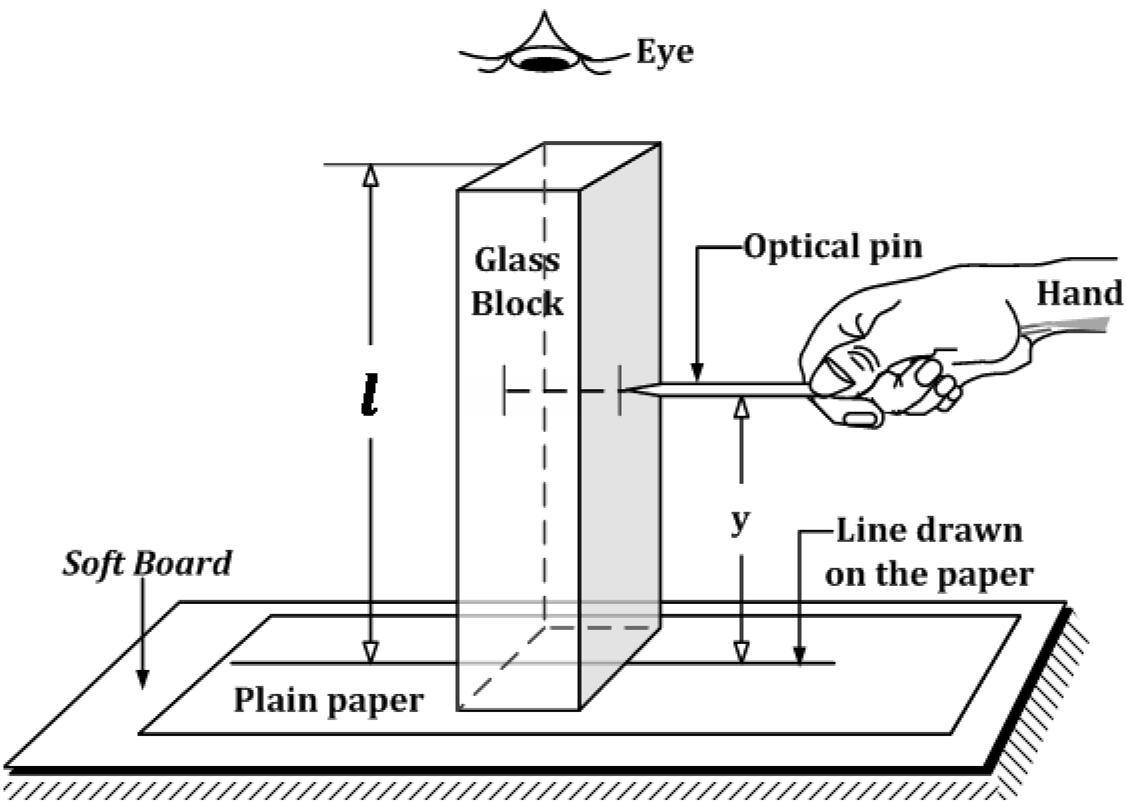
ORDINARY LEVEL PHYSICS PRACTICAL WORK BOOK



NAME:

CLASS: **STREAM:**

SCHOOL:

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1. Mr. Kasumba James { Head of Physics department}
2. Mr. Bagira Daniel
3. Mr. Dumba Micheal
4. Mr. Katumba Umar

To Teachers: "*Teachers who make Physics boring are criminals*" *–Prof. Walter Lewin (Dutch astrophysicist and former professor of physics at the Massachusetts institute of technology)*.

To students: "*However difficult life may seem, there is always something you can do and succeed*" *– Stephen Hawking (Theoretical Physicist)*

1.0 : INTRODUCTION TO PHYSICS PRACTICAL

1.1: INTRODUCTION TO 535/3 PHYSICS

Physics is sometimes called the science of measurements because without observation and measurement it would not exist.

- In order to develop and test theories it is important to make measurements that are precise and accurate
- This workbook therefore discusses the recording of measurements (data), data manipulation and its usage and interpretation at ordinary level (UCE).

1.2 Ordinary Level Physics Practical course should enable students to:

- Carry out experiments on fundamental laws and principles encountered in the theoretical work e.g. Hooke's law, Snell's law, Principle of moments etc.
- Carry out measurements in the determination of a wide variety of physical constants e.g. acceleration due to gravity, refractive index of glass or liquid, mass of a metre rule, density of a substance, internal resistance of a cell, focal length of a lens or mirror, resistance per metre of a wire.
- Gain experience of a variety of measuring instruments and learn to handle them with skills and also appreciate their limitations.

1.3 Objectives of the practical exam are to test students on;

- The ability to handle apparatus and use measuring instruments effectively and safely and to gain experience in the use of a number of instruments.
- The ability to plan the presentation of practical work
- The ability to interpret, evaluate and report upon observations and experimental data
- Ability to verity the fundamental laws of physics encountered in the theory lessons.
- Ability to measure the various physical constants.
- Ability to develop an inquisitive mind.

1.4 To students, each student should possess the following scholastic materials;

- Long transparent rule, Scientific calculator, Geometrical set, Sharp pencil and a rubber, Graph paper

The duration of the Practical paper is 2 hours and 15 minutes. (15 minutes for reading and planning, 2 hours for working).

Question one – always mechanics question and compulsory
Question Two – always light or heat
Question Three – always-current electricity

Options

Total number of questions to be answered is **2**, each question is **30** marks, and the whole paper is marked out of **60 marks**.

PLANNING THE EXPERIMENT (15 MINUTES)

1.1 The purpose is to help students to :

- Think ahead and plan, Set up the apparatus as shown in the diagram, Avoid making careless mistakes due to panic
- Properly record data with appropriate units

1.2 The students therefore should :

- Reflect on the aim of the experiment. Read through the procedures or instructions carefully one by one. Identify any instruction requiring him or her to ***Measure, Note, Read and Record*** a given quantity. Identify the quantities to be measured and plan where and how to record them.

- Identify the quantities to be actually measured (Identify the Single measurements if any and the repeated measurements) and those to be calculated or derived as well as the given quantities which control the experiment.

- Draw a detailed columnar table of results for all the measurements that are to be repeated and their associate calculations.

- Draw the axes of the graph, properly label them, and write the collect title for the graph as given in the instructions.

- Identify and arrange the apparatus basing on the diagram, following the instructions one by one in their order. The diagram should act as a plan and so the apparatus should be positioned in the same arrangement like in the diagram.

2.0: OBTAINING PRACTICAL RESULTS

The values recorded during the Physics Experiment Practical, are divided into three. i.e. They can be given in the procedure, measured using an instrument or derived from the given and measured values.

(a) **Given values of varying quantity**: These are usually given in the procedures. They must be recorded the way they are given in the instructions unless told to record otherwise.

(b) **Experimental values** (or measured values): These are values of a varying quantity that are determined using an instrument. They are recorded to the accuracy of the instrument used. For example;

Table A:

Instrument	Quantity measured	Unit	Accuracy (Number of decimal places)
Metre-rule & Foot ruler	Length ($l \geq 10$ cm)	(cm)	**1 dp.**
Vernier Calipers	Length ($1\text{cm} \leq l < 10$ cm)	(cm)	**2 dp.**
Micrometer screw gauge	Length ($l < 1$cm)	(mm)	**2 dp.**
Stop clock	Time	(s)	**1 dp.** (last digit reading **.0** or **.5**) 8.0s, 10.0s, 22.5s, 55.0s
Stop watch	Time	(s)	**2 dp.** 1.20s, 4.07s, 50.00s, 54.38s.
Ammeter	Current	(A)	**2 dp.** 0.14A, 0.22A, 0.58A, 0.90A
Voltmeter	Voltage	(V)	**2 dp.** 0.35V, 0.80V, 1.25V, 2.95V
Protractors	Angles	(^{0})	**0dp.** e.g.19°, 50°, 87°, 32°
Measuring cylinders, Burettes, Pipettes	Volume	(cm^3) or (ml)	7ml, 15ml, 49ml.
Thermometer	Temperature	^{0}C	
Digital electronic balance, Triple beam balance	Mass	Grams (g)	**1dp.** e.g 2.5g, 35.8g

Row data consist of readings or measurements taken directly from a measuring instrument.

It should be expressed to a fixed number of decimal places dictated by the scale of the instrument the units used and the precision of the instrument.

All the raw reading of a particular quantity should be recorded to the same number of decimal places and should be consistent with the precision and accuracy of the apparatus

Each reading recorded from an instrument should consist of two parts namely:-

a) A numerical value recorded to the nearest smallest scale division (Least count value) of the given instrument. Mid-point estimation of the smallest division is acceptable except for a metre rule. *It is advisable to estimate the mid-point readings only when the readings are constant*.
b) Units.

N.B
When given an instrument for carrying out measurements one need to study the scale and establish the least Count or **What 1 small scale division represents** and then **Units**.

(c) **Derided quantity values**

- The values of trigonometric ratios logarithms, surds (square roots, cube roots etc of whole numbers) are recorded to 3dp.
  It should be noted that for square roots, cube roots etc of decimal fractions, the significant figures of the fraction under consideration should be maintained.

- **Calculated values:**
  These are usually obtained from the experimental values. It must be noted that calculations cannot increase either the precision (exactness or accuracy) or the number of significant figures of a measured or given quantity. The accuracy of a calculated value can only be as great as the least precise term in a calculation.

  For addition and subtraction of quantities, the least number of decimal places (d.p) should be maintained in the calculated result (sum and Difference respectively).

  For multiplication and division of quantities, the least number of significant figures (s.f) should be maintained in the calculated result (Product and Quotient respectively).

  A float value (A value which is neither given, nor measured but is just b used in a calculation) should not be considered when determining the least number of significant figures to be maintained.

3.0 RECORDING PRACTICAL RESULTS IN AN EXPERIMENT

(i) Single measurements.

These are measurements whose procedure is not repeated. These should therefore NOT be recorded in the main table of results. They should be recorded before other observations that change during the experiment. They are divided into ***two***

(a) Doubtless observations

These are observations which whether taken by different people or at different points of the object being measured remain the same. They include;

- Room temperature
- Mass of an object eg metre rule, pendulum bob e.t.c
- Original pointer reading, i.e initial position of the pointer before attaching a mass on it, (if it is constant),
- Centre of gravity of a body e.g metre rule.
- Approximate focal length, (or rough distance of the image of a distant object in a concave mirror or convex lens),

In this case the value you get is the one you write without taking the average.

(b) Doubtful observations

These are observations which whether taken by different people or the same person or at different points of the object being measured, we obtain different results. They include;

- Diameter of a wire, test tube, pendulum bob e.t.c
- Estimated focal lengths of mirrors or lenses
- Width of the glass block or metre rule
- Thickness of a metre rule

E.g measure and record the diameter of the wire

In this case, measure the quantity at least 3 times and then calculate the average (but maintain the degree of accuracy of the instrument).

Example:

If you required to measure and record the breadth b, of the meter rule, measure of the breadth three times and record in a small table as shown below.

b_1(cm)	b_2 (cm)	b_3 (cm)
2.68	2.69	2.69

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

$$b = \frac{b_1 + b_2 + b_3}{3}$$

$$b = \frac{2.68 + 2.69 + 2.69}{3}$$

$$b = 2.69 \text{ cm}$$

- If the measurement is required to be recorded in SI units, then record all the values in S.I units before finding the average.
  E.g. if you are required to measure and record the breadth b in meters then record as follows;

b_1(m)	b_2(m)	b_3(m)
0.0268	0.0269	0.0269

$$b = \frac{b_1 + b_2 + b_3}{3}$$

$$b = \frac{0.0268 + 0.0269 + 0.0269}{3}$$

$$b = 0.269 \text{ m}$$

(ii) Repeated measurements.

These are measurements whose procedures are repeated for given set of given values. These can be differentiated from the non-repeated measurements by using the instruction in the procedure saying ***"Repeat procedures, ( ) to ( ) for values of -… to …, …, …, … and…"***

- ➢ These measurements are put in the main table of results to the accuracy of the instrument used.
- ➢ In any column the number of decimal places in that column must be the same.

The main table of results should have only values of varying quantities. Constant values of non-repeated quantity should be recorded before the main table of results.

The main table of results

- ❖ It must be a column table and it must be closed at the top, bottom and the sides. A closed columnar table of results with only three horizontal lines should be drawn.
- ❖ **Note:** All values given to control the extent of performing the experiment (i.e. given values) should be filled in the first column of the table while keeping the order in which they are stated and the units.
  The 1st column is for the given variables, 2nd measured variable and then followed by the derived quantities (values).
- ❖ **Column headings**.
  Each column must have a heading i.e. (symbol for the quantity and unit in brackets. the given symbols must be used correctly. The unit of each quantity must be in brackets ( ) e.g. m (kg), l (cm), l (m), v (ms^{-1}), θ(^{o}) etc.

- Label columns using the symbol or letter given in the procedure e.g. if required to tabulate values of $m = \frac{v}{u}$ then, the label for magnification should be m & not $m = \frac{v}{u}$ or $\frac{v}{u}$.

- Equations and words should not be used in tables of results. When a quantity has not been assigned a symbol, choose an appropriate symbol or letter to represent it. e. g. suppose a step in the procedure reads :- Determine the time for 20 0scillations.Then,
  - ✓ Choose a letter, say, t, to represent the time for 20 1oscillations, instead of writing "time for 20 oscillations" as a column heading.
  - ✓ The first letter of the names of the quantity is usually preferred. **t**- for time, **m**- for mass, ***l***-for length, **h**-for height, **p**-for pointer positions, e.t.c.
  - ✓ Avoid the use of equations in column headings especially when the quantity has been defined, e. g when the extension is calculated from e= (P_1-P_0), the column heading should be e (cm) but not e= (P_1-P_0) (cm).
  - ✓ However, (P_1-P_0) (cm) is a good column heading when the extension ***e*** is not defined.
  - ✓ Avoid column headings such as l_1-l_2 (cm) or $\frac{y-x}{a}$ (cm) rather use (l_1-l_2) (cm) and $\left(\frac{y-x}{a}\right)$(cm).

- **Columns of calculated quantities.**
  The table must be detailed, in case a derived quantity is obtained from other quantities, all these other quantities must be included in the main table of results.
  Some quantities can be calculated from a formula or given expression and you should not omit steps that lead to the final results of the formula e. g when asked to tabulate your results including values of : if $\sin^2\theta$ is required in the table, then values of θ, sinθ , & $\text{sn}^2\theta$ must also be included in the main table of results. ⋅. For $\frac{x^2}{y}$, progress from ***x***, to ***y*** to x^2 and then $\frac{x^2}{y}$.

- **Units of calculated quantities.**
- Units of calculated quantities can be derived from the formulae or equations that relates the different quantities by mathematical substitution e.g: Column labeled $\frac{V}{I}$ can have VA^{-1} or Ω as its units, for $\frac{\mathbf{I}}{l}$ the unit is A cm^{-1}.
  In case you are told to tabulate values of say, resistance $R = \frac{l_1}{l_2}$, then the units of resistance should be used, R(Ω).

MANIPULATION OF CALCULATED VALUES

(i) Decimal Places
The number of decimal places (dp) is the number of digits to the right end of a decimal point. E.g. the number 3.6420 is given to 4dp.Thus 3.6420 ≈ 3.642(3dp), 3.6420 ≈ 3.64(2dp), 3.6420 ≈ 3.6(1dp), 3 .6420 ≈ 4 (0dp).

(ii) Significant Figures
The Significant Figures of a number refer to those digits that have meaning in reference to a measured or specified value. Correctly, accounting for Significant Figures is important while performing arithmetic so that the resulting answers accurately represent numbers that have computational significance or value.

