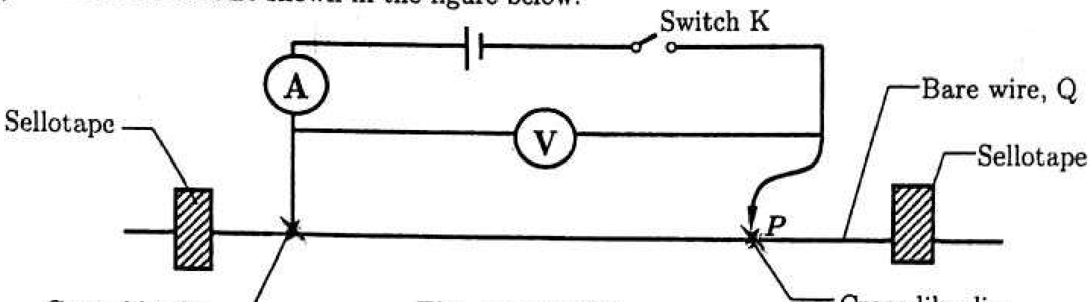

Fig. expt 67(ii)

(e) Close switch, K.

(f) Adjust the position of the crocodile clip, P, until the ammeter reading, I = 0.50 A.

(g) Read and record the voltmeter reading, V.

(h) Open switch, K.

(i) Repeat the procedure from (c) to (e) for values of I = 0.45, 0.40, 0.35, 0.30 and 0.25 A.

(j) Record your results in a suitable table.

(k) Plot a graph of I (**along the vertical axis**) against V (**along the horizontal axis**).

(l) Find the slope, S, of the graph.

(m)Read and record the intercept, C on the I-axis.

(n) Calculate the internal resistance, *r*, of the cell from the expression $r = -\frac{1}{S}$.

(o) Find but e.m.f, E of the cell from the expression $E = \frac{1}{2}(rC + V_o)$.

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EXPERIMENT 68

In this experiment, you will determine the resistance per metre, ρ of the wire provided.

Apparatus

2 fresh dry cells, 1 ammeter(0 – 1A), 110cm of constantan wire SWG 28, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 1 resistor of resistance 2Ω labelled, R, 1 voltmeter (0 - 3V), 2 crocodile clips, 1 switch labelled K and 2 single cell holders.

Procedure:

(a) Connect the voltmeter across the dry cells as shown in the figure below.

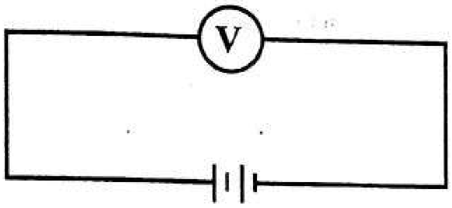

Fig. expt 68(i)

(b) Record the reading, E, of the voltmeter.

(c) Fix the bare wire labelled, AB, firmly on the table using sellotape.

(d) Connect the circuit shown in the figure below.

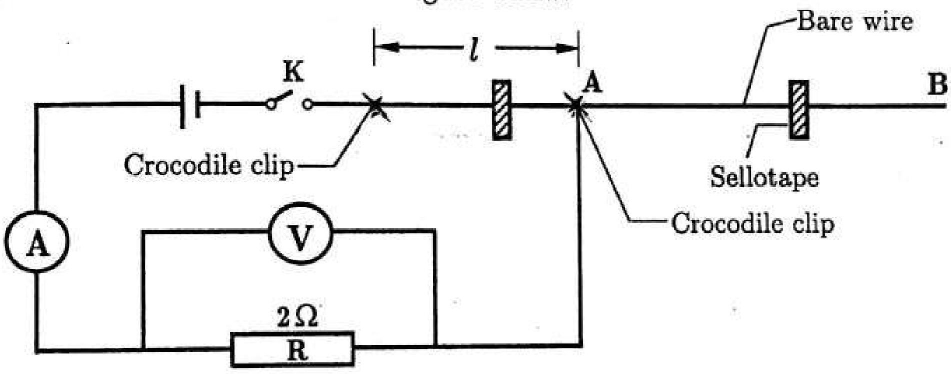

Fig. expt 68(ii)

(e) Starting with $l = \mathbf{0.100}$ **m**, close switch, K.

(f) Read and record the voltmeter reading, V and the ammeter reading, I.

(g) Open switch, K.

(h) Repeat the procedure from (e) to (g) for values of $l =$ **0.200, 0.300, 0.400, 0.500 and 0.600 m.**

(i) Record your results in a suitable table including values of **(E -V)** and $\left(\frac{E-V}{I}\right)$.

(j) Plot a graph of $\left(\frac{E-V}{I}\right)$ **(along the vertical axis)** against l **(along the horizontal axis)**.

(k) Find the slope, ρ, of the graph.

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EXPERIMENT 69

In this experiment, you are required to determine the resistance of the resistor labelled R in parallel a constantan wire labelled W.

Apparatus:

1 dry cell, 1 ammeter(0 – 1A), constantan wire W(SWG 32), connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 2 crocodile clips and a single cell holder.

Procedure:

a) Connect up the circuit as shown in the figure below.

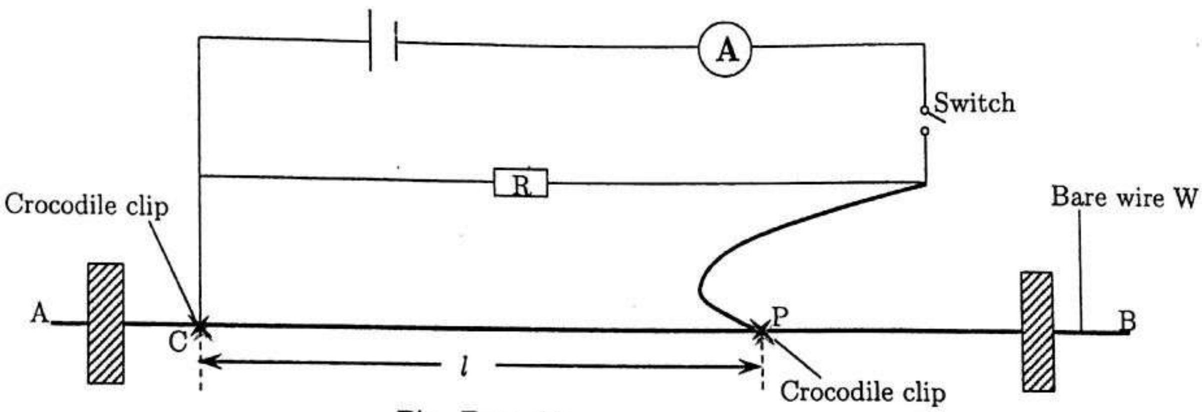

Fig. Expt 69

b) Starting with the crocodile clip P not making contact with the wire AB. Close the switch, read and record the current I.

c) Clip the crocodile clip on the wire CB with l = CP = 100.0 cm.

d) Read and record the current I.

e) Repeat procedures (c) to (d) for values of l = 80.0, 70.0, 60.0, 50.0 and 40.0cm.

f) Tabulate your reading including values of $\frac{1}{l}$.

g) Plot a graph to find the value of I against $\frac{1}{l}$.

h) Use the graph to find the value of I_0 when $l = \frac{1}{2}$CP.

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EXPERIMENT 70

In this experiment, you will determine the resistivity of the wire labelled P.

Apparatus:

1 dry cell, 1 ammeter (0 – 1A), constantan wire SWG 30, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 2 crocodile clips and a single cell holder.