There are three rules that are used to determine how many significant figures are in a number. There are also rules for determining how many digits should be included in numbers computed using addition/subtraction, multiplication/ division, or a combination of these operations.

(iii) Rules for determining how many Sig Figs are in a number:
Rule #1: **Non zero digits** (1, 2, 3, 4, 5, 6, 7, 8 and 9). All non zero digits in a recorded measurement is significant.
Examples:- 5.39 has three significant figures, 1.892 has four significant figures, 1.37mm, 5.42cm, 99.8 cm are expressed to 3 s.f.

Rule #2: **Trapped zeros.** Zero between non-Zero digits are significant. Example; 4023 has four significant figures, 50014 has five significant figures, 10.5cm, 9.06cm, 2.04, 504 have 3 s.f

Rule #3: **Trailing zeros.**
- These are Zero at the right end of a number. These are only significant if they were obtained by using an instrument i.e. if they are not as a result of rounding off.eg the numbers 30^o, 30.0cm, 300g have got 2s.f, 3s.f and 3s.f respectively because the trailing zeros are not obtained as a result of rounding off given numbers.

- However, if a number e.g. 348 is rounded off to 1 s.f, we get 300 and if it`s rounded off to 2 s.f we get 350. The trailing zeros in these approximations (i.e. 300 and 350) are due to rounding off and therefore are not significant. They just keep or show the place value of the digits in the number (place value zeros).Without them, the meaning of the number would change.

- Trailing zeros as a result of rounding off are only significant if a decimal point is present in the number. E.g rounding off 4.2897 to 3dp gives 4.290. This zero is significant.

- **Note. 39.9** rounded to **2sf** is **40.** [Please note the decimal point at the end of the trailing zero. It makes the zero trapped and hence significant]

Rule #4: **Leading zeros.** Zeros to the left of the first non-Zero digit are NOT significant. Example; 0.000034 has only 2 s.f, 0.001111 has 4 s.f, 0.0075m, 0.000089m, 0.00037m are expressed to 2 s.f

(iv) Rules for determining the number of decimal places of calculated values in a column:

The number of decimal places or significant figures to which these values are to be recorded is obtained using the two basic rules of data manipulation. These are;

(a) Addition and subtraction of quantities.

- The number of ***decimal places (dp)*** in the answer should be the same as the least number of dps in any of the numbers being added or subtracted. E.g.
- (i) $4.721\ (3\text{dp}) + 1.18\ (2\text{dp}) = \mathbf{5.90\ (2dp)}$

  (ii) $420.03(2\text{dp}) + 299.270(3\text{dp}) + 99.068(3\text{dp})$
  $= 818.368 = \mathbf{818.37(2dp)}$.

- 420.03 is the least precise (2 decimal places). So the answer 818.368 MUST BE rounded to 2 decimal places to give 818.37 (2Decimal place)

  (iii) $504.009(3\text{dp}) + 246.8(1\text{dp}) - 119.32(2\text{dp})$
  $= \mathbf{631.6(1dp)}$. .

(b) Multiplication & division of quantities

The number of ***significant figures (s.f)*** in the answer should be the same as the least number of s.f in any of the numbers being multiplied or divided. E.g.

(i) 5.90 x 0.05 = 0.3
(3 s.f) x (1s.f) = (1s.f)

(ii) 7.0 x 0.560 = 3.9
(2 s.f) x (3 s.f) = (2 s.f)

(iii) $\frac{1.80(3\ s.f)}{0.10(2\ s.f)} = 18\ (2\ \text{s.f})$

(iv) $\frac{0.045_{(2sf)} \times 0.00465_{(3sf)}}{4.2_{(2sf)}} = 0.000050_{(2sf)}$

Note:

(i) **$(53.4)^2$ = 2852 (0dp)** and not 2850 (3sf) as the rules could have predicted, because the value 2850 (3sf) would increase the error seriously.

(ii) **(2400)(3.45)(16.21) = 134218.8 = 134219**

The number 2400 only has 2 Sig Figs (and its the least no. of sfs), so the answer 134218.8 must be rounded to 2 Sf's to give 130000. However, this creates a very large error, so we just round off to a whole number 134219.

Thus if the number of significant figures before a decimal point exceed those predicted by rule, then just round off to a **whole number (0dp).**

(c) A float;

A float is a whole number or a constant, which has an infinite number of decimal places e.g. 1, 20, 100, 1000, π etc. A float is neither a given value nor an experimental value. It's only used in calculations.
Floats do not affect the number of significant figures of the result of the calculation where they appear. E.g:

Floats are common when taking reciprocals, converting from centimetres to metres and vice versa, converting from grams to kilograms and vice versa, finding the period time by diving with the given number of oscillation, etc.

(i) $\frac{29.5\ (3\ s.f)}{20(float)} = 1.48\ (3\ \text{s.f})$. Not considering **20** because it is a **float** value.

(ii) $\frac{\mathbf{1}(float)}{\mathbf{0.204\ (3\ s.f)}} = 4.90\ (3\text{s.f})$. Not considering **1** because it is a **float** value.

Note: 1: A float like 1000 can be written to have a precise number of significant figures. E.g
$1000 \text{ to } 2\text{s.f} = 1.0 \times 10^3$
$1000 \text{ to } 3\text{s.f} = 1.00 \times 10^3$
$1000 \text{ to } 4\text{s.f} = 1.000 \times 10^3$

Note: 2: If values of a given variable are whole numbers, they have a precise number of **dps** and **s.fs** and are not float values. Eg when required to vary the mass, M starting with $M = 100\text{g}$, and repeating the procedure for $M = 200, 300, 400, 500, \text{and } 600\text{g}$, then the values of M in this case are not float values. They are all given precisely to **0dps** and **3sfs**.

(v) Finding the number of significant figures for calculated values in the main table of results

- Largest value in the column (i.e **Largest product** or **Largest quotient**) to determine significant figures of the processed value and this fixes the number of decimal places of all the other processed values in that column.

- In case of a product or quotient in two columns, multiplication and division rule apply to the pair which gives the largest product or quotient and this fixes the number of decimal places of all the other processed values in that column.

Example 1

$\boldsymbol{l = 0.500m}$

$x(m)$	$y(cm)$	$y(m)$	$xy(m^2)$	$x^2(m^2)$	$\frac{x}{y}$	$\frac{xl}{y}(m)$	$\frac{1}{y}(m^{-1})$	$y^2(cm^2)$	$\log xy$	$-10\log xy$
0.05	26.1	0.261	0.01	0.003	0.19	0.10				
0.10	31.0	0.310	0.03	0.010	0.32	0.16				
0.15	38.0	0.380	0.06	0.023	0.39	0.20				
0.20	45.0	0.450	0.09	0.040	0.44	0.22				
0.25	53.2	0.532	0.13	0.063	0.47	0.23				
0.30	**62.0**	**0.620**	**0.19**	**0.090**	**0.48**	**0.24**				

- In the column of $\frac{xl}{y}$, using the largest value in this column, we have**;** $\frac{0.30_{(2sf)} \times 0.500_{(3sf)}}{0.620_{(3sf)}} = \mathbf{0.24}_{(2sf)}$. Thus, all values in this column should be recorded to **2dp.**

- In the column of x^2, using the largest value in the columns of $\boldsymbol{x}$, we have; $0.30_{(2sf)} \times 0.30_{(2sf)} = \mathbf{0.090}_{(2sf)}$. Thus, all values in the column of x^2 should be recorded to **3dp.**

Example 2

$\boldsymbol{E = 3.00V}$ $(\boldsymbol{Measured\ value})$

$y(m)$	V(V)	I(A)	$\frac{1}{V}(V^{-1})$	$\frac{1}{I}(A^{-1})$	$\frac{V}{I}(\Omega)$	$\frac{E}{V}$	$\frac{1}{y}(m^{-1})$	IV(W)
0.200	0.50	0.40	**2.0**	2.5	1.3	**6.0**	**5.00**	
0.300	0.60	0.36	1.7	2.8	1.7	5.0	3.33	
0.400	0.70	0.32	1.4	3.1	2.2	4.3	2.50	
0.500	0.90	0.28	1.1	3.6	3.2	3.3	2.00	
0.600	1.00	0.24	1.0	4.2	4.2	3.0	1.07	
0.700	1.10	0.20	0.9	**5.0**	**5.5**	2.7	1.43	

- In the column of y, the values are given precisely to 3 d.p. In the column of V, the values of voltage were measured from a voltmeter to the accuracy of 2dp. Similarly, In the column of I, the values of current were measured from an ammeter to the accuracy of 2dp.

- In the column of $\frac{1}{V}$, using the largest quotient in this column, we have; $\frac{\mathbf{1}_{(float)}}{\mathbf{0.50}_{(2sf)}} = \mathbf{2.0}_{(2sf)}$. Thus, all values in this column should be recorded to **1 dp.**

- In the column of $\frac{1}{I}$, using the largest quotient in this column , we have; $\frac{\mathbf{1}_{(float)}}{\mathbf{0.20}_{(2sf)}} = \mathbf{5.0}_{(2sf)}$. Thus, all values in this column should be recorded to **1 dp.**

- In the column of $\frac{V}{I}$, using the largest value in this column, we have; $\frac{\mathbf{1.10}_{(3sf)}}{\mathbf{0.20}_{(2sf)}} = \mathbf{5.5}_{(2sf)}$. Thus, all values in this column should be recorded to **1 dp.**

- In the column of $\frac{1}{y}$, using the largest value in this column (**Largest Reciprocal of y,** Use Least value in the column o**f y**), Hence, we have; $\frac{\mathbf{1}_{(float)}}{\mathbf{0.200}_{(3sf)}} = \mathbf{5.00}_{(3sf)}$. Thus, all values in this column should be recorded to **2 dp.**

Example 3.

$l(m)$	$l^3(m^3)$	$t(s)$	$\mathrm{T}(s)$	$\mathrm{T}^2(s^2)$	$\frac{1}{\mathrm{T}^2}(s^{-2})$
$\mathbf{0.900}_{(3sf)}$	$\mathbf{0.729}_{(3sf)}$	$\mathbf{17.75}_{(4sf)}$	$\mathbf{0.8875}_{(4sf)}$	$\mathbf{0.7877}_{(4sf)}$	
These values were given precisely to 3d.p	↓ (3 sf)	These values were obtained from a stop watch to 2d.p	↓ (4 sf)	↓ (4 sf)	
0.400	0.0640	6.50	0.3250	0.1056	

- In the Column of $\boldsymbol{l^3}$**;** Using the largest value in the column of $\boldsymbol{l}$, we have; $0.900_{(3sf)} \times 0.900_{(3sf)} \times 0.900_{(3sf)} = 0.729_{(3sf)}$. Thus all values in the column of $\boldsymbol{l^3}$ should be recorded to **3dp.**

- In the Column of $\boldsymbol{T}$**;** Using the largest value in the column of $\boldsymbol{t}$, we have; $\frac{17.75_{(4sf)}}{20} = 0.8875_{(4sf)}$. Thus, all values in the column of T should be recorded to **4dp.**

- In the Column of $\boldsymbol{T^2}$**;** Using the largest value in the column of T , we have; $0.8875_{(4sf)} \times 0.8875_{(4sf)} = 0.7877_{(4sf)}$. Thus, all values in the column of $\boldsymbol{T^2}$ should be recorded to **4dp.**

Example 4.

u(cm)	v(cm)	(u+v) (cm)	uv(cm^2)	$\frac{v}{u}$	$\cos u$	$\log v$	$uv\cos u\ (cm^2)$	$\log uv$
20.0	**66.6**		**1332**	**3.33**				
25.0	41.7		1043	1.67				
30.0	32.8		984	1.09				
35.0	28.5		998	0.81				
40.0	26.5		1060	0.66				
45.0	24.2		1089	0.54				

- For $\boldsymbol{uv}$ **:** Using the **largest product**, Largest value in this column, we have: $20.0_{(3sf)} \times 66.6_{(3sf)} = \mathbf{1332}_{(\mathbf{0dp})}$. Thus, all values in the column of $\frac{v}{u}$ should be recorded to **0dp.**

- For $\frac{v}{u}$ **:** Using the **largest quotient**, in this column, we have: $\frac{66.6_{(3sf)}}{20.0_{(3sf)}} = \mathbf{3.33}_{(\mathbf{3sf})}$. Thus, all values in the column of $\frac{v}{u}$ should be recorded to **2dp.**

Example 5.

$i(^0)$	$r(^0)$	$x(cm)$	$l(cm)$	$sini$	$cosr$	$xcosr(cm)$	$\sin^2 i$	$\frac{1}{sin^2 i}$
10	6	0.8	7.0	0.156	**0.996**	0.8		
20	14	1.6	7.2	0.342	0.970	1.6		
30	20	2.4	7.4	0.500	0.940	2.3		
40	28	3.5	7.8	0.643	0.883	3.1		
50	30	4.0	8.1	0.766	0.866	3.5		
60	35	4.8	8.5	**0.866**	0.819	**3.9**		

For $\boldsymbol{xcosr}$: Using the largest product in this column of $\boldsymbol{xcosr}$, We have: $\mathbf{0.819}_{(\mathbf{3sf})} \times \mathbf{4.8}_{(\mathbf{2sf})} = \mathbf{3.9}_{(\mathbf{2sf})}$. Hence values in the column of $\boldsymbol{xcosr(cm)}$ shouldbe recorded to $\mathbf{1}$ $\boldsymbol{dp}$.

Example 6

Given that the-values of f_0(cm), x_l(cm) and x_2(cm)are experimental values, all measured using a meter rule. Complete the table of results for values of l (cm), d (cm), d^2(cm^2)and (l^2-d^2) (cm^2);where d = (X_2- X_l) and f_0= 10.0cm.

SOLUTION

l(cm)	*l(cm)*	x_l (cm)	x_2(cm)	*d*(cm)	l^2 (cm^2)	d^2 (cm^2)	(l^2-d^2) (cm^2)
6.5f_0	**65**	**52.0**	8.8	-43.2	**4225**	**1866**	**2359**
6.0f_0	60	46.6	9.2	-37.4	3600	1399	2201
5.5f_0	55	36.2	11.0	-25.2	3025	635	2390
5.0f_0	50	41.1	10.0	-31.1	2500	967	1533
4.5f_0	45	30.0	11.9	-18.1	2025	328	1697
4.0f_0	40	24.9	**13.0**	**-11.9**	1600	142	1458

To determine the number of decimal places for the values in a given column we first determine the number of decimal places for the leading value in the column (i.e. by using the rules for data manipulation) and then we write the remaining values to the same number of decimal places.

How the numbers of decimal places for the calculated values in the above table of results were determined.

- Values of x_1, and x_2 are experimental values obtained using a meter rule. They must be recorded to the accuracy of the meter rule (i.e. **1dpl).**

- In the column for l, using the largest value we've;
  $6.5f_0 = 6.5_{(2s.f)} \text{ x } 10.0_{(3s.f)} = \mathbf{65}_{(2s.f).}$
  Since the largest value is to 2sf, all the values in the column of l (cm) should be written to **2dp**.

- In the column for d, using the largest value (-43.2), we've;
  $d = x_2 – x_1$
  $d = 13.0_{(ldp)}-24.9_{(ldp)} = \mathbf{-\ 11.9}_{(ldp).}.$
  All the values in the column of d (cm) should therefore be written to **1dpl**.

- In the column for d^2, using the largest value we've;
  $d^2 = (-43.2)^2=(-43.2)_{\ (3s.f's)} \text{ x } (-43.2)_{\ (3Sf's)}$,
  $d^2 = 1866.24 \approx \mathbf{1866}_{\ (0dp)}$

It is important to note that the value 1866.24 is supposed to be written to 3sf's (if we follow the rule for multiplication). However, if the value 1866.24 is written to 3sf's we get **1870**. In this case, the error created due to rounding off is quite big.