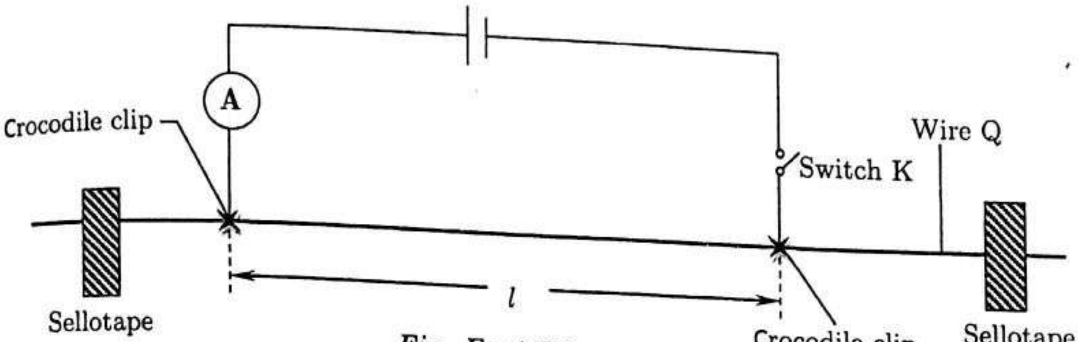

Fig. Expt 70

Procedure:

a) Connect the dry cell, ammeter A, the switch K and the wire Q in series as shown in the figure above.

b) Starting with $l = 0.200$ m record the reading I on the ammeter when switch K is closed.

c) Repeat the procedure (b) above for values of $l = 0.300$ m, 0.400 m, 0.500 m, 0.600 m, 0.700 m and 0.800 m.

d) Record your results in a suitable table including values of $\frac{1}{I}$.

e) Plot a graph of $\frac{1}{I}$ against l.

f) Find the slope, S, of the graph.

g) Calculate the resistivity ρ of the wire from the expression:

$$\rho = 1.6 \times 10^{-7} S.$$

Where S is the slope of your graph.

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EXPERIMENT 71

In this experiment, you will determine the resistance R of the bare wire labelled Q.

Apparatus:

2 fresh dry cells, 1 ammeter(0 – 1A), 100cm of constantan wire SWG 28, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, Rheostat(0 - 20Ω or 0 - 50Ω), 1 voltmeter (0 - 3V), 2 crocodile clips, 1 switch labelled K and 1 double cell holder .

Procedure:

a) Fix the bare wire, Q, provided on the metre rule using sellotape

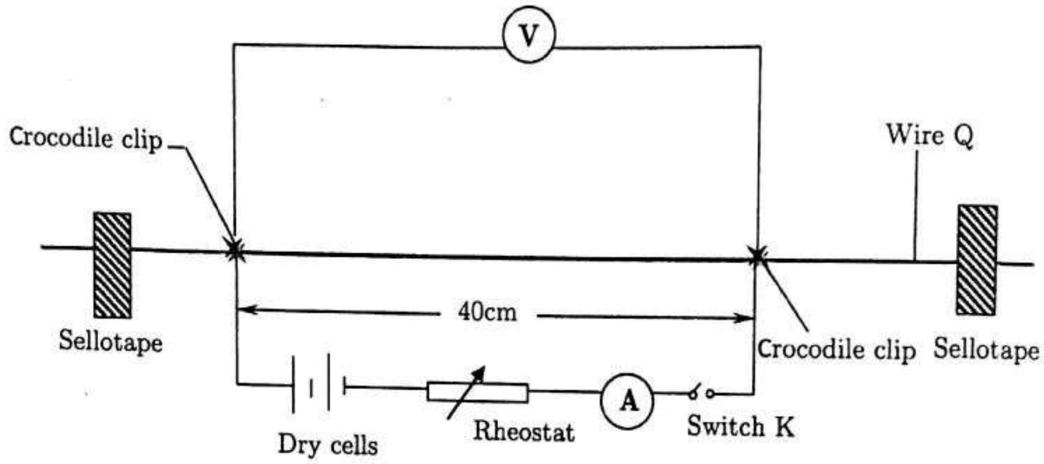

Fig. Expt 71

b) Connect the circuit as shown in the figure above using the length of Q equal to 40cm

c) Close switch K

d) Adjust the rheostat such that the voltmeter reading V is 0.30V

e) Read and record the ammeter reading I

f) Open switch K

g) Repeat the procedures (c) to (f) for values of V =0.50, 0.70, 0.90. 1.10 and 1.30V

h) Record your results in a suitable table

i) Plot a graph of I against V

j) Find the slope, S, of the graph

k) Calculate the resistance, R, of the wire from the expression; $R = \frac{1}{S}$

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EXPERIMENT 72

In this experiment, you will determine the resistance of the wire provided.

Apparatus:

2 dry cells, 1 ammeter(0 – 1A), 1 voltmeter(0 – 3V), constantan wire SWG 30, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 2 crocodile clips and a double cell holder.

Procedure:

a) Fix the resistance wire provided firmly on the metre rule using sellotape.

b) Connect the circuit as shown in the figure below with the length PQ = 20.0 cm and close the switch.

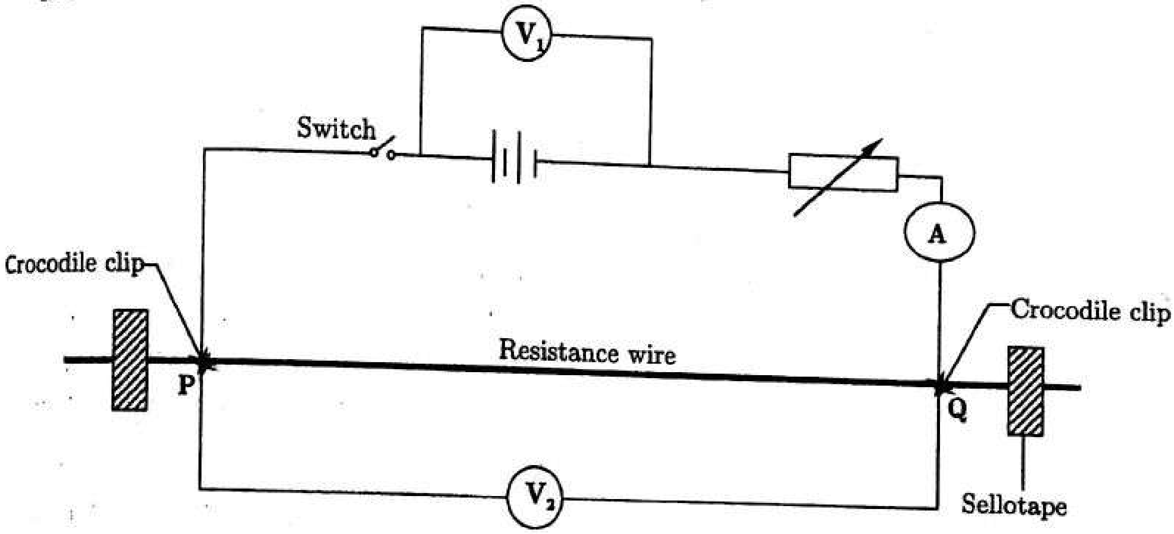

Fig. Expt 72

c) Adjust the rheostat so that the ammeter reading I = 0.60A.

d) Connect a voltmeter across the cells and record its reading V_1.

e) Disconnect the voltmeter from the cells and connect it across PQ. Record its reading V_2.

f) Repeat procedures (c), (d) and (e) for values of I = 0.50A, 0.40A, 0.30A, 0.20A and 0.10A.

g) Record your results in a suitable table.

h) On the same axes, plot a graph of V_1 against I and V_2 against I.

i) Read the value of the current I_0 and the voltage V_0 where the two graphs meet.

j) Calculate the ratio $\frac{V_0}{I_0}$.

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EXPERIMENT 73

In this experiment, you will determine the internal resistance of the cell provided.

Apparatus:

1 dry cell, 1 ammeter (0 – 1A), 1 voltmeter (0 – 3V), constantan wire SWG 30, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 2 crocodile clips and a single cell holder.