Thus to minimize the rounding off error, we round this number off but write it as a whole number i.e. round it off to remove the decimal point. Thus, we write the result 1866.24 ≈ 1866(**0dpl**). Since the largest value is to 0dpl, all the values in the column of d^2 should be written to 0dpl.

- In the column for l^2, using the largest value we've;
  $l^2=65.0_{(3s.f)} \text{ x } 65.0_{(3s.f)} = 4225_{\ (3s.f)}$
  Thus, all values in the column should be written to **0dp**l.

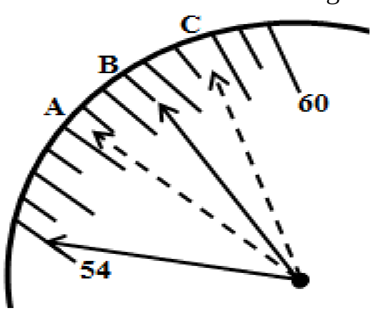
- In the column for (l^2-d^2),using the largest value we have;
  $(l^2\text{-}d^2) = 4225_{(0dpl)} - 1866_{(0dpl)} = 2359_{(0dpl)}$.
  Thus, all values in the column should be written to **0dpl**

How to deal with constant values in a table of results.

(i) Experimental values.

Experimental values may be constant if the graph to be plotted is a curve. However the constant values must not follow each other, except for heat experiments. It's important to note that for a straight line graph, the values of the quantities to be plotted cannot be constant i.e. it's not correct to get the same experimental values following each other if they are values of a quantity to be plotted and the graph to be plotted is a straight line graph e.g. balance length, l (cm) = 24.5cm, 24.5cm, 24.5cm, It's therefore advisable in such a case to check your values by repeating procedure to obtain more accurate values.

It should be noted that the number of decimal places of any measured value is determined by the least count (or least possible value on the instrument being used).



However, in a situation where the readings being obtained are constant, midpoint estimation of the smallest division (i.e. a half the smallest division) is acceptable for all measuring instruments except for the metre rule.
E.g At **A**, reading is **56.25** seconds, while at **C**, the reading is **58.75** seconds

(ii) Calculated values.

If the values given in the procedure are used to determine values of another quantity and the values obtained (calculated) are constant; then increase the number of significant figures of the largest value in the column for the calculated values by one and then write the rest of the values in the column to the same number of decimal places.

E.g. suppose values of x (m) are given in the procedure and you are required to tabulate values of $\frac{1}{x}$ (m^{-1})**.** If the rules for data manipulation are applied and the values of $\frac{1}{x}$ obtained are constant, then increase the number of significant figures for the leading value in the column for $\frac{1}{x}$ by one and then write the other values in this column to the same number of decimal places.

x(m)	$\frac{1}{x}$ (m^{-1})
0.2	5
0.5	3
0.4	3
0.5	2
0.6	2
0.7	1
0.8	1

In the column for $\frac{1}{x}$ (m^{-1}), applying the rule for division and using the first value in the column for x we have; $\frac{1}{x}$ = $\frac{1_{(float\ )}}{0.2_{(1sf)}} = 5_{(1\ sf)}$. Since the largest value has 0dpl, all values in this column are supposed to be recorded to 0dpl.

But if we follow this rule and record the values in the column for $\frac{1}{x}$ to 0dpl, we obtain constant values as shown in the table above.

To avoid obtaining constant values, it is advisable to increase the number of significant figures of the largest product or quotient in the column for $\frac{1}{x}$ by one {i.e. In this case from 1sf to 2sf's} and write the other values in the column to the same number of decimal places. (i.e to 2dps) as shown below.

x (m)	$\frac{1}{x}$ (m^{-1})
0.2	5.0
0.3	3.3
0.4	2.5
0.5	2.0
0.6	1.7
0.7	1.4
0.8	1.2

Note:

- *The above rules only apply to the value(s), which give the **largest value** in a column under consideration.*
- *For uniformity, all values in a particular column in the table must be written to the **same number of decimal places as the largest value in that column.***
- *In case the number of significant figures before a decimal point exceeds those predicted by the rules, then just round off to the nearest whole number.*
- *If the rules give constant values in a column, then increase the number of significant figures by one.*

Complete the tables bellow using the rules of data manipulation above.

Question 1

$\boldsymbol{l}$**(cm)**	**I(A)**	$\frac{\mathbf{1}}{\mathbf{I}}(\mathbf{A^{-1}})$
10.0	0.32	
20.0	0.30	
30.0	0.28	
40.0	0.26	
50.0	0.22	
60.0	0.20	

Question 2

$\boldsymbol{y}$**(cm)**	**V(V)**	$\frac{\mathbf{1}}{\mathbf{V}}(\mathbf{V^{-1}})$	$\frac{\mathbf{1}}{\mathbf{y}}(\mathbf{cm^{-1}})$
30.0	0.90		
40.0	0.95		
50.0	1.15		
60.0	1.35		
70.0	1.55		

Question 3:

i(°)	α(°)	y(cm)	Z(cm)	tan α	Ztan α (cm)	$\frac{y}{\text{Ztan}\,\alpha}$
10	75	3.3	6.8			
20	68	4.4	7.0			
30	60	4.8	7.3			
40	53	5.1	7.8			
50	47	5.4	8.5			
60	42	5.7	9.5			

Table 1:

x(cm)	x^2(cm^2)	l(cm)	l^2(cm^2)	(x^2-l^2) (cm^2)	$\frac{1}{x}$ (cm^{-1})
85.0		48.6			
75.0		42.1			
70.0		33.5			
65.0		29.7			
60.0		18.4			
55.0		15.8			

Table 2:

l(m)	t(s)	T(s)	T^2(s^2)	l^3(m^3)	$\frac{1}{T^2}$(s^{-2})
0.9	17.75				
0.8	15.25				
0.7	12.94				
0.6	10.62				
0.5	8.40				
0.4	6.50				

Table 3:

d(cm)	$2\theta(^0)$	$\theta(^0)$	20T(s)	T(s)	$T^2(s^2)$	$\cos\theta$
70	120		24.33			
60	95		26.30			
50	76		27.90			
40	60		28.62			
30	46		29.42			
20	32		29.70			

(a) Plot a graph of T^2 against $\cos\theta$

(b) Find the slope S of your graph.

Table 4:

t(cm)	x(cm)	y(cm)	$x^2(cm^2)$	$y^2(cm^2)$
1.5	1.7	2.6		
1.7	2.1	3.2		
1.9	2.3	3.6		
2.1	2.5	3.8		
2.3	2.8	4.2		
2.5	3.0	4.6		

a) Plot a graph of y^2 against x^2

b) Find the slope s of your graph.

c) Compute the critical angle C, of the glass from the expression;

$$\mathbf{C = \cos^{-1}\frac{1}{2}(\sqrt{S})}$$

Table 5:

x(m)	$x^2(m^2)$	20T(s)	T(s)	$T^2(s^2)$	$\frac{1}{x}(m^{-1})$	$\frac{1}{T^2}(s^{-2})$
0.10		14.5				
0.15		15.0				
0.20		16.0				
0.25		17.0				
0.30		18.5				
0.35		20.0				

a) Plot a graph of T^2 against x^2

b) Determine the intercept, C on the T^2 – axis.

c) Find the slope S of your graph.

Table 6:

d(cm)	$d^2(cm^2)$	y_1(cm)	y_2(cm)	$(y_2 - y_1)$(cm)	$(y_2 - y_1)^2(cm^2)$
41.0		15.3	24.6		
46.0		13.5	31.8		
51.0		12.5	37.5		
56.0		11.8	42.7		
61.0		11.5	48.1		
66.0		11.0	53.4		

a) Include values of $\mathbf{d^2 - (y_2 - y_1)^2}$.

b) Plot a graph of $d^2 - (y_2 - y_1)^2$ against d.

c) Find the slope, S of your graph.

d) Calculate the focal length of the convex lens from; **S = 4f.**

Table 7:

R(Ω)	l(cm)	$(100 - l)(cm)$	$\frac{(100 - l)}{l}$
1	75.0		
2	60.9		
3	50.9		
4	44.1		
5	38.4		
6	34.4		

a) Plot a graph of $\frac{(100-l)}{l}$ against R

b) Determine the slope S of the graph.

c) Find the unknown resistance Rs from the expression

$$\mathbf{R_s = \frac{1}{s}}$$

Table 8:

$i(^0)$	$r(^0)$	l(cm)
10	6	6.5
20	13	6.6
30	20	6.8
40	26	7.1
50	30	7.4
60	36	7.9

a) Plot a graph of $\frac{1}{l^2}$ against $\sin^2 i$

b) Find the slope K of the graph.

c) Read and record the intercept C on the $\frac{1}{l^2}$ axis.

d) Calculate the width w of the glass block from the expression:

$$\boldsymbol{W = \left(\frac{1}{C}\right)^{\frac{1}{2}}}$$

e) Determine the refractive index of the glass block from the expression;

$$\boldsymbol{n = \left(\frac{C}{-K}\right)^{\frac{1}{2}}}$$

4.0 GRAPH WORK

(a) ***Title of the graph at the top of the graph paper.***

- ❖ Clearly written in only 1 line e.g. A graph of T^2 Against x^2 (i.e. T^2 plotted along the vertical axis &x^2 along the horizontal axis).
- ❖ No units should be included in the title.
- ❖ Must be noted as given in the procedures or instruction requiring you to plot the graph.

(b) ***Axes***

- ❖ Must be drawn perpendicularly to each other with an arrow at the end of each axis.
- ❖ Each axis must be clearly and correctly labeled horizontally with the quantity and unit in brackets.
- ❖ It must be clearly marked every after 10 small squared (2cm) starting from the origin.
- ❖ The starting point of each axis must be clearly shown.

(c) ***Intercepts***

- ❖ 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.
- ❖ Therefore, if the intercept on the vertical (y – axis) is required, the starting point on the vertical can be anywhere (i.e. any value slightly below the smallest value in the column to be plotted on that axis) but the horizontal axis (x-axis) must start from zero. Similarly, if the intercept on the horizontal axis is required, then the vertical axis must begin from zero.
- ❖ Intercepts should be read directly from the graph basing on the scale of the graph for the required axis. The scale considered is what 1 smallest square represents. If the scale for 1 smallest square has 1dp, the intercept on that axis must have 1dp.

(d) ***Scale***

(i) Obtaining the Suitable, Convenient and consistent Scale

A scale is **suitable** if it covers at least 50% of the graph paper. It is **convenien**t if it is easy to plot and follow. It is **consistent** along an axis, if it is uniform (has equal intervals) along that axis.

Obtain the range on both vertical axis (VA) and horizontal axis (HA). Where;

$$\textbf{R打nge} = \left(\begin{array}{c}\textbf{Greatest value}\\ \textbf{to be plotted}\end{array}\right) - \left(\begin{array}{c}\textbf{Smallest value}\\ \textbf{to be plotted}\end{array}\right)$$

PROCEDURES	HORIZONTAL	VERTICAL
$1 : \dfrac{\textbf{Range}}{\textbf{No. ssq}}$	$1 : \dfrac{\text{Range on H.A}}{\text{No. ssq}}$	$1 : \dfrac{\text{Range on V.A}}{\text{No. ssq}}$
	$1 : \dfrac{\text{Rang eon H.A}}{80}$	$1 : \dfrac{\text{Range on V.A}}{100}$
(This gives what one smallest square represents on each axis of the graph)		

- ❖ For convenience use digits **1, 2, 2.5** and **5** then **submultiples** e.g. 0.1, 0.2, 0.25 and 0.5; 0.01, 0.02, 0.025, and 0.05 etc. and the **multiples** e.g. 10, 20, 25 and 50, 100, 200, 250 and 500, etc.
  Note: 4 & 8 are however not convenient digits though they are at times used.

- ❖ If the value of $\left[\frac{\textbf{Range}}{\textbf{No.ssq}}\right]$ does not fall exactly on one of the convenient scales, take the nearest **upper** value from the set of convenient scales (i.e. the scale should be rounded to the nearest greater (upper) suitable value of **one significant figure**.

- ❖ In case the first nonzero digit is 1, make it 2. If it is 2, make it 2.5. If it is 3 or 4, make it 5. If it is 5, 6, 7, 8, or 9, make it 10.

1; ⟶ **2**	2: ⟶ **2.5**	3,4; ⟶ **5**	5, 6, 7, 8, 9; ⟶ **10**

1.011; ⟶ **2**	0.**1**1344; ⟶ **0.2**	0.0**1**5432 ⟶ **0.02**
2.02 ⟶ **2.5**	0.**2**134; ⟶ **0.25**	0.0**4**5432 ⟶ **0.05**
5.57 ⟶ **10**	0.**6**789 ⟶ **1**	0.0**7**432 ⟶ **0.1**
0.00895432 ⟶ **0.01**		

- ❖ Multiply by 10 to get what 2cm (10small squares) represent.
- ❖ If the interval between zero and the 1st reading is extremely bigger than the interval between the first reading and second reading, then the first reading or lowest value should be shifted closely to the origin or to the starting point of that axis.

(ii) Choosing the starting value along each axis

- When marking the axes, if the question does not involve finding the intercept, the starting value should not necessarily be zero. Start from **a convenient** value, which **is slightly smaller than** and **a bit distant from** the smallest value in the column.

- The starting value on any axis should be a multiple of the scale on that axis.
- There are only two cases where the starting value on a given axis must be zero, **0**. These are:
  - (i) When the smallest value (top or bottom value) in a column is very close to zero.
  - (ii) When an intercept is required on the other (perpendicular) axis.

- ❖ In order to plot a point accurately on a particular axis, get the value to be plotted from the main table of results (without rounding off), subtract the nearest value on that axis from the value to be plotted, and then divide the result by the scale (**for 1 smallest square**) of that axis. This gives the number of smallest squares to be counted from the chosen nearest value when plotting that value.

For example, In the worked out example 1, to accurately plot point **1.602** from the column of $\log X$, Just dial this value on your calculator, then go on the already consistently marked graph paper and looking along the $\log X$- axis, identify the interval where this value lies (in this case it lies between 1.60 and 1.65). Then subtract the smaller value (1.602-**1.60**) and then divide the result by the scale for 1 smallest square (i.e $\frac{\mathbf{0.002}}{\mathbf{0.005}} = 0.4 \approx 0$ small squares). Thus we count 0 small squares from 1.60 to plot this value.

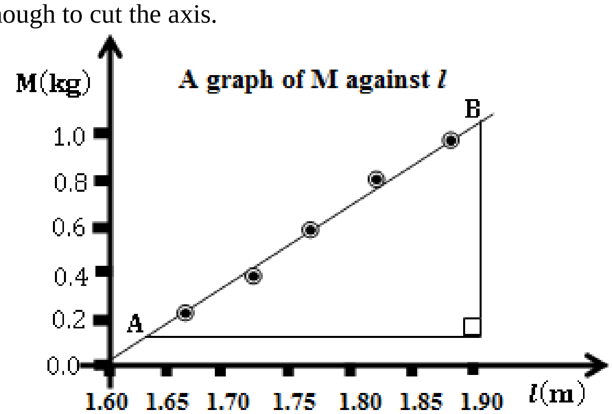
Candidates are advised to avoid rounding off values in the table of results with the aim of easing their plotting.

Always use accepted signs for plotting a point. E.g cross, plus, dot and all these enclosed in a circle of the size of the smallest square of the graph paper.

i.e, $\times$, $\otimes$, $+$, $\oplus$, $\cdot$, $\odot$

(e) ***Line of best fit or best curve***

Either the plotted points lead to a curve or best straight lines. In the case of a straight, then it should be a line through most of the points leaving almost equal no. of points on either side if the points are scattered. This line should be produced long enough to cut the axis.