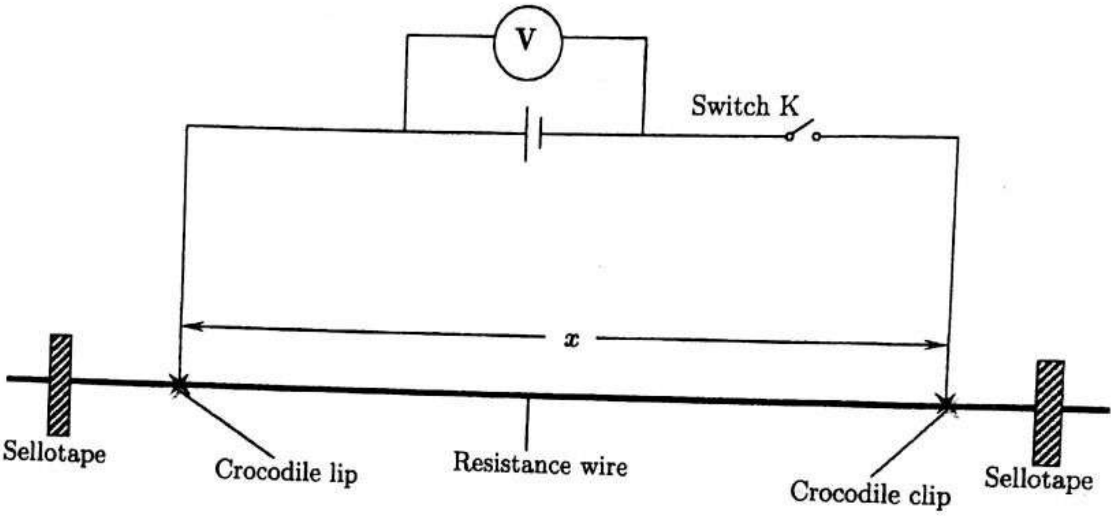

Fig.Expt 73

Procedure:

a) Connect the circuit as shown above.

b) Adjust the distance x to 0.100 m.

c) Close switch K.

d) Read and record the reading ,V, of the voltmeter.

e) Repeat procedures (b) to (d) for values of $x = 0.200$, 0.300, 0.400, 0.500 and 0.600 m.

f) Tabulate your results including values of $\frac{1}{V}$ and $\frac{1}{x}$.

g) Plot a graph of $\frac{1}{V}$ against $\frac{1}{x}$.

h) Find the slope, S, of your graph.

i) Calculate the internal resistance r of the cell from $r = 7.95$ S

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EXPERIMENT 74

In this experiment, you will determine the resistance of the resistor R provided.

Apparatus:

2 dry cells, 1 ammeter (0 – 1A), 1 voltmeter (0 – 3V), constantan wire SWG 28, 1 resistor, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 2 crocodile clips and a double cell holder.

Procedure:

a) Connect the dry cells, resistant wire, resistor R, voltmeter V and ammeter A as shown below.

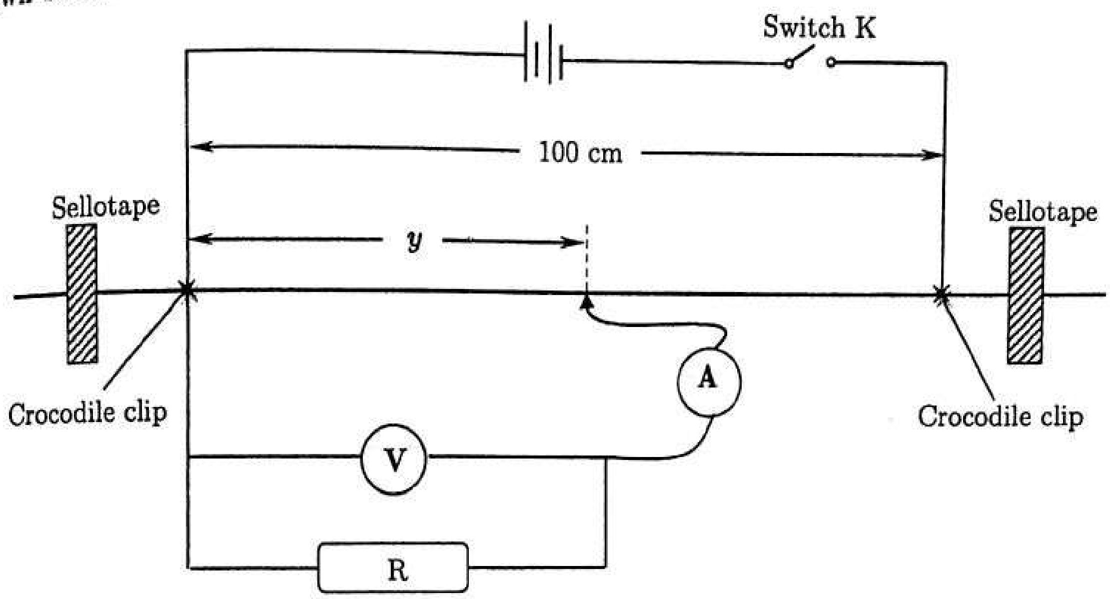

Fig. Expt 74

b) Adjust the length y of the resistance wire to 20.0 cm.

c) Close switch K and record the reading V of the voltmeter and I of the ammeter.

d) Open switch K.

e) Repeat procedures (b) and (c) for values of y = 30.0 cm, 40.0 cm, 50.0 cm, 60.0 cm and 70.0 cm.

f) Record your results in a suitable table.

g) Plot a graph of V (along the vertical axis) against I (along the horizontal axis).

h) Find the slope, S, of the graph.

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EXPERIMENT 75

In this experiment, you will determine the resistance of the filament of the touch bulb provided.

Appartus:

2 dry cells, 1 ammeter (0 –1A), 1 voltmeter (0 – 3V), 1 torch bulb, constantan wire SWG 28, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 2 crocodile clips and a double cell holder.

Procedure:

a) Fix the bare wire P on the metre rule using the pieces of sellotape provided.

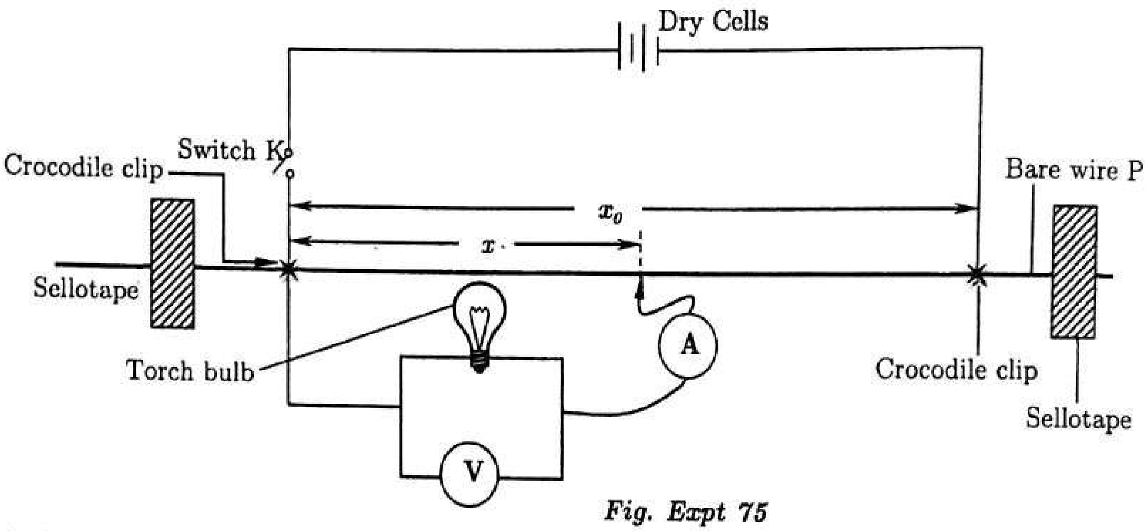

Fig. Expt 75

b) Connect the circuit as shown in the figure above.

c) Starting with length $x_0 = 1.000$m and $x = 0.200$m, close the switch K.

d) Read and record the voltmeter reading V and the ammeter reading I.

e) Open switch K.

f) Repeat procedures (b) to (e) for values of $x = 0.300$, 0.400, 0.500, 0.600 and 0.700m.

g) Record your results in a suitable table.

h) Plot a graph of V (along the vertical axis) against I (along the horizontal axis).

i) Find the slope S of the graph.

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EXPERIMENT 76

In this experiment, you will determine the internal resistance r of the cells provided.

Apparatus:

2 dry cells, 1 ammeter (0 – 1A), constantan wire SWG 26, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 2 crocodile clips, a double cell holder and a resistor R of known resistance.

Procedure:

a) Record the resistance R_S of the resistor R.

b) Connect the two dry cells in series across the voltmeter and record the reading V_0 of the voltmeter.

c) Fix the bare wire P provided on the bench using sellotape.

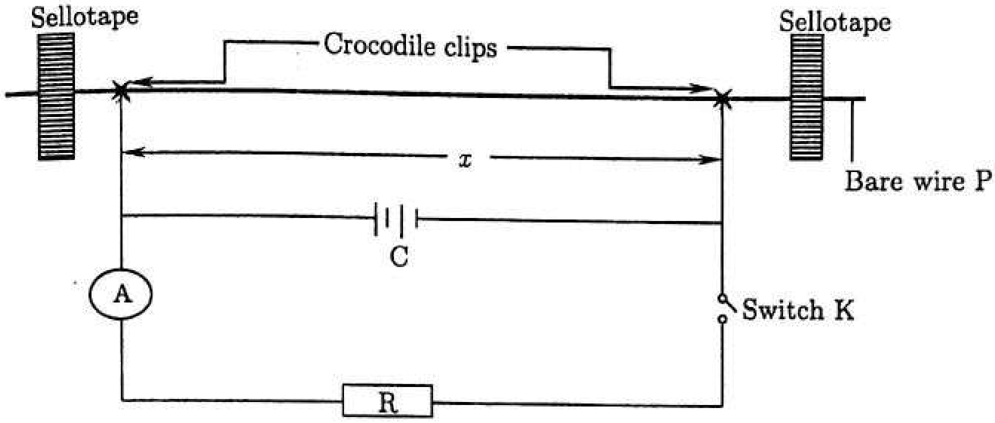

Fig. Expt 76

d) Connect the circuit as shown in the figure above starting with a length $x = 0.200$ m.

e) Close switch K.

f) Record the reading I of the ammeter.

g) Open the switch K.

h) Repeat procedures (d) to (g) for values of $x = 0.300, 0.400, 0.500, 0.600$ and 0.700 m.

i) Record your results in a suitable table including values of $\frac{1}{I}$ and $\frac{1}{x}$.

j) Plot a graph of $\frac{1}{I}$ against $\frac{1}{x}$.

k) Find the intercept C on the $\frac{1}{I}$ - axis.

l) Calculate the internal resistance r from the expression: $r = V_0C - R_S$.

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EXPERIMENT 77

In this experiment, you will determine the resistance R of the resistor labelled X.

Apparatus:

2 dry cells, 1 voltmeter (0 – 3V), constantan wire SWG 28, 1 resistor of 1.0Ω, 1 resistor X of unknown resistance, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 2 crocodile clips and a double cell holder.

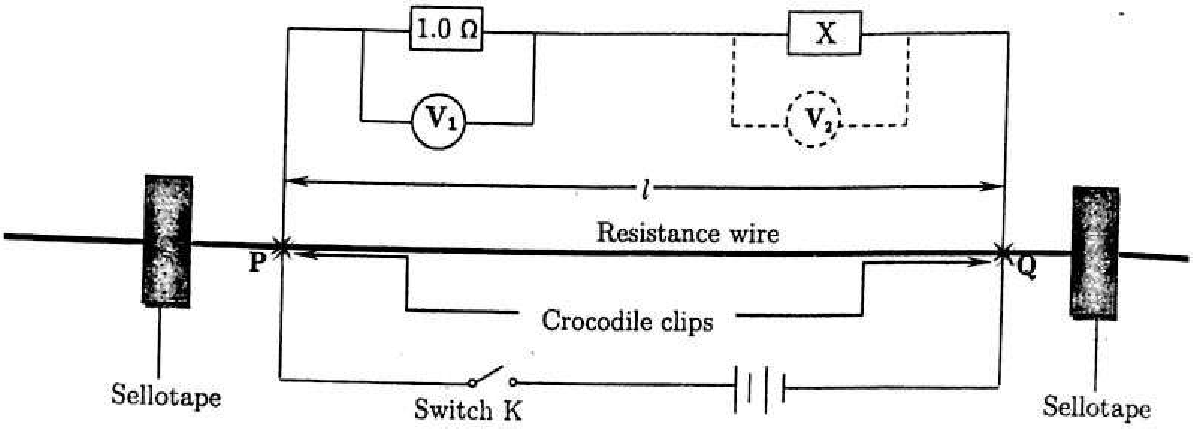

Fig. Expt 77

Procedure:

a) Fix the bare wire on the table using sellotape.

b) Connect the circuit as shown in the figure above.

c) Starting with a length of the bare wire $l = 20.0$ cm, close switch K.

d) Read and record the voltmeter reading V_1 across the $1.0\,\Omega$ resistor.

e) Disconnect the voltmeter and connect it across X.

f) Read and record the voltmeter reading V_2.

g) Repeat procedures (c) to (f) for values of $l = 40.0, 60.0, 80.0, 100.0$ cm.

h) Record your results in a suitable table.

i) Plot a graph of V_1 (along the vertical axis) against V_2 (along the horizontal axis).

j) Determine the slope S of the graph.

k) Calculate the resistance R of the resistor X from the expression: $R = \frac{1}{S}$

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EXPERIMENT 78

In this experiment, you will determine the ratio P of the internal resistance of a pair of dry cells to the resistance per centimeter of the wire labelled W.

Apparatus:

2 dry cells, 1 voltmeter, constantan wire SWG 28, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 2 crocodile clips and a double cell holder.

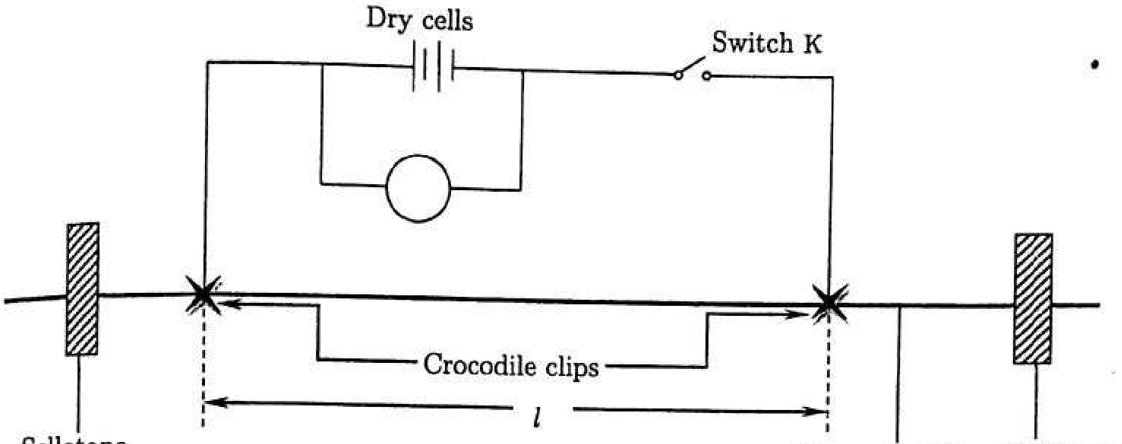

Figure 78

Procedure:

a) Fix the bare wire labelled W, on the metre rule using sellotape.

b) Connect the circuit as shown in the figure above.

c) Starting with a length l = 20.0 cm and with switch K open, read and record the voltmeter reading V_o.

d) Close switch K.

e) Read and record the voltmeter reading V_1.

f) Open switch K.

g) Repeat procedures (c) to (f) for values of l = 30.0, 40.0, 50.0, 60.0 and 70.0 cm.

h) Record your results in a suitable table including values of $V = (V_0 - V_1)$ and $\frac{V_1}{l}$.

i) Plot a graph of V against $\frac{V_1}{l}$.

j) Determine the slope P of the graph.