(f) ***Slope***

When finding the slope, a large triangle covering all the plotted points should be drawn. The points to be used to find the slope should be correctly read and written on the graph.

The calculation of the slope should be based on the values read from the graph, and then apply the rules of data manipulation (i.e for Addition-Subtraction and Multiplication-Division).

$$\text{Slope, S} = \frac{\begin{bmatrix}\text{Change in Quantity on the} \\ \text{Verical axis(with units)}\end{bmatrix}}{\begin{bmatrix}\text{Change in Quantity on the} \\ \text{Horizontal axis(with units)}\end{bmatrix}}$$

$$\text{Slope, S} = \frac{\Delta \text{ Vertical}}{\Delta \text{ Horiontal}}$$

The slope should have the appropriate units obtained from the quantities of the labelled axes, except when it is a ratio of quantities of the same unit.

The slope from A to B can be determined as follows:
Using the coordinates, $A(1.63, 0.10)$ and $B(1.92, 1.20)$ as read from the graph, we shall have:

$$\text{Slope, S} = \frac{\text{Change in M(kg)}}{\text{Change in } l\text{(m)}}$$

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

$$\text{Slope, S} = \frac{1.20 - 0.10}{1.92 - 1.63}$$

$$\text{Slope, S} = \frac{1.10}{0.29}$$

$$\text{Slope, S} = 3.8 \text{ kg m}^{-1}$$

Note: In the above graph, both axes are marked and labelled every after 10 small squares.
The scale for 1 Smallest square on the *l*-axis is : $\frac{1.65-1.60}{10} = \mathbf{0.05}$ **(2dp)**. Therefore all values read from this axis must be recorded to 2decimal places.
The scale for 1 Smallest square on the M-axis is : $\frac{0.2-0.0}{10} = \mathbf{0.02}$ **(2dp)**. Therefore all values read from this axis must be recorded to 2decimal places.

(g) **Calculation**

Before substituting any quantity in the formula or expression, it must be converted to S.I units first. The values should be correctly substituted in the given expression.

- The accuracy of the final answer should be that of the least accurate measurement involved in the calculation. (i.e. put into account the rules of data manipulation).

- Put the units of the quantity under investigation if any. It is important at this stage to recall the aim of the experiment and attach the appropriate unit of the quantity that has been determined. E.g If the aim of the experiment is “To determine acceleration, **g** due to gravity using a pendulum bob”, then the units of acceleration should be used, i.e, **ms^{-2}**.

WORKED EXAMPLES

Example 1:

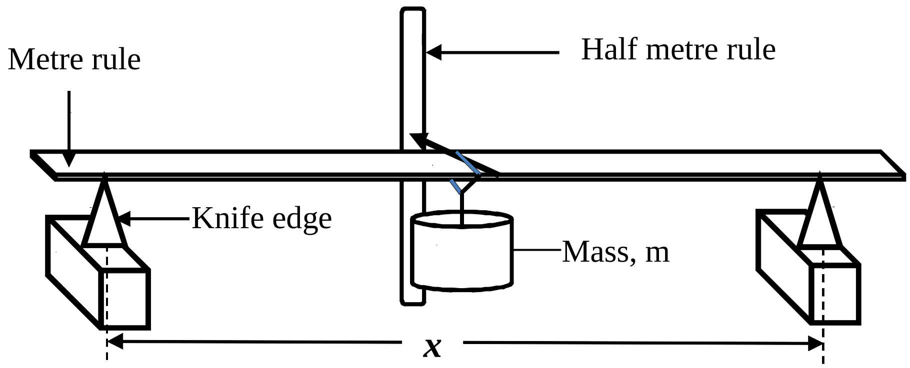
In this experiment, you will investigate the relationship between the depression of a loaded beam and the distance between the supports.

Procedure.

a) Attach a pointer at the 50cm mark of the meter rule, use cello tape.

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

c) Clamp a scale vertically and place it near the 50cm mark of the meter rule as shown in the figure below.



d) Adjust the knife-edges such that the distance x between them is equal to 90cm and they are equidistant from 50cm mark of the metre rule.

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

f) Suspend a mass, m of 500g at the 50cm 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 at its midpoint

h) Remove the mass from the metre rule.

i) Repeat the procedures (d) to (h) for values of x = 80cm, 70cm, 60cm, 50cm, and 40cm.

j) Enter your results in a suitable table including values of $\log_{10}$ D and $\log_{10} X$

k) Plot a graph of $\log_{10}$ D (along the vertical axis) against $\log_{10}$ X (along the horizontal axis)

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

-END-

Apparatus: *A meter ruler, Half meter rule, 2 knife edges, a 500g mass and retort stand with a clamp, pointer, Cellotape.*

SOLUTION

Recording single readings:

e) Let P_o be the initial position and pointer and P be the new position of the pointer

P_o= 80.0cm.

g) P = 84.8cm; D = P - P_o

= 84.8cm - 80.0cm

$= \mathbf{4.8\ cm}$

Recording repeated readings:

j) **The table of results**

X(cm)	P(cm)	D(cm)	$\log_{10} X$	$\log_{10} D$
90	84.8	4.8	1.954	0.681
80	82.8	2.8	1.903	0.447
70	81.7	1.7	1.845	0.230
60	81.2	1.2	1.778	0.079
50	80.6	0.6	1.699	- 0.222
40	80.3	0.3	1.602	- 0.523

i) From the graph,

Using the points read from the graph: $A(1.57, -0.60)$ and $B(1.97, 0.66)$

Slope; $N = \dfrac{0.66-(-0.60)}{1.97-1.57}$

$= \dfrac{1.26}{0.40}$

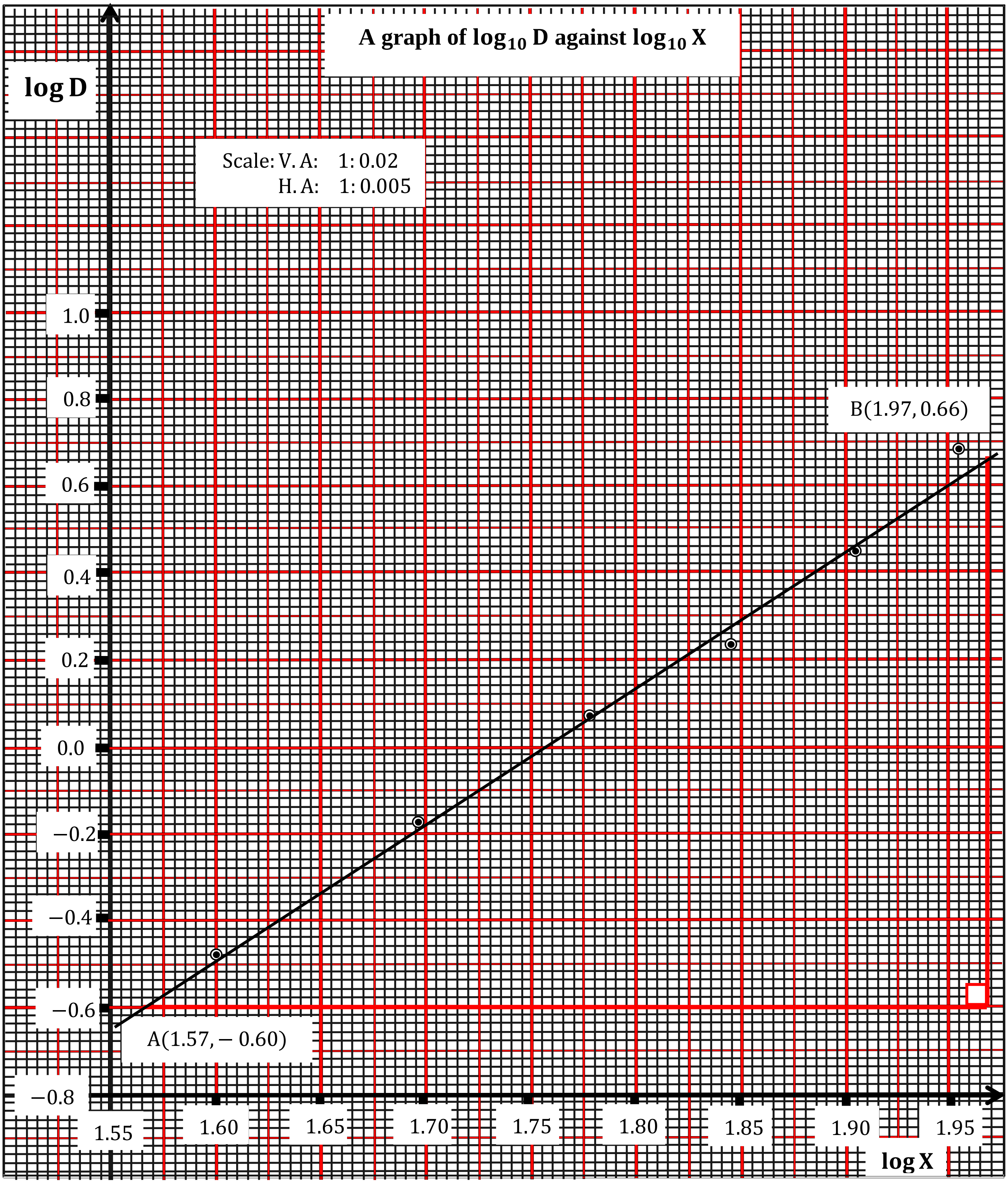
$\mathbf{N = 3.2}$

<table>
<tr><td colspan="2">NOTE: Calculation for the scale should be done as side work and should not be included on the answer sheet because no marks are awarded for the working.
SIDE WORK</td></tr>
<tr><td>Horizontal scale ($\log_{10}^{x}$ - axis)
$1:\dfrac{R_{HA}}{80}$
$1:\dfrac{1.954-1.602}{80}$
$1:\dfrac{0.352}{80}$
1: 0.044
1: 005

1 small square = 0.005
10 small squares = 0.05</td><td>Vertical scale ($\log_{10}^{D}$ –axis)
$1:\dfrac{R_{VA}}{100}$
$1:\dfrac{0.681-(-0.523)}{100}$
$1:\dfrac{1.204}{100}$
1: 0.01204
1: 0.02

1 small square = 0.02
10 small squares = 0.2</td></tr>
</table>

(k)


A graph of $\log_{10} D$ against $\log_{10} X$
log D
Scale: V. A: 1: 0.02
H. A: 1: 0.005
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
B(1.97, 0.66)
A(1.57, − 0.60)
1.55
1.60
1.65
1.70
1.75
1.80
1.85
1.90
1.95
log X

Example 2

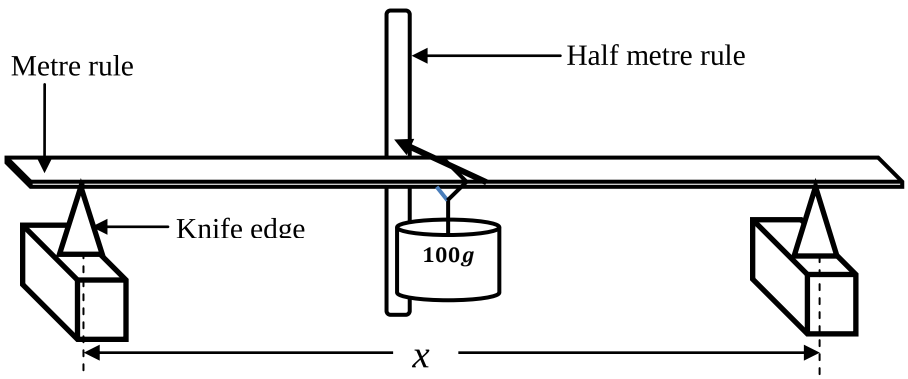
In this experiment, you will determine the Young's modulus of wood by two methods.

Method I

(a) Measure and record the thickens, ***t***, for the meter rule provided.

(b) Measure and record the width W of the meter rule.

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



(d) Fix a pointer at the 50 cm mark of the meter rule.

(e) Adjust the knife-edges such that their distance of separation is 0.9 m and 5cm from each free end.

(f) Read and record the position of the pointer.

(g) Suspend a mass M = 0.100 kg at 50 cm mark. Read and record the position of pointer, hence the depression d in meters.

(h) Repeat (g) for M = 0.200, 0.300, 0.400, 0.500 and 0.600 kg.

(i) Tabulate your results.

(j) Plot a graph of d against M.

(k) Find the slope, S.

(l) Find Young's modulus; $\mathbf{Y_1}$, from; $Y_1 = \dfrac{1.79}{W t^3 S}$

Method II

(a) Using the set up in the figure above, adjust the knife edges such that they are equidistant from the 50 cm mark of the meter rule and their separation $\mathbf{X_1}$, is 0.40 m.

(b) Read and record the position of the pointer on the half meter rule.

(c) Suspend a mass of 500 g at the 50 cm mark of the meter rule.

(d) Record the new position of the pointer and hence determine the depression, h_1 of the pointer in metres.

(e) Remove the mass, M.

(f) Repeat procedures (a) to (c) for $\mathbf{X_2} = 0.70$ m.

(g) Record the new position of the pointer and hence determine the depression, h_2, of the pointer in meters.

(h) Calculate Young's modulus; Y_2, from $Y_2 = \frac{1.47}{Wt^3\varphi}$ where $\varphi = 0.5\left(\frac{h_1}{x_1^3} + \frac{h_2}{x_2^3}\right)$

(i) Comment on the values of Y_1 and Y_2

-END-

Apparatus:
Meter rule, 2 knife edges, 1 mass of 50g, vernier calipers, and a micrometer screw gauge.

SOLUTION:

Method I

Recording Single readings:

(a) Thickness of metre rule

t_1(mm)	t_2(mm)	t_3(mm)
6.20	6.22	6.21

$$t = \frac{t_1 + t_2 + t_3}{3}$$

$$t = \frac{6.20 + 6.22 + 6.21}{3}$$

$\therefore$ t = 6.21mm

(b) Width of mete rule

w_1(cm)	w_2(cm)	w_3(cm)
1.69	1.68	1.68

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

$$w = \frac{1.69 + 1.68 + 1.68}{3}$$

w = 1.68 cm

Recording Repeated readings:

(f) Let; Po be the initial position of the pointer,
P_1 be the new position of the pointer.