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EXPERIMENT 79

In this experiment, you will determine the resistance per metre r of the bare wire provided.

Apparatus:

1 dry cell, 1 voltmeter (0 – 3V), 1 ammeter (0 – 1A), constantan wire SWG 30, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 2 crocodile clips and a single cell holder.

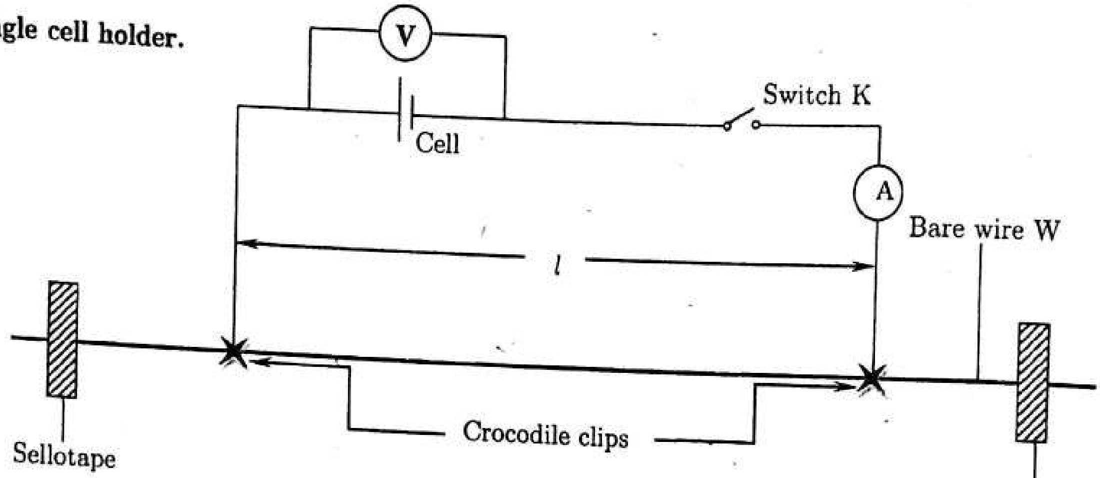

Fig. Expt 79

Procedure:

a) Connect the apparatus as shown in the figure above.

b) Starting with $l = 20.0$cm, close switch K.

c) Read and record the reading V and I of the voltmeter and ammeter respectively.

d) Open switch K.

e) Repeat procedures (b) to (d) for values of $l = 30.0$, 40.0, 50.0, 60.0 and 70.0cm.

f) Tabulate your results including values of $\frac{V}{I}$.

g) Plot a graph of $\frac{V}{I}$ against l.

h) Find the slope S of the graph.

i) Find the resistance per metre r from $r = 100$ S.

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EXPERIMENT 77

In this experiment, you will determine the diameter d of the bare wire provided.

Apparatus:

1 dry cell, 1 voltmeter (0 – 3V), 1 ammeter (0 – 1A), constantan wire SWG 30, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 2 crocodile clips and a single cell holder.

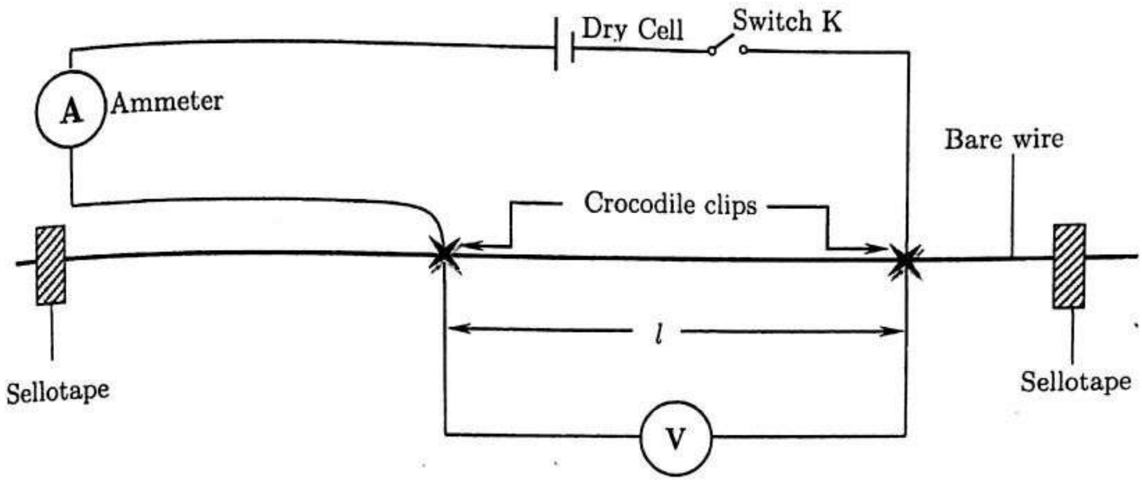

Fig. Expt 77

a) Fix the bare wire on the table using sellotape.

b) Set up the circuit as shown in the figure above.

c) Adjust the position of the crocodile clips such that $l = 0.850$ m.

d) Close the switch K.

e) Read and record the ammeter reading, I and voltmeter reading V.

f) Open switch K.

g) Repeat procedures (b) to (c) for values of $l = 0.750$, 0.650, 0.550, 0.450 and 0.350m.

h) Enter your results in a suitable table including values of $\frac{1}{I}$ and $\frac{l}{V}$.

i) Plot a graph of $\frac{1}{I}$ against $\frac{l}{V}$.

j) Find the slope S of the graph.

k) Calculate the diameter of the bare wire d from the expression,

$$d = \frac{7.90\times10^{-4}}{S^{\frac{1}{2}}}$$

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EXPERIMENT 78

In this experiment, you are to determine the internal resistance of two cells in series.

Apparatus:

2 dry cells, 1 voltmeter(0 – 3V), 1 ammeter (0 – 1A), constantan wire SWG 26, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape and a double cell holder.

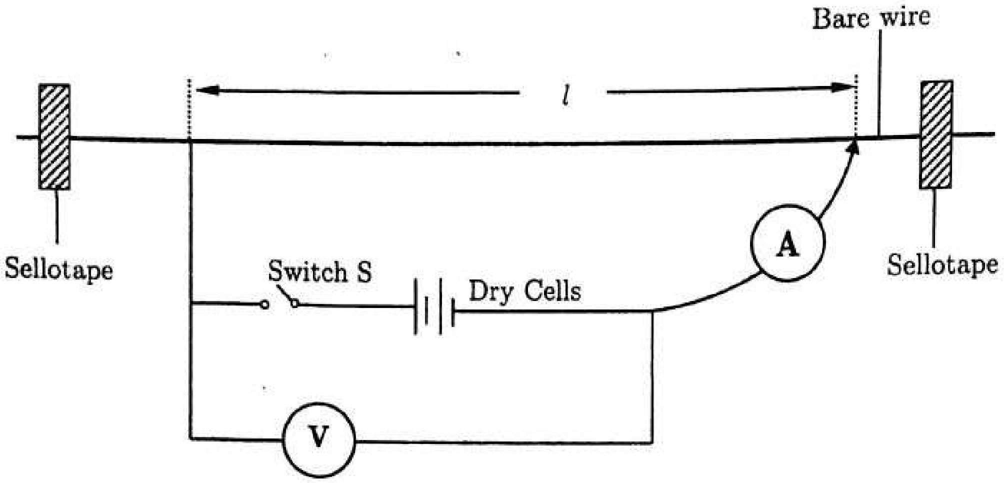

Fig. Exp. 78

a) Connect the circuit as shown in the figure above.

b) Starting with l = 20.0 cm, close the switch S. Read and record the values of V and I of the voltmeter and ammeter respectively.

c) Open switch S.

d) Repeat procedures in (b) and (c) for l = 30.0, 40.0, 50.0, 60.0 and 70.0 cm.

e) Record your results in a suitable table.

f) Plot a graph of V against I.

g) Determine the intercept V_0 on the V - axis and intercept I_0 on the I - axis.

h) Calculate C from the expression: $C = \frac{V_0}{I_0}$.