(g) P_o= 21.7cm = P_o= 0.217m
P_1= 22.5cm = P_o= 0.225m

(h) Table of results

m(kg)	P_1(cm)	P_1(m)	d(m)
0.100	22.5	0.225	0.008
0.200	23.1	0.231	0.014
0.300	24.1	0.241	0.024
0.400	25.0	0.250	0.033
0.500	25.9	0.259	0.042
0.600	26.8	0.268	0.051

(a) From the graph,	**j)**
$\text{Slope, S} = \dfrac{\text{Change in Depression, d}}{\text{Change in mass, M}}$ $\text{Slope, S} = \dfrac{(0.06 - 0.006)\text{m}}{(0.7 - 0.1)\text{kg}}$ $S = 0.09\ \text{mkg}^{-1}$	$Y_1 = \dfrac{1.79}{W t^3 S}$ $Y_1 = \dfrac{1.79}{(1.68\times10^{-2})(6.21\times10^{-3})^3(0.09)}$ $Y_1 = 5\times10^{9}\ \text{Nm}^{-2}$

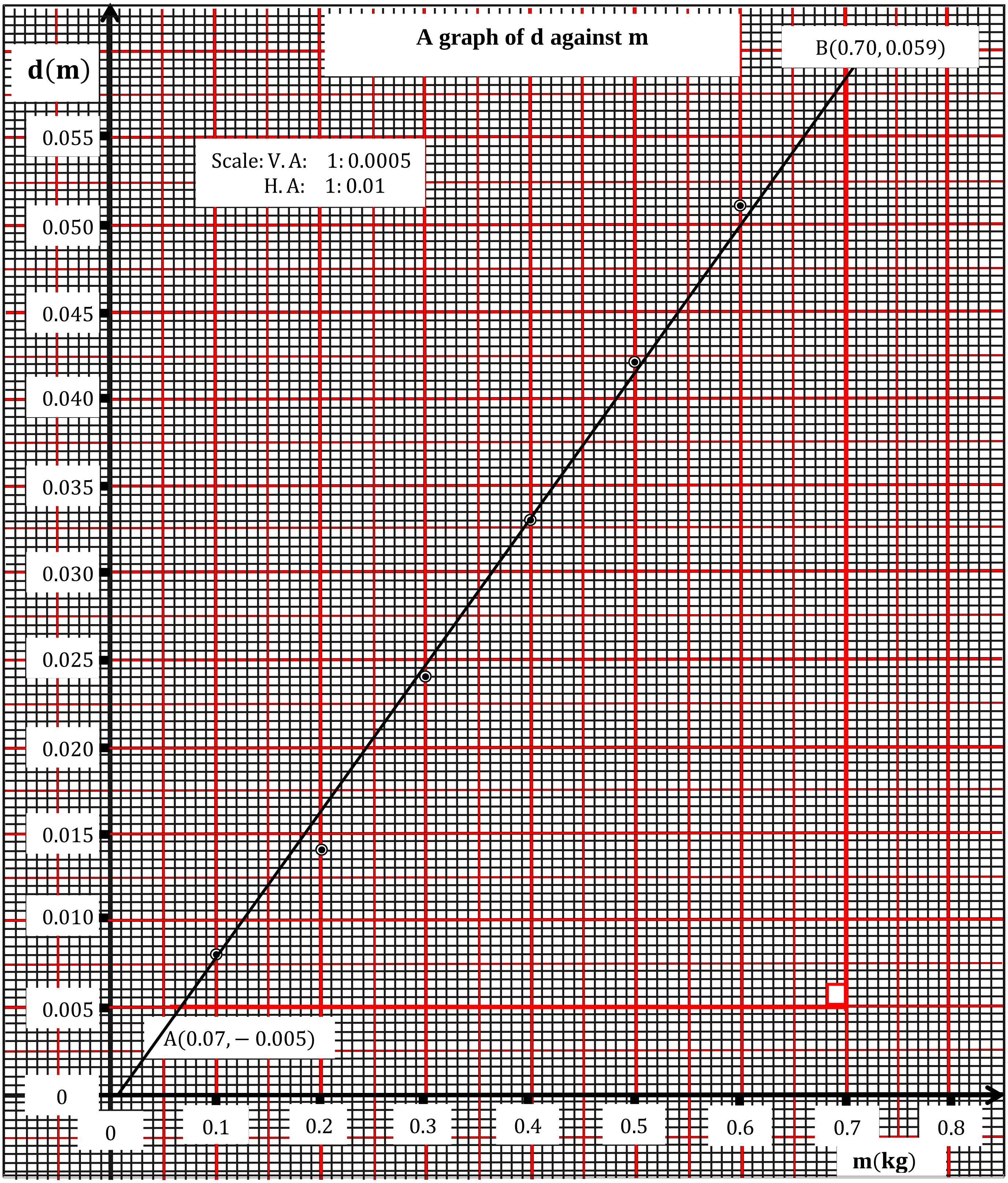
Method II

$X_1 = 0.40$ m **a)** $P_0 = 21.0$ cm $= 0.210$ m **b)** $P_1 = 21.3$ cm $= 0.213$ m $h_1 = P_1 - P_0$ $= 0.213-0.210$ $= 0.003$ m **g)** $X_2 = 0.70$ m $P_0 = 21.2$ cm $= 0.212$ m $P_2 = 23.1$ cm $= 0.231$ m $h_2 = P_2 - P_0$ $= 0.231-0.212$ $= 0.019$ m	**h)** $\varphi = 0.5\left(\dfrac{h_1}{x_1^3} + \dfrac{h_2}{x_2^3}\right)$ $\varphi = 0.5\left(\dfrac{0.003}{(0.40)^3} + \dfrac{0.019}{(0.70)^3}\right)$ $\varphi = 5\times10^{-2}\ \text{m}^{-2}$ t = 6.12 mm = 0.00612m w = 1.68 cm = 0.0168m $Y_2 = \dfrac{1.47}{W t^3 \varphi}$ $Y_2 = \dfrac{1.47}{0.0168\times(0.00612)^3\times0.05}$ $Y_2 = 7\times10^{9}\ \text{Nm}^{-2}$

NOTE: Calculation for the scale should be done as side work and should not be included on the answer sheet because no marks are awarded for the working.

SIDE WORK

Horizontal scale (m - axis)	**Vertical scale (d –axis)**
$1 : \dfrac{R_{HA}}{80}$ $1 : \dfrac{0.6 - 0}{80}$ 1: 0075 1: 01 **1 small square = 0.01** **10 small squares = 0.1**	$1 : \dfrac{R_{VA}}{100}$ $1 : \dfrac{0.051 - 0.005}{100}$ 1: 0.00046 1: 0.0005 **1 small square = 0.0005** **10 small squares = 0.005**



A graph of d against m
d(m)
B(0.70, 0.059)
Scale: V. A: 1: 0.0005
H. A: 1: 0.01
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0
A(0.07, − 0.005)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
m(kg)

Example 3

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

Procedure

(a) Suspend the pendulum bob from a retort stand such that it is at a distance h = 0.10 m from the floor.

(b) Adjust the length of the pendulum to 1.20 m.

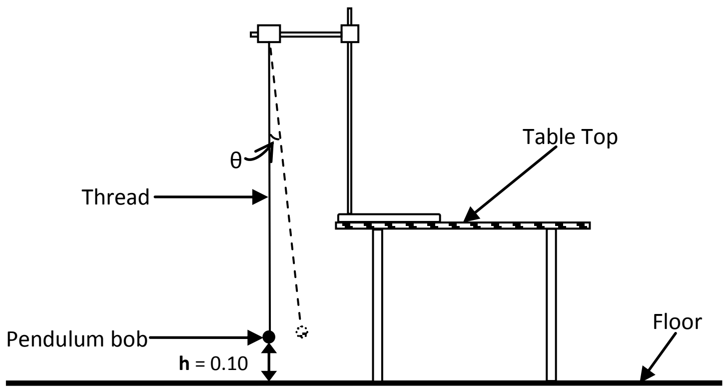


Fig. 3

(c) Displace the bob through a small angle θ as shown in Fig. 2 above. Release it to oscillate in a vertical plane.

(d) Determine the time for 20 oscillations.

(e) Find the time, T, for one oscillation.

(f) Raise the pendulum bob (by reducing the length of the pendulum) by a distance h = 0.20, 0.30, 0.40, 0.50 and 0.60 m and in each case repeat procedures (c) to (e).

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

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

(i) Find the slope, **s**, of the graph.

(j) Calculate the acceleration due to gravity, g, from the expression

$$\boldsymbol{s = \frac{-4\pi^2}{g}}$$

Apparatus :
Thread (130cm long), metre-rule, pendulum bob, retort stand with clamp and a stop clock or stop watch

SOLUTION

Recording single readings:

Let t be the time for twenty oscillations.

a) For h = 0.10 m ,

d) t = 20T = 44.57s; $T = \frac{t}{20} = \frac{44.57}{20} = 2.229$ s

Recording repeated readings:

e) **The table of results**

h(m)	t(s)	T(s)	$T^2(s^2)$
0.10	44.57	2.229	4.968
0.20	43.05	2.153	4.635
0.30	41.03	2.052	4.210
0.40	39.21	1.961	3.846
0.50	36.48	1.824	3.327
0.60	34.33	1.717	2.948

i) From the graph,

Using the points from the graph**:** A(0.66,2.80 and B(0.07, 5.06)

g) Slope S from A to B;

$$S = \frac{5.06 - 2.80}{0.07 - 0.66}$$

$$S = \frac{2.26}{-0.59}$$

$$S = -3.8\ s^2m^{-1}$$

h) From;

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

$$g = \frac{-4\left(\frac{22}{7}\right)^2}{-3.8}$$

$$g = 10.4\ ms^{-2}$$

NOTE: Calculation for the scale should be done as side work and should not be included on the answer sheet because no marks are awarded for the working.

SIDE WORK

Horizontal scale (h-axis)

$$1 : \frac{R_{HA}}{80}$$

$$1 : \frac{0.6 - 0}{80}$$

$1 : 0.0075$

$1 : 0.01$

1 small square = 0.01 m

10 small squares = 0.1 m

Vertical scale (T^2 –axis)

$$1 : \frac{R_{VA}}{100}$$

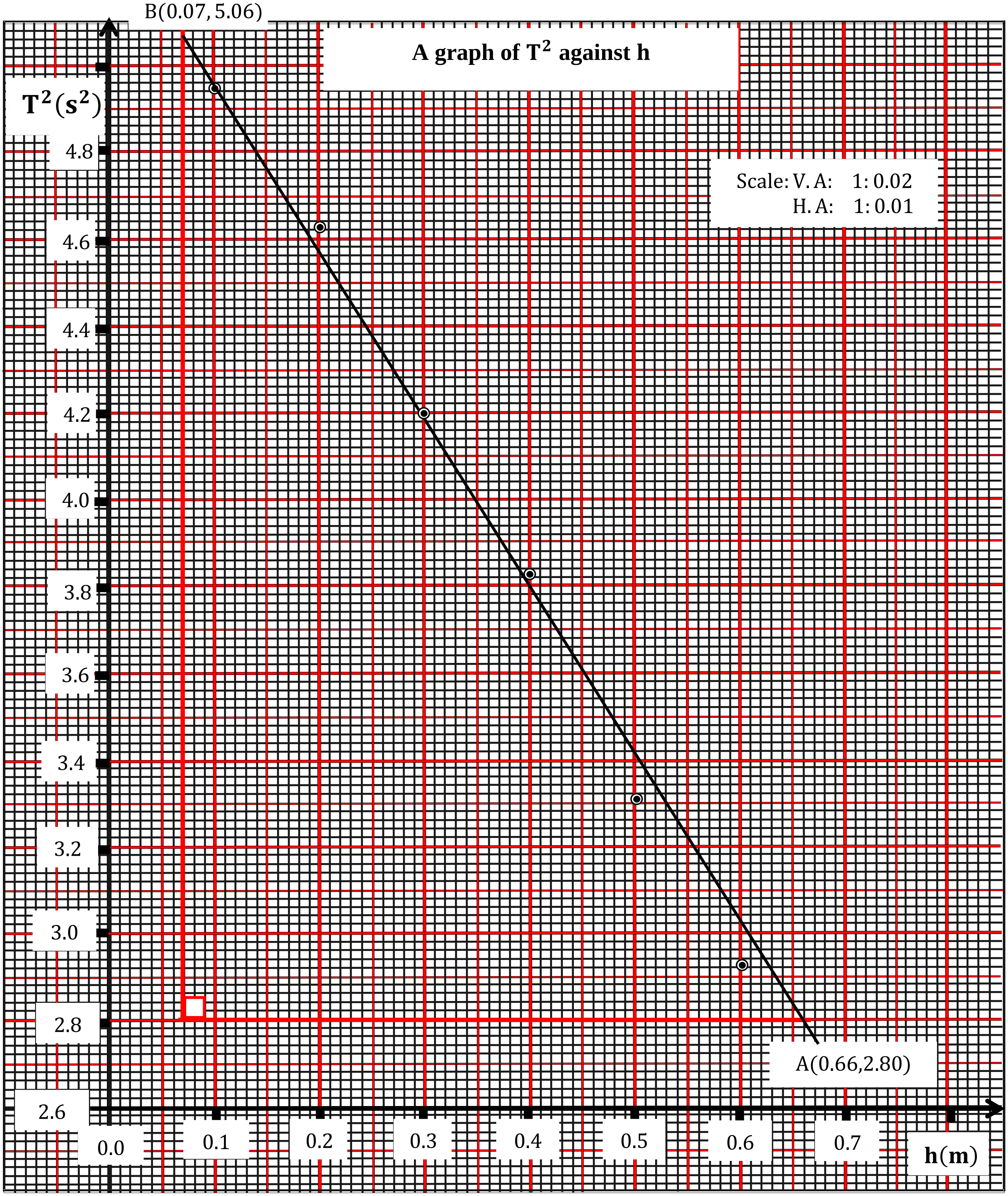
$$1 : \frac{4.97 - 2.99}{100}$$

$1 : 0.0198$

$1 : 0.02$

1 small square = 0.02 s^2

10 small squares = 0.2 s^2



B(0.07, 5.06)
A graph of T^2 against h
$T^2(s^2)$
4.8
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
Scale: V. A: 1: 0.02
H. A: 1: 0.01
A(0.66,2.80)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
h(m)

Example 3:

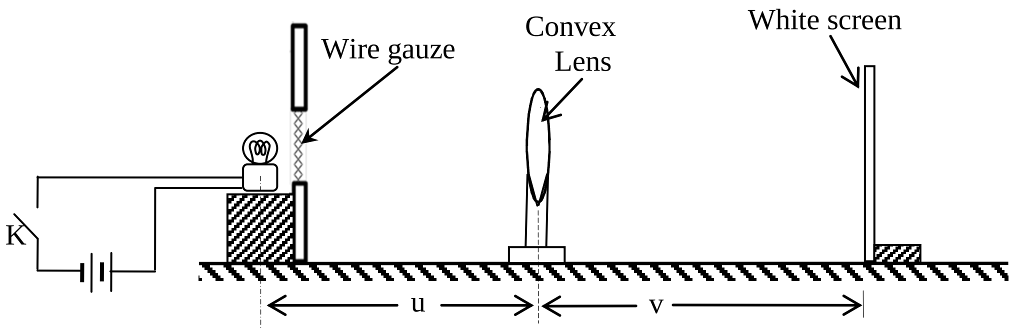
In this experiment, you will determine the focal length of the lens provided.

Procedure:

(a) Focus a distant object on to the screen.

(b) Measure and record the distance, f, between the object and the screen.

(c) Arrange the apparatus as shown in the figure bellow.



(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 procedure (d) and (e) for value 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.

Apparatus
A convex lens, white screen, 2 dry cells in a cell holder, a torch bulb in bulb holder and wire gauze fixed in a vertical board with a hole

SOLUTION

Recording single readings:

c) F =10.0 cm

e) v = 29.0 cm.