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EXPERIMENT 79

In this experiment, you will determine the e.m.f, E, and the internal resistance r of the cells provided.

Apparatus:

2 dry cells, 1 voltmeter (0 – 3V), 1 ammeter (0 – 1A), constantan wire SWG 28, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 1 jockey and a double cell holder.

Procedure:

a) Connect the circuit as shown below.

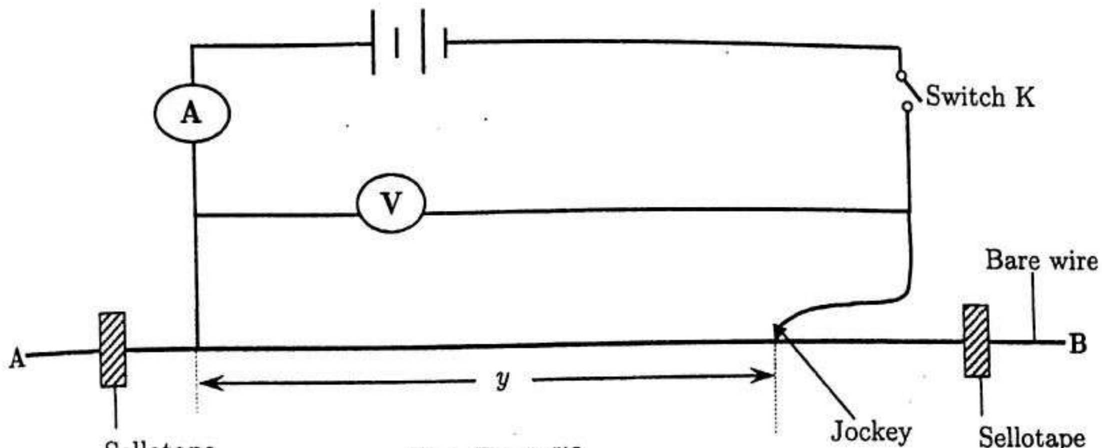

Fig. Expt 79

b) Close the switch K.

c) Starting with about 15.0 cm from the end of the wire A, move the jockey towards B until the ammeter reading, I = 0.30A.

d) Read and record the reading V of the voltmeter.

e) Repeat procedures (c) and (d) for values of I = 0.40, 0.50, 0.60, 0.70, 0.80 and 0.90A.

f) Record your results in a suitable table.

g) Plot a graph of I against V.

h) Find the slope S of your graph.

i) Calculate r from the expression: $r = \frac{1}{S}$.

j) Find from your graph, the value of V when I = 0.

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EXPERIMENT 80

In this experiment, you will determine the resistivity ρ of the material of the wire provided.

Apparatus:

1 dry cell, 1 voltmeter (0 – 3V), 1 ammeter (0 – 1A), constantan wire SWG 30, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 1 jockey and a single cell holder.

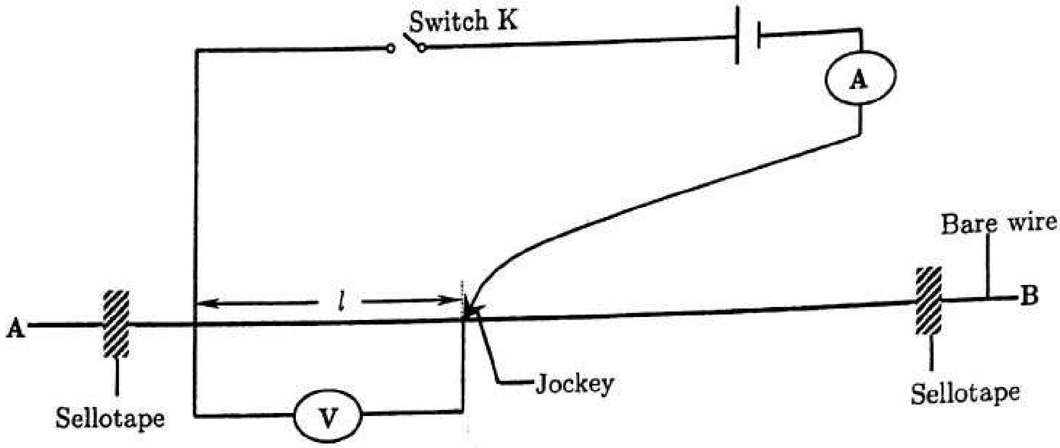

Fig. Expt 80

Procedure:

a) Connect the circuit as shown in the figure above.

b) With the switch K open, adjust the position of the jockey along the bare wire such that: $l = 0.200$m.

c) Close switch K.

d) Read and record the ammeter reading I and the voltmeter reading V.

e) Open switch K.

f) Repeat procedures (b) to (e) for values of $l = 0.300, 0.400, 0.500, 0.600$ and 0.700m.

g) Enter your results in a suitable table including values of $\frac{V}{I}$.

h) Plot a graph of $\frac{V}{I}$ against l.

i) Find the slope S of the graph.

j) Calculate the resistivity ρ of the material of the bare wire from the expression:

$\rho = 2.04 \times 10^{-7}S$.

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EXPERIMENT 81

In this experiment, you will determine the internal resistance r of the dry cell provided.

Apparatus:

1 dry cell, 1 voltmeter (0 – 3V), 1 ammeter (0 – 1A), constantan wire SWG 30, connecting wires, 1 switch, 1 metre rule, 2 pieces of sellotape, 2 crocodile clips and a single cell holder.

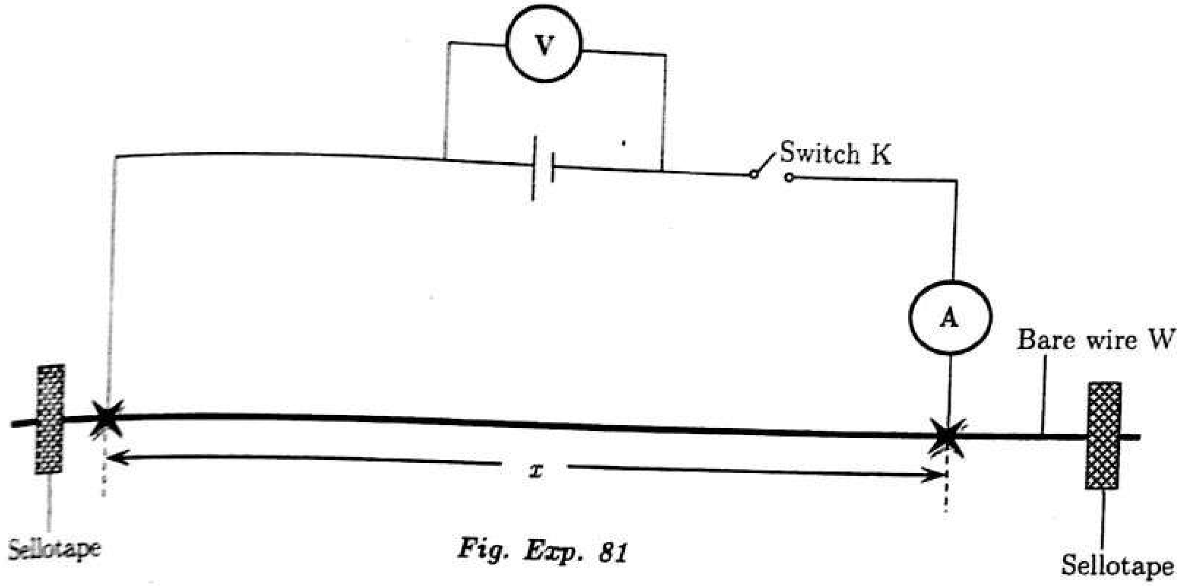

Fig. Exp. 81

a) Fix the bare wire labelled W on the metre rule using sellotape.

b) Connect the rest of the circuit as shown in the figure above.

c) Measure a length x equal to 30.0cm.

d) Close switch K.

e) Read and record the voltmeter reading V and the ammeter reading I.

f) Open switch K.

g) Repeat procedures from (c) to (f) for x = 40.0, 50.0, 60.0, 70.0 and 80.0cm.

h) Record all your results in a suitable table.

i) Plot a graph of V against I.

j) Find the slope S of your graph.

k) Calculate r from the expression: r = - S.

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EXPERIMENT 82

In this experiment, you will determine the resistances per unit length of a conductor.

Apparatus:

2 cells, a double cell holder, 1 resistor of 4Ω labelled Q, 100.0cm of clean bare resistance wire P (SWG 28), 1 metre rule, connecting wires and 1 voltmeter (0 – 3V).

PART I

(a) Record the resistance, R_q, of the resistor Q.

(b) Connect P, Q and the cells in series and use the voltmeter to determine the p.d across the cells V_c.

PART II

a) Connect the circuit shown in figure below.

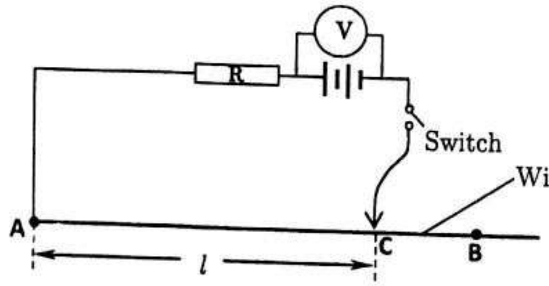

Fig. Expt 82

b) Connect the jockey to point C where l = 10.0cm. Read and record the voltmeter reading.

c) Repeat procedure (b) for values of l = 20.0, 30.0, 40.0, 50.0, 60.0, 70.0 and 80.0cm.

d) Record your results in a suitable table.

e) Plot a graph of V against the length l.

f) Find the intercept V_0 on the V-axis.

g) Find the value of l_0 where $V = \frac{V_o}{2}$

h) Calculate the resistance per metre, R, of the wire P, from the expression;

$$R = \frac{100 R_q V_c}{l_0 V_0}.$$

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CHAPTER FIVE

MAGNETISM EXPERIMENTS

EXPERIMENT 83

In this experiment you will determine the constant, U, of the magnet provided.

Apparatus:

2 similar magnets labelled P and Q, 1 non- magnetic retort stand with a clamp, 1 stop clock or stop watch, 1 piece of manila paper(6.0cm x 1.0cm) and a piece of nylon thread about 80.0cm long.

Procedure:

(a) Wrap the manila paper provided around the magnet labelled P.

(b) Suspend the magnet P from the retort stand so that it is just off the bench. Allow it to settle.

(c) Place magnet Q such that it can attract the end of P as shown in the figure below.

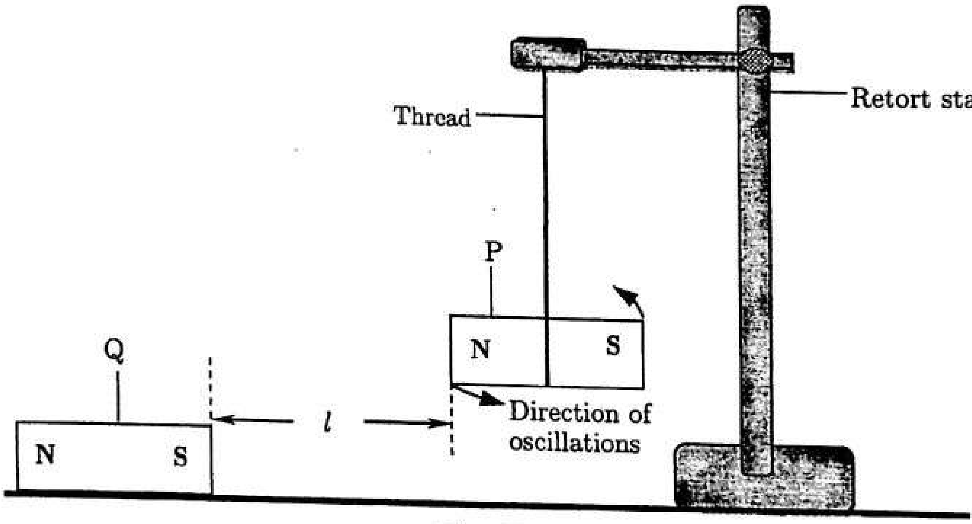

Fig. Expt 83

(d) Move magnet Q so that the distance, l is equal to 20.0cm.

(e) Displace the magnet P slightly as shown above and release it so that it oscillates.

(f) Determine the t time for 10 oscillations. Hence find the period T

(g) Calculate the frequency of oscillation, f.

(h) Repeat procedure (d) to (g) for values of l = 18.0, 16.0, 14.0, 12.0 and 10.0cm.

(i) Tabulate your results and include values of $\frac{1}{l^2}$

(j) Plot a graph of f against $\frac{1}{l^2}$ and determine the intercept, f_o on the frequency axis.

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EXPERIMENT 84

In this experiment, you will determine the magnetic field lines around different arrangements of bar magnets.

Apparatus:

Iron fillings, two bar magnets, a compass needle and 1 plain white sheet of paper.

Procedure:

PART I

(a) Place the bar magnet under a plain white sheet of paper and sprinkle iron fillings on its top above the paper.

(b) Draw the diagram showing the distribution (concentration) of the iron fillings

(c) Place two bar magnets with their opposite poles directly facing each other and 3.0cm away under the paper.

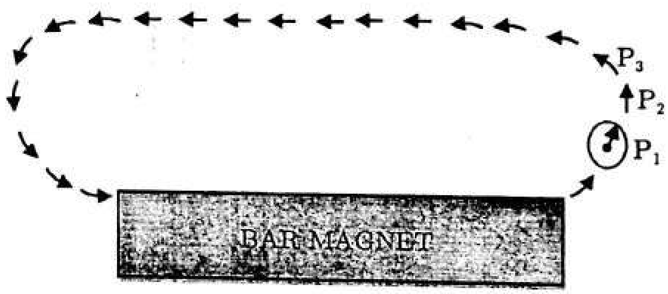
(d) Sprinkle the iron fillings and draw the outlook.

(e) Repeat the procedure (a) and (b) for other arrangements of magnets as may be provided by the teacher.

PART II

(a) Place a bar magnet on top of the plain white sheet of paper.

(b) Place a compass needle near one of its ends as shown in the figure below.



(c) Mark the end of the needle. *Fig. Expt 84*

(d) Move the compass needle to other points such as P_1, P_2, P_3... and so on and every time mark the end point of the needle

(e) Join the marked points using a smooth line (curve).