Recording repeated readings:
g) **The table of results**

u(cm)	v(cm)	(u + v) (cm)
15	29.0	44
20	19.6	40
25	17.2	42
30	16.0	46
35	15.0	50
40	13.0	53
45	12.5	58

i) **From the graph**,

Using the point read from the graph: $\mathrm{W} = 40\ \mathrm{cm}$

$$\text{Focal length, } \mathrm{F} = \frac{\mathrm{W}}{4}$$

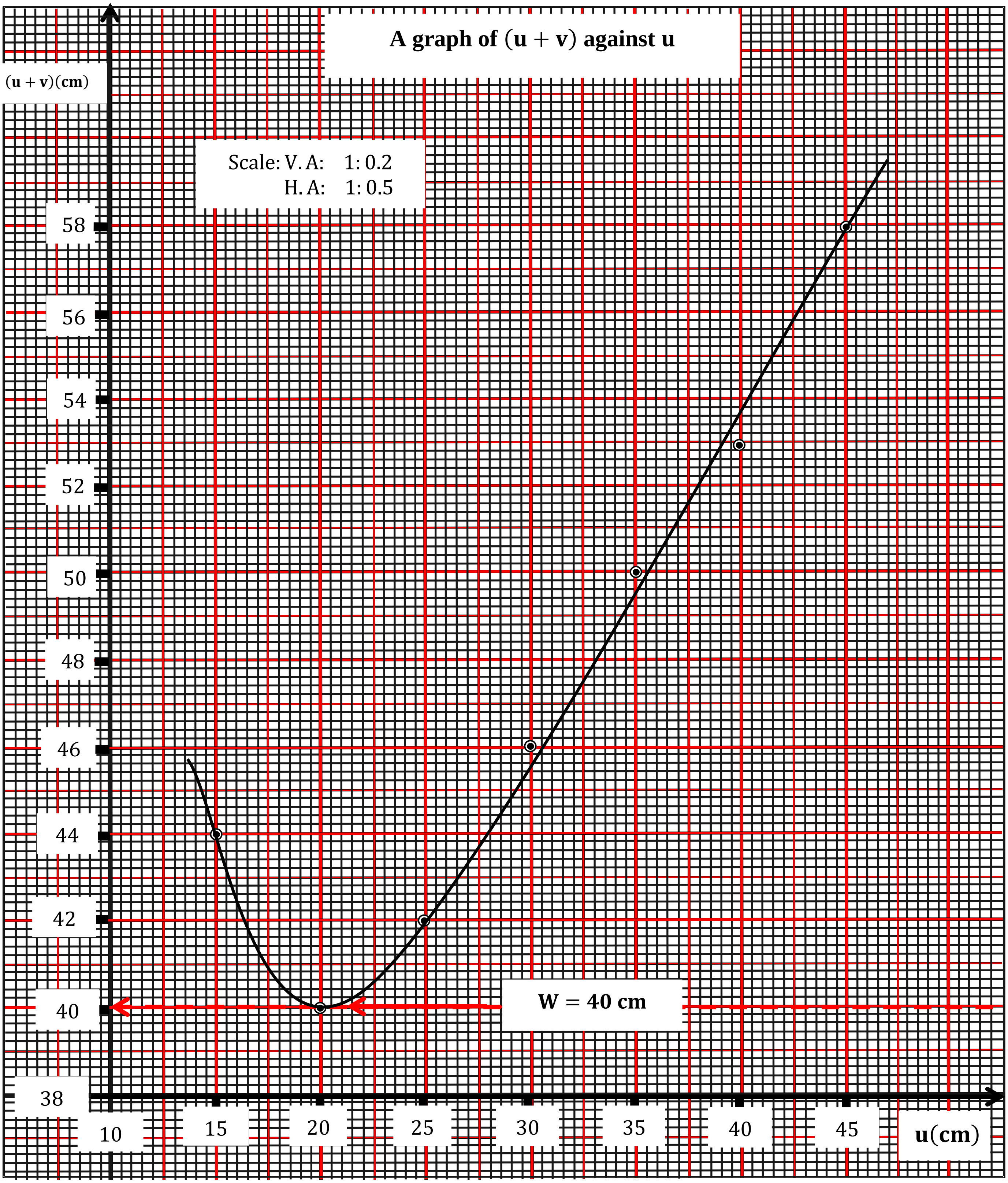
$$\mathrm{F} = \frac{40\ \mathrm{cm}}{4}$$

$$\mathrm{F} = 10\ \ \mathrm{cm}$$

NOTE: Calculation for the scale should be done as side work and should not be included on the answer sheet because no marks are awarded for the working.

SIDE WORK

Horizontal scale: (u - axis)	**Vertical scale: (u+v)–axis**
$1:\frac{R_{HA}}{80}$	$1:\frac{R_{VA}}{100}$
$1:\frac{45-10}{80}$	$1:\frac{58-38}{100}$
1: 0.4375 1: 0.5	1: 0.2
1 small square = 0.5 cm **10 small squares = 5.0 cm**	**1 small square = 0.2 cm** **10 small squares = 2.0 cm**


A graph of (u + v) against u
(u + v)(cm)
Scale: V. A: 1: 0.2
H. A: 1: 0.5
58
56
54
52
50
48
46
44
42
40
38
W = 40 cm
10
15
20
25
30
35
40
45
u(cm)

Example 4:

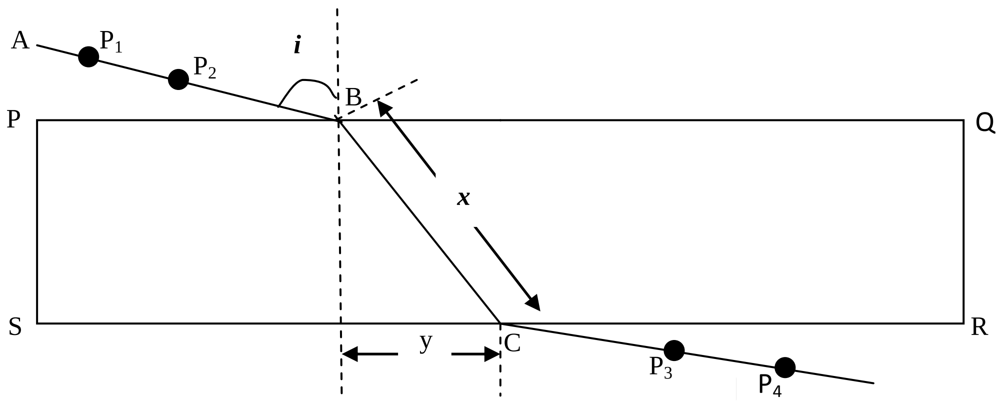
In this experiment, you will determine the refraction index 'n' of a glass block provided.

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 sheet and using a pencil, mark the outline PQRS of the glass block

c) Remove the glass block. Draw 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 its outline.

f) Stick two pins P_1 and P_2 along AB and looking through the glass block the opposite face SR, stick 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. Measure and record the distance *x* and y

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

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

j) Plot a graph of $\sin \boldsymbol{i}$ against $\frac{\boldsymbol{x}}{\boldsymbol{y}}$

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

l) State the significance of your value for the slope in (k) above.

Apparatus
Glass block, white sheet of paper,4 optical pins, 4 drawing pins, soft board and a complete geometry set

SOLUTION

Recording single readings:

h) For $i = 10^0$,

g) x = 1.0 cm,

y = 6.6 cm

Recording repeated readings:

i) **The table of results**

$i(^0)$	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

l) **From the graph**,

Using the points read from the graph: $\mathrm{A}(0.10, 0.10)$ and $\mathrm{B}(0.65, 1.00)$

$$\text{Slope, n} = \frac{1.00 - 0.10}{0.65 - 0.10}$$

$$\text{Slope, n} = \frac{0.90}{0.55}$$

$$n = 1.6$$

k) Significance of the slope:

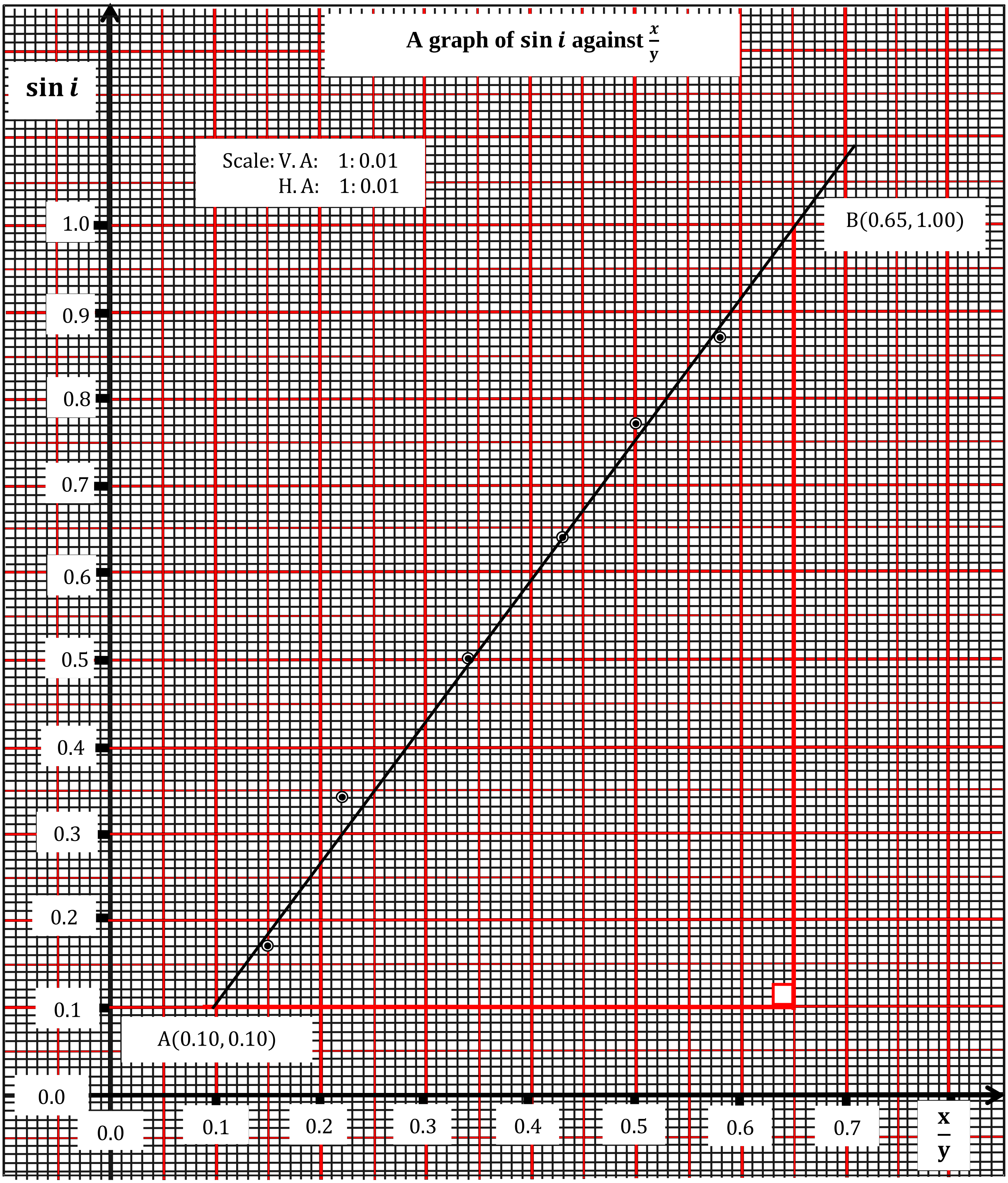
The slope represents the refractive index of the material of the glass block that was provided.

NOTE: Calculation for the scale should be done as side work and should not be included on the answer sheet because no marks are awarded for the working.

SIDE WORK

Horizontal scale ($\frac{x}{y}$ - axis)	**Vertical scale (sin*i* –axis)**
$1 : \frac{R_{HA}}{80}$	$1 : \frac{R_{VA}}{100}$
$1 : \frac{0.58 - 0.15}{80}$	$1 : \frac{0.866 - 0.174}{100}$
1: 0.005375 1: 0.01 **1 small square = 0.01** **10 small squares = 0.1**	1: 0.00692 1: 0.01 **1 small square = 0.01** **10 small squares = 0.1**

(j)



A graph of sin i against $\frac{x}{y}$
sin i
Scale: V. A: 1: 0.01
H. A: 1: 0.01
B(0.65, 1.00)
A(0.10, 0.10)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
$\frac{x}{y}$

HOW TO MAKE A PHYSICS PRACTICAL MARKING GUIDE

The marking guide for a Physics practical paper is coded (i.e letters are used). These codes include:
Ds, For drawings or diagrams, **R**s, For recording single measurements or noon repeated measurements, **T**s, for marks scored on the table, **G**s, for marks scored on the graph, **C**s, for marks awarded on the calculation using the given formula and **I**s, for marks awarded on intercepts read from the graph. However, any other code may be used for convenience.

1. Drawings or Diagrams		
$\mathbf{D_s}$: D_1, D_2, D_3, e.t.c	$\mathbf{D_s}$: are used for diagrams on questions of light involving tracing of light rays through a glass block or a glass prism.	Each should be awarded $\frac{1}{2}$ or 1 mark.
2. Recording Single readings (Non repeated measurements)		
$\mathbf{R_s}$: R_1, R_2, R_3, e.t.c	$\mathbf{D_s}$: are used for marks scored on recording non repeated values. Marks may be given for the value **and** the unit or for the value **with** the unit. **Value and unit** means, the value scores and the unit also scores. **Value with unit** means, both the value and the unit must be correct for the mark to be given. A candidate scores zero if only one is correct.	Each should be awarded $\frac{1}{2}$ or $1\frac{1}{2}$ marks @
3. Table of results $\mathbf{T_s}$: are used for marks scored on the table of results. Values of repeated quantities and their corresponding derivatives should be presented in 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.		
$\mathbf{T_s}$: T_1, T_2, T_3.	$\mathbf{T_1}$: For labeling columns of given values. Candidates should record the values, symbols and units as they are given in the question. Eg. $y(\text{cm}), \text{m}(\text{kg}), \text{t}(\text{s}), \text{T}^2(\text{s}^2)$ etc All values of the independent variable should be entered in the table.	$\frac{1}{2}$ mark.
	$\mathbf{T_2}$: For labeling columns of the remaining repeated measured and derived quantities with units if any. Marks can be awarded as follows: $\frac{1}{2}$ for 1 extra column, $\frac{1}{2}$ for @ extra column, $\frac{1}{2}$ for any 2 columns 1 for all columns.	$\frac{1}{2}, 1, 1\frac{1}{2}$ or 2 marks
	$\mathbf{T_3}$: For directly measured repeated and derived values. E.g Read and record V, I, Tabulate results including values of $\frac{1}{I}$. ❖ Recording all repeated measurements e.g $V(V), I(A)$ ❖ Recording all derived values correctly e.g $\frac{1}{I}(A^{-1}), \frac{V}{I}(\Omega)$ (Subtotal up to this stage should be 10 or 11 or 12 marks)	$\frac{1}{2}$, 1 or $1\frac{1}{2}$ marks @. No marks for wrong values or fabricated values recorded in the table.
4. Graph work		
$\mathbf{G_s}$: G_1, G_2, G_3 e.t.c	$\mathbf{G_1}$: For the **title** of the graph. It should be quoted from the instruction requiring the candidate to draw the graph. The title should have units. It should be written on one line.	$\frac{1}{2}$ mark
	$\mathbf{G_2}$: For labeling the **axes** with quantity and units is any. Correct symbols should be used and the units must be in brackets.	$\frac{1}{2}$ mark @ axis
	$\mathbf{G_3}$: For suitable, convenient and consistent **scales** used on both axes of the graph.	$\frac{1}{2}$ mark @ axis
	$\mathbf{G_4}$: For correctly **plotting** the required points from the table of results. Candidates should use accepted signs for plotting a point. E.g cross, plus, dot and all these enclosed in a circle of the size of the smallest square of the graph paper. i.e, •, ⊙, +, ⊕	$\frac{1}{2}$ mark @ correctly plotted point.

	Wrong values (those out of the required range) in the table of results should score when correctly plotted. Fabricated and over rounded off values in the table of results <u>should not</u> score when correctly plotted.	
	$\mathbf{G_5}$: For drawing the **line of best fit**. It must fulfill the following conditions. ✓ At least 3 correctly plotted points seen ✓ Line of best fit 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 sides of the line. ✓ It can also be a line which does not pass through any of the plotted points but just averages the plotted points.	$\frac{1}{2}$ mark
	$\mathbf{G_6}$: For the method of finding the slope. A right angled triangle covering all the plotted points should be drawn. No marks are awarded for a triangle drawn in the area of distorted scale.	$\frac{1}{2}$ mark
5. Calculations		
$\mathbf{C_s}$: C_1, C_2, C_3 e.t.c	$\mathbf{C_s}$: For awarding marks on calculations as follows. ✓ Correct formula used, ✓ Correct substitution into the formula, ✓ Correct arithmetic, ✓ Correct units attached, ✓ Accuracy of the calculated value. (i.e, value within the stipulated range)	$\frac{1}{2}$, 1 or $1\frac{1}{2}$ marks
6. Intercepts		
$\mathbf{I_s}$: I_v and I_h,	$\mathbf{I_V}$: For intercept on the vertical axis $\mathbf{I_h}$: For intercept on the horizontal axis. Marks may be given for the correct value **and** the unit or for the correct value **with** the unit. **Conditions:** ✓ Line of best must be seen ✓ Scales should not be distorted ✓ Intercept must be correctly read from the graph ✓ If intercepts on both axes are required, both axes must begin from zero. ✓ For intercept on the vertical axis, the horizontal axis must begin from zero. ✓ For intercept on the horizontal axis, the vertical axis must begin from zero. ✓	$\frac{1}{2}$, 1, $1\frac{1}{2}$ or 2 marks

SAMPLE MARKING GUIDE FOR THE ABOVE EXPERIMENT

CODE	DESCRIPTION	MARKS
D_1	Tracing the outline PQRS of the glass block	= ½mrk
D_2	Drawing a perpendicular at point B_1 =1.5cm from P	= ½mrk
D_3	Drawing a line AB such that angle I =10^o and sticking pins P_1 and P_2 along AB	= ½mrk
D_4	Sticking pins P_3 and P_4 in line with the images of P_1 and P_2	= ½mrk
D_5	Drawing a line through pin marks P_3 and P_4 to meet SR at C and joining C and B	= ½mrk
	Sub-total	**2½marks**
R_1	Recording the values of x to 1dp when ***i*** =10^o and unit: range (0.8 – 4.8) (cm) value = ½ ;unit: (cm) = ½ mrk	=2½mrks
R_2	Recording the values of y to 1dp when *i* = 10^o and unit range (6.4 – 8.6) (cm) value = ½ mrk; unit (cm) = ½ mrk	=2½mrks
	Sub-total	**05marks**
T_1	Design of the table of results with 5 columns, *i* – column labeled with unit $i(^o)$ and all values entered	=2½mrk
T_2	Label of the rest of the 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) (@½ mrk)	=3mrks
T_3	Recording 7 values of sini and x/y correctly calculated (any 3 correct) (@½ mrk)	=7mrks
	Sub-total	**12½ marks**
G_1	Title of the graph; A graph of sini against x/y	=½mrk
G_2	The label of the axes with units; sini and x/y (@½ mrk)	=1mrk
G_3	Suitable and convenient scales for the axes covering at least 50% of graph paper (@½ mrk)	=1mrk
G_4	7correctly plotted points (@½ mrk)	=2½ mrks
G_5	The best straight line that fits the plotted points	=½ mrk
G_6	The method of finding the slope. Big triangle covering all plotted points	=½ mrk
	Sub-total	**06 marks**
C_1	Calculation of the slope, n	=1mrk
C_2	Correct substitution	=1 mrk
C_3	Arithmetic	=1 mrk
C_4	Accuracy	=1 mrk
	Sub-total	**04 marks**
	TOTAL	**<u>30 marks</u>**

1. MECHANICS EXPERIMENTS

Precautions in Mechanics experiments.

(i) Timing oscillations

- ✓ Disturbances due to wind can be avoided by switching off the fans and closing windows and doors.
- ✓ Ignore the first few oscillations and start timing only when the oscillations are steady.
- ✓ Make sure that the angle through which the pendulum swings is small. Always give the pendulum a small displacement.
- ✓ The length of the pendulum should be measured from the point of suspension to the centre of the bob.
- ✓ When the oscillations of the pendulum become elliptical, stop timing and displace the pendulum bob again.

(ii) Parallax errors

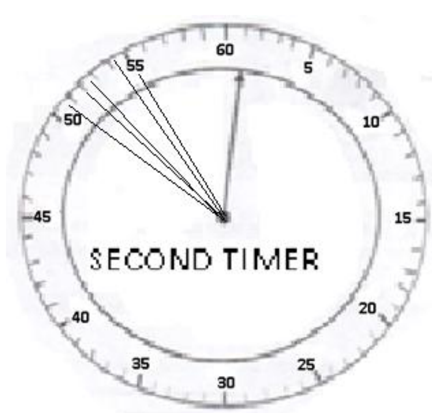
- ✓ When reading a measuring cylinder or thermometer, parallax errors can be minimized by viewing the reading at eye- level and at the meniscus.
- ✓ When reading analogue meters such as ammeters, voltmeters, stop clocks, e.t.c, minimize parallax errors by viewing the pointer from a point directly opposite such that the pointer coincides with its image.

(a) MEASUREMENT OF TIME

The instruments commonly used for measuring time in the laboratory are the stop clock and stop watch. Before using these instruments, ensure that the initial reading is zero.

(i) Stop clock

- ✓ It measures time in seconds. 1 small division on the scale of stop clock=1s OR 1 small division = 0.5s
- ✓ It is possible to estimate time to 1 d.p with both Stop Clocks.
- ✓ Both Clocks record time to one decimal place (1 d.p) and the last digits in any values should be a .0 or .5. Typical Values are 8.0s, 10.0s, 22.5s, 55.0s



In the figure, the reading of the stop clock is 60.5s or 0.5s (to 1 decimal place).

In the 2nd figure above, the stop clock reading for the pointer in position A, B, C, D and E is as follows;

In position A, stop clock reading = 50.5s

In position B, stop clock reading = 52.0s

In position C, stop clock reading = 53.0s not 52.8s

In position D, stop clock reading = 54.0s not 54.4s

In position E, stop clock reading = 55.0s

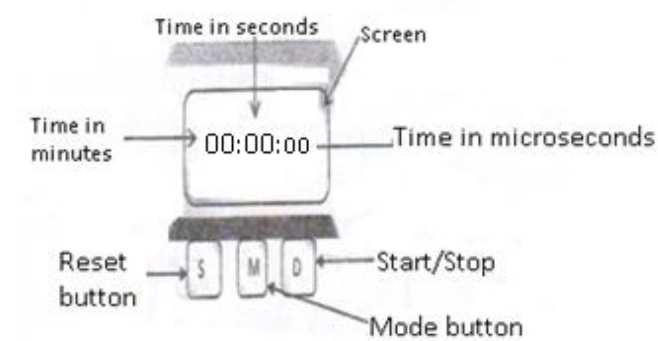
If the smallest division on the stop clock is **0.5s**, like the one above, then values of time are recorded to 1dp. However, if the smallest division is 1s,of time are recorded to **0dp** (as whole numbers)

(ii) Stop watch

The stop watch measures time in seconds(s) to two decimal places. All values of time obtained using a stop watch must be recorded to two decimal places e.g. 7.23, 25.56, 48.89 etc.

- ✓ The Stop Watch records time to the nearest 0.01s (2 d.p)
- ✓ Every reading recorded with this Stop watch must therefore be recorded to 2 d.p. Typical readings 1.20s, 4.07s, 50.00s, 54.38s. Wrong readings 7.321s, 20s, 41.6s, 48.0s

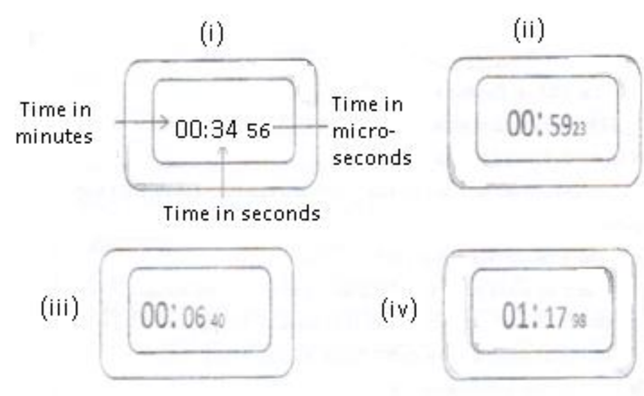
  Note: The stop watch may give values of time in minutes, seconds and microseconds. These values should be converted and recorded in seconds. Values of time should be recorded in minutes only when required in minutes.



Before using the stopwatch, reset it such that its initial reading is zero as in the figure above.

Examples

Convert the time t, in the figures below to seconds



(i) The reading is 34.56 seconds

(ii) The reading is 59.23 seconds

(iii) The reading is 6.40 seconds

(iv) The reading is 77.38 seconds i.e
$(1 \times 60 + 17.38 = 77.38 \text{ seconds})$

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

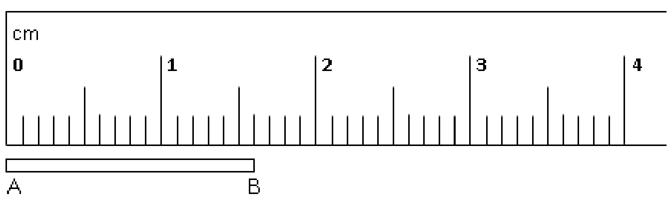
(b) MEASUREMENT OF LENGTH

Linear measurements in a physics laboratory are carried out using three basic instruments i.e.
Micrometer screw gauge, venier calipers and meter rule.
The use of these instruments depends on the linear size of the specimen.

(i) RULERS (E.g Metre- rule)

The different types of rulers are 15cm ruler, 30 cm rulers, half-metre rule and a metre-rule. They are all used in the same way.

- ✓ The metre rule measures lengths in Centimetres (cm)
- ✓ 1 Small division on the scale is equal to a length of 0.1cm
- ✓ This Value has one decimal place and it means that all measurements with a metre rule should be recorded to 1 decimal place in cm
- ✓ In metres 0.1cm = 0.001m, so when measurements on a metre rule are converted into metres, they should be recorded to 3 decimal places following the fact that ; 1 Small division= 0.1cm = 0.001m (3d.p)



From; 0 to 1, 1 to 2, 2 to 3, etc, there are 10 equal divisions.

$\Rightarrow \mathbf{10 divisions = 1cm}$

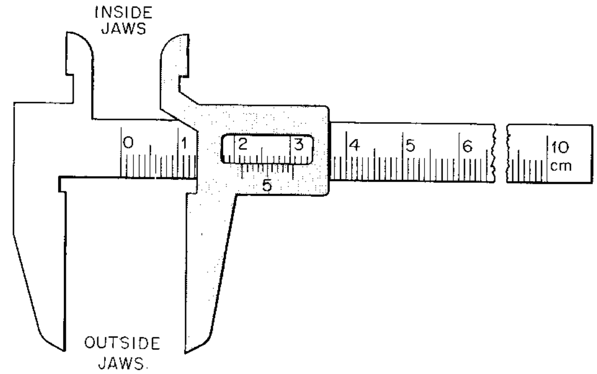
$$1 \text{ division} = \frac{1 \text{ cm}}{10} = 0.1 \text{ cm}$$

Therefore any reading from rulers is accurate 1 decimal place. Hence, such readings should be recorded to 1dp.

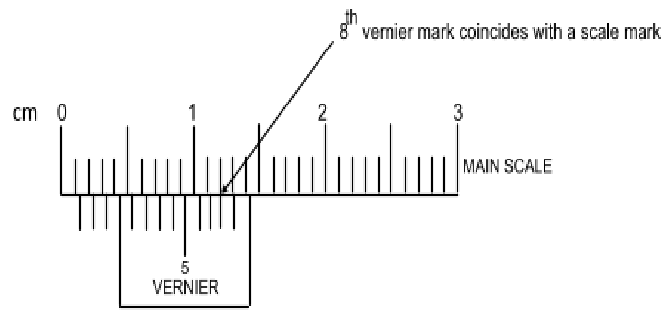
Length AB $= 1.0 \text{ cm} + (6 \times 0.1) \text{ cm}$
Length AB $= 1.6$ cm
Or Length AB $= 16 \times 0.1 = 1.6$ cm
Or Length AB $= 16 \times 0.1 = 1.6$ cm

(ii) THE VERNIER CALIPERS

The Vernier calipers is used for measuring length between 1cm and 10cm inclusive.
It also has two scales i.e. the main scale and the vernier scale.
The main scale is graduated in centimeters whereas the vernier scale is constructed by dividing 0.1cm into 10 equal divisions i.e. each division on the vernier scale is equal to 0.01cm.
The vernier calipers read to an accuracy of 2 decimal places in cm.



How to read a vernier Caliper

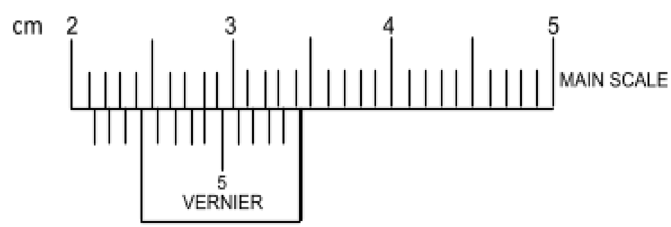


- The main scale is in centimeters, 1cm has 10 divisions each division is $\frac{1}{10}$ cm = 0.1cm.
- Vernier scale, each division is $\frac{1}{100}$ cm = 0.01cm.

Reading of vernier calipers,

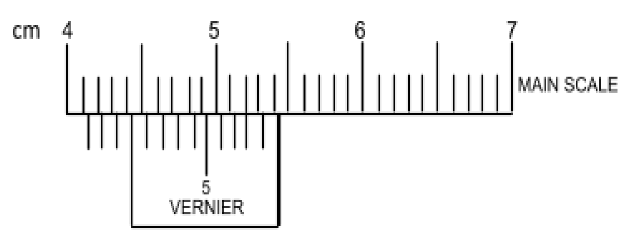
1. Record the reading on the main scale to two places in cm.
2. Look along the Vernier scale carefully until you see division on it which coincides with the main scale, this gives the second decimal place.

Examples:



Main scale = 2.40cm
Vernier scale = 0.04cm
Final reading = 2.44cm

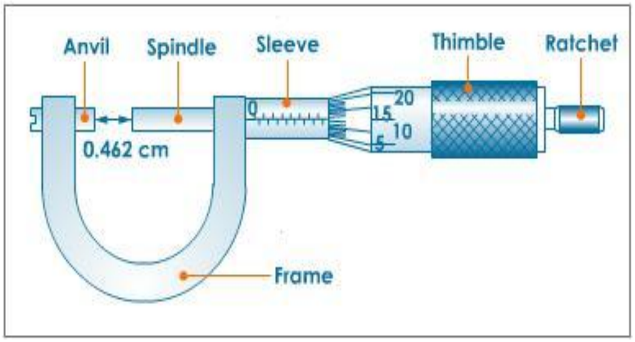
Qn: What readings are represented in the diagram?



(iii) MICROMETER SCREW GUAGE

The micrometer screw gauge is used for measuring smaller lengths of at most 1cm or 10mm such as diameter of wire and thickness of a metre rule.

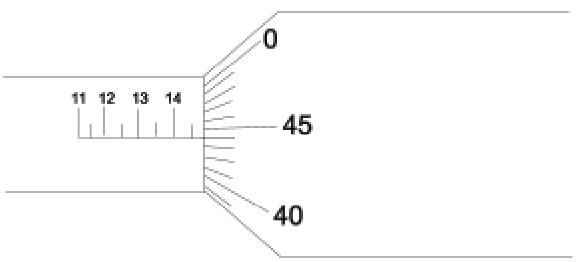
It has two scales i.e. the sleeve scale and the thimble or circular scale. The main scale is graduated in millimeter whereas the circular scale has either 50 or 100 divisions.