(f) Repeat procedure (d) to (e) for other lines around the magnet and draw the arrows as pointed by the compass needle on all lines around the magnet.

(g) Place two opposite poles of the two magnets facing each other and plot the field lines around them as described in procedures (b) to (f).

(h) Repeat the experiment for other arrangements of magnets as may be instructed by the teacher.

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CHAPTER SIX:

HEAT EXPERIMENTS

EXPERIMENT 85

In this experiment, you will determine the temperature of the surroundings.

Apparatus:

1 thermometer, water, 1 beaker, 1 calorimeter, 1 stop clock/stop watch and 1 measuring cylinder.

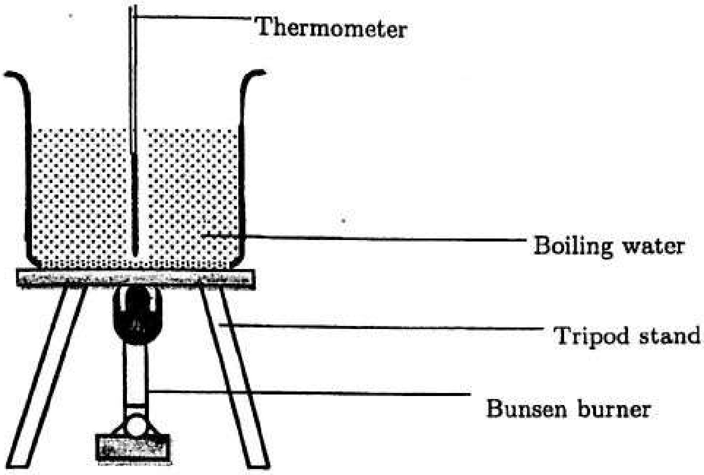

Fig. Expt 85

Procedure:

a) Measure and record the room temperature θ_o.

b) Heat 100 cm^3 of water in a beaker to a temperature of about 90°C.

c) Transfer the hot water quickly into the calorimeter.

d) Place the thermometer in the hot water and start the stop clock when the temperature of the water is 65° C.

e) Record the temperature, θ of the water after every two minutes for 14 minutes.

f) Record your results in a suitable table including values of $(\theta - \theta_o)$ and

g) Plot a graph of $\log_{10}(\theta - \theta_o)$ (along the vertical axis) against time t (along the horizontal axis).

h) Find the value I of $\log_{10}(\theta - \theta_o)$ when $t = 0$.

i) Find the antilog of I.

j) Calculate the temperature of the surroundings θ_R using the expression antilog of $I = 65 - \theta_R$.

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EXPERIMENT 86

In this experiment, you will determine the cooling constant K of water.

Apparatus:

1 thermometer, water, 1 beaker, 1 calorimeter, 1 stop clock/stop watch and 1 measuring cylinder.

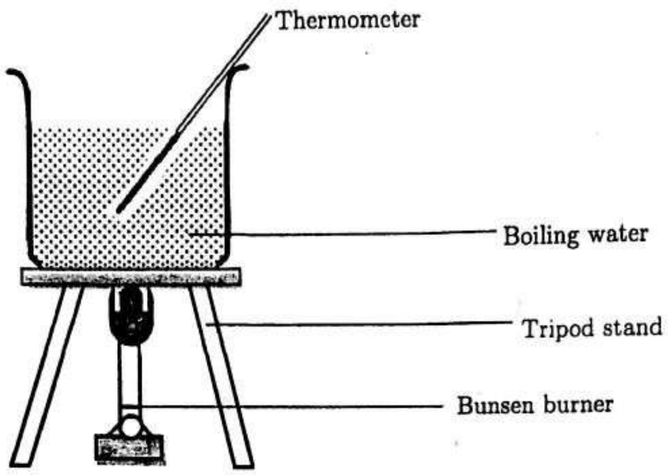

Fig. Expt 86

Procedure:

a) Record the room temperature θ.

b) Heat 100 cm^3 of water in the beaker until it boils.

c) Transfer the hot water quickly into the calorimeter.

d) Place the thermometer in hot water and start the stop watch when temperature of water is 70^0C.

e) Record the temperature θ_1 of the water after every two minutes for 14 minutes.

f) Record your results in a suitable table including values of $(\theta_1 - \theta)$ and $\log_{10}(\theta_1 - \theta)$.

g) Plot a graph of $\log_{10}(\theta_1 - \theta)$ against time t.

h) Find the slope S of the graph.

i) Calculate the cooling constant K from the expression, $S = 26.06\ K$.

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EXPERIMENT 90

In this experiment, you will determine the cooling constant β of water.

Apparatus:

1 thermometer, water, 1 beaker, 1 calorimeter, 1 stop clock/stop watch, 1 measuring cylinder and a stirrer.

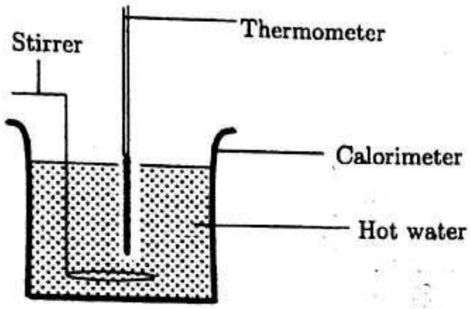

Fig. Expt 90

Procedure:

a) While holding a thermometer with the bulb in air (away from the heating source), read and record the room temperature θ_0.

b) Pour 100 cm^3 of boiling water into the calorimeter.

c) Insert the thermometer into the calorimeter containing hot water.

d) Start the stop watch/clock when the temperature θ reaches 70^0 C.

e) Record the temperature θ of the water in the calorimeter after every time interval ***t*** of 2 minutes for 14 minutes.

f) Record your results in a suitable table including values of $(\theta - \theta_0)$.

g) Plot a graph of $\log_{10}(\theta - \theta_0)$ against t.

h) Find the slope 'S' of the graph.

i) Calculate the cooling constant β from the expression: $\beta = \dfrac{S}{\theta_0}$

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EXPERIMENT 91

In this experiment, you will determine the rate of cooling R of a body.

Apparatus:

1 thermometer, water, 1 beaker, 1 calorimeter, 1 stop clock/stop watch and 1 measuring cylinder.

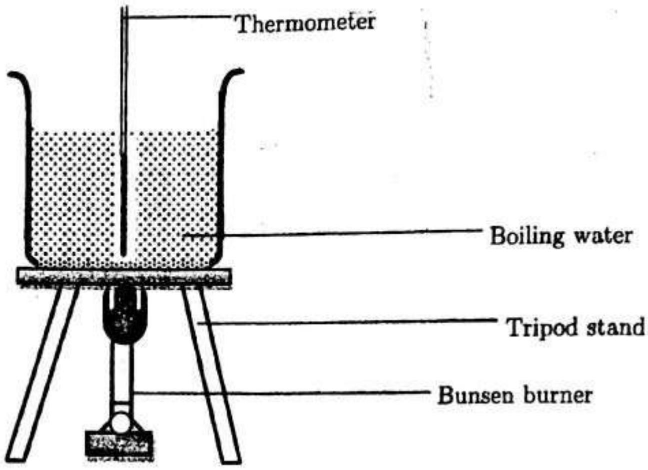

Fig. Expt 91

Procedure:

a) Pour 300 ml of water in the beaker provided.

b) Heat the water until it boils.

c) Place a thermometer in the beaker of boiling water. Read and record the steady temperature T_0 of the water.

d) Remove the thermometer and immediately start the stop clock.

e) While holding the thermometer in air, record the reading T of the thermometer at half-a minute time interval t for five minutes.

f) Record the results in a suitable table.

g) Plot a graph of T against time t.

h) Determine the time t_1 taken for the temperature to fall from 60^0 C to 50^0 C.

i) Calculate R from the expression: $R = \frac{-10}{t_1}$.

END

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