For each turn the spindle moves through 0.5mm.The fraction of each turn is indicated on the thimble. This has a scale of 50 divisions on the thimble and represents $\frac{1}{50}$ of half a millimeter i.e. $\frac{1}{10} \times 0.5$ mm = 0.01mm.

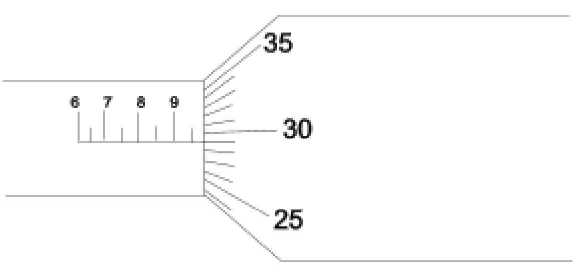
The sleeve-reading gives units to the 1st two decimal places and the thimble gives 2nd decimal place.

Example I:



Sleeve scale reading = 14.50mm
Thimble scale reading = 0.44mm
= 14.94mm

Example II:



Sleeve scale reading = 9.50mm
Thimble scale reading = 0.29mm
= 9.79mm

Precautions taken when using a micrometer screw gauge

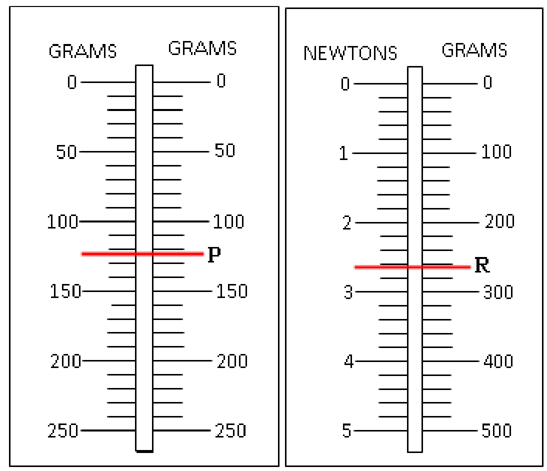
(i) The faces of the anvil and the spindle must be cleaned to remove dust so as to get accurate readings.
(ii) The reading must be checked.

(c) MEASUREMENT OF MASS AND WEIGHT

Using a spring balance

A spring balance can be used to measure mass only or both mass and weight.

If it measures both mass and weight, it has two scales, one for measuring weight in newtons (N) and the other for measuring mass in grams (g) as shown in the figure below.



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

Reading of Pointer P:

From 0 to 50g, there are 5 equal divisions:

The mass (Reading of pointer P) is obtained using the scale on the left or right side as follows;

5 divisions $= 50\text{g}$ 1 division $= \frac{50}{5}\text{g} = 10\text{g}$ Mass of object $= 10 \text{ x}12$ $= 120\text{g}$	OR: $= 100 + 2 \times 10\text{g}$ $= 100 + 20\text{g}$ $= 120\text{g}$

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

If the mass is required in kg, then record in kg as 0.120 kg.

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

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

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

Reading of Pointer R:

From 0 to 1N, there are 5 equal divisions:

5 divisions $= 1\text{N}$ 1 division $= \frac{1}{5}\text{N} = 0.2\text{N}$ Weight of object $= 0.2 \text{ x}13$ $= 2.6 \text{ N}$	OR: $= 2 + 0.2 \times 3 \text{ N}$ $= 2 + 0.6\text{N}$ $= 2.6\text{N}$

1.01 Experiment 01

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

(a) Balance the metre rule provided on a knife-edge with the graduated side facing upwards.

(b) Note the balance point **P** and record its distance, $\boldsymbol{l_o}$, from end B.

(c) Place a mass **m** of 10 g on top of the metre rule at the 10 cm mark and balance the arrangement as shown in Fig. 1 below.

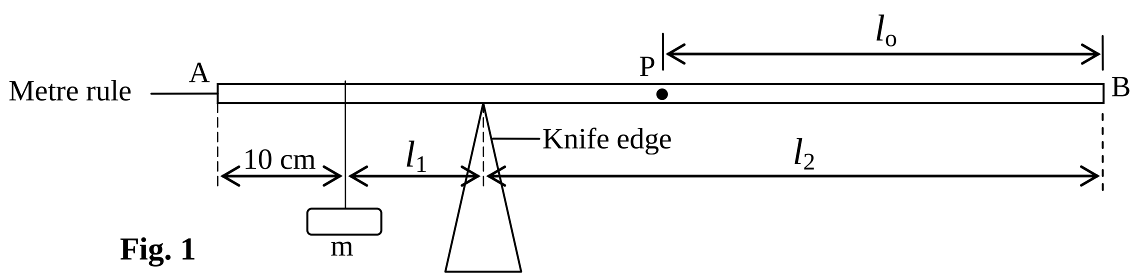


Fig. 1

(d) Read and record the distances l_1 and l_2.

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

(f) Record your results in a suitable table including the values of $(l_2 - l_o)$ and $\frac{l_2 - l_o}{l_1}$.

(g) Plot a graph of **m** against $\boldsymbol{\frac{l_2 - l_o}{l_1}}$.

(h) Find the slope, m of your graph.

Apparatus: *Knife edge; Metre rule; One mass of 10 g, Two masses of 20 g, One mass of 50 g [or you may use six 10 g masses]*

1.02 Experiment 02

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

(a) Suspend the metre rule provided from a clamp using a piece of thread.

(b) Adjust the metre rule until it balances horizontally.

(c) Read and record the balance point C.

(d) Place the thread at a distance of y = 10 cm from C as shown in Fig.2 below.

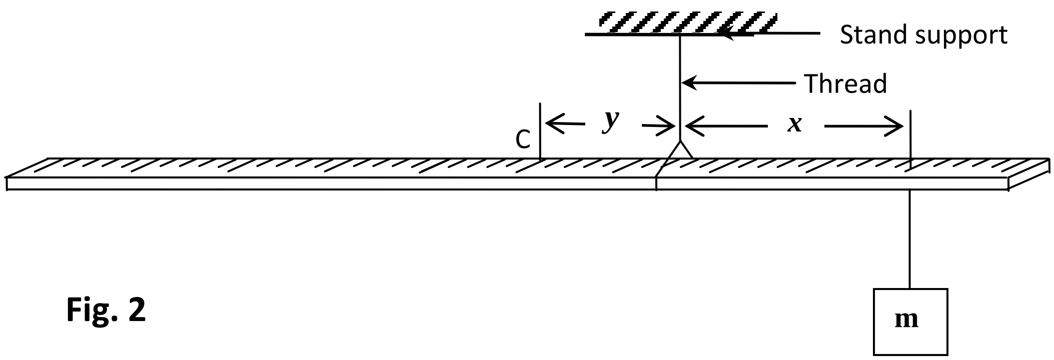


Fig. 2

(e) Starting with m = 40 g adjust the position of the mass m until the metre rule balances horizontally again.

(f) Measure and record the distance x.

(g) Repeat procedures (d) to (e) for values of m = 50, 60, 70, 80 and 100 g.

(h) Record your results in a suitable table including values of $\frac{1}{x}$.

(i) Plot a graph of m against $\frac{1}{x}$.

(j) Find the slope, S.

(k) Calculate the mass of the metre rule from the expression;

$$\mathbf{M = 0.10S.}$$

Apparatus: *One 10 g mass, two 20 g masses, one 50g mass and one 100g mass (slotted on a mass hanger); a metre rule; two pieces of thread, 30 cm each, Retort stand with clamp.*

1.03 Experiment 03

In this experiment you will determine the density, ρ, of the rubber bug provided.

(a) Record the mass, M of the metre rule provided.

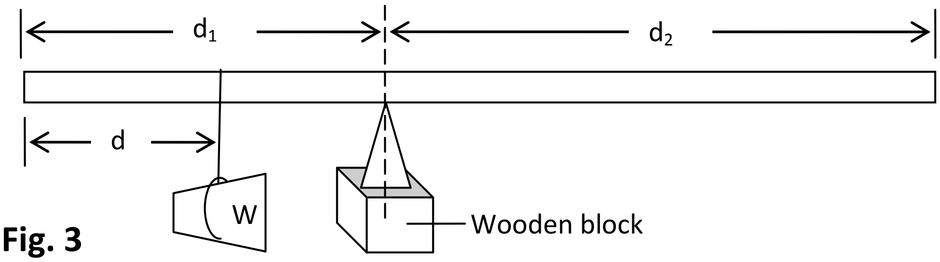


Fig. 3

(b) Suspend the rubber bung, W, at a distance d = 5 cm from the zero end of the metre rule.

(c) Balance the metre rule with its graduated face upwards on the knife edge as shown in Fig.3 above.

(d) Measure and record the distances, d_1 and d_2, of the knife edge from the zero and 100 cm marks of the metre rule respectively.

(e) Repeat procedures, (b) to (d) for values of d equal to 10, 15, 20, 25 and 30 cm.

(f) Tabulate your results, including values of $(d_2 – d_1)$ and $(d_1 – d)$.

(g) Plot a graph of $(d_2 – d_1)$ against $(d_1 – d)$.

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

(i) Determine the density, ρ, of rubber from the expression;

$$\boldsymbol{\rho = 0.5\ S.}$$

Apparatus: *Rubber bung; a metre rule labelled with its mass M; knife edge; wooden block, 20 cm × 15 cm × 15 cm and a piece of thread, 20 cm.*

1.04 Experiment 04

In this experiment, you will determine the density of water.

(a) Record the radius, r, of the small beaker (or can) provided

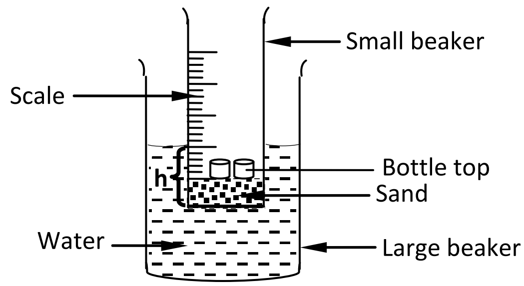


Fig. 4

(b) Place the small beaker (or can) into the large beaker containing water.

(c) Add small quantities of sand gradually into the small beaker until the beaker floats upright in the water as shown in Fig. 4 above. Make sure the small beaker does not touch the sides of the large beaker.

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

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

(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 number of bottle tops against h.

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

(j) Calculate the density of water, ρ, from the expression

$$\mathbf{2.5\,S = \rho\pi r^2.}$$

Apparatus : *A small beaker with its radius,* ***r*** *indicated and linear scale using a graph paper strip attached; a large beaker; 15 soda bottle tops; small amount of sand and water.*

1.05 Experiment 05

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

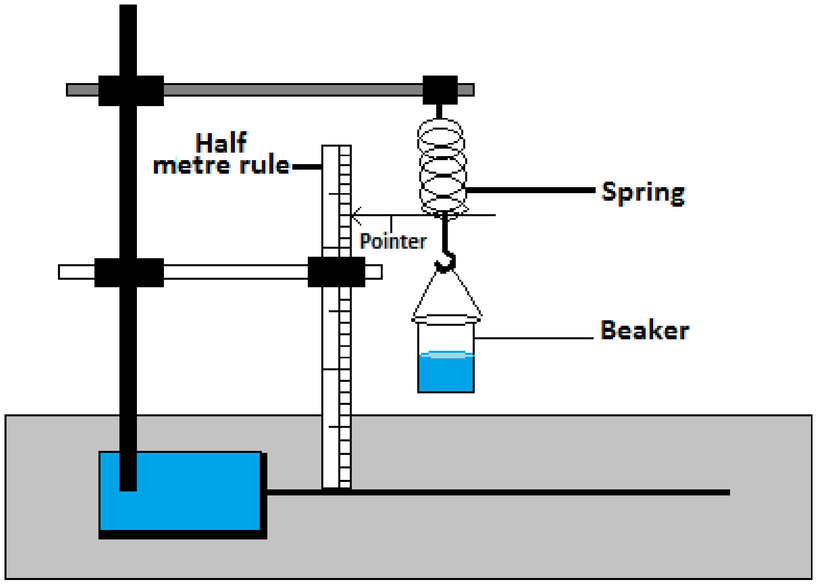


Fig.5

Procedure

a) Clamp the spring provided vertically and suspend the empty beaker as show in Fig.5

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

c) Pour volume, **V= 50 cm^3** of water into a beaker and record the new position of the pointer.

d) Find the extension, ***x*** produced.

e) Repeat the procedures (c) to (d) for **V= 100, 150, 200 and 250 cm^3**.

f) Pour out water and dry the beaker.

g) Repeat the procedures (a) to (e) using the liquid ***l*** and find its extension, ***y*** produced.

h) Record results in a suitable table.

i) Plot a graph of ***y*** against ***x***

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

Apparatus:
*Liquid, **l** (paraffin or Cooking oil or Petrol), water, Retort stand with 2 clamps, Metre rule, pointer, spiral spring, thread, measuring cylinder and a beaker.*

1.06 Experiment 06

In this experiment, you will determine the acceleration due to gravity, g using a spiral spring.

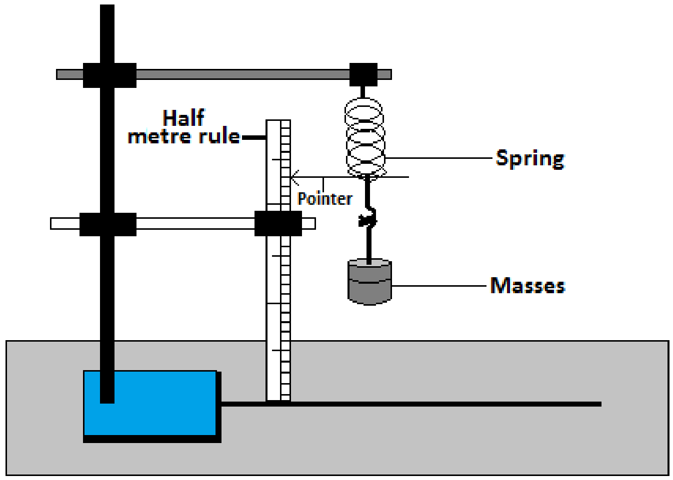


Fig. 6

PART ONE

a) Suspend the spiral spring provided from a clamp as shown in Fig. 6.
b) Read and record the position of the pointer on the metrerule.
c) Suspend the mass, **M** = 50 g from the free end of the spiral spring.
d) Read and record the new position of the pointer, find the extension, ***e*** of the spring.
e) Repeat the procedure in (c) and (d) for values of **M** = 100, 150, 200, and 250 g.
f) Tabulate your results in a suitable table.
g) Plot a graph of ***e*** against **M**.
h) Find the slope, $\mathbf{S_1}$ of the graph.

PART TWO

a) Remove the metre rule.
b) Displace the mass, **M** = **50 g** suspended from the spring through a small vertical distance and release it.
c) Determine the time, t for 20 oscillations.
d) Find the periodic time, T for an oscillation
e) Repeat the procedures (b) to (d) for values of **M** = **100,150, 200, and 250 g**.
f) Enter your results in a suitable table including values of T and T^2.
g) Plot a graph of T^2 against M
h) Determine the slope, $\mathbf{S_2}$ of the graph.
i) Find the value of acceleration due to gravity, **g**.From;

$$\mathbf{g} = \frac{4\pi^2 S_1}{100 S_2}$$

Apparatus: A retort stand with 2 clamp, 5 masses of 50 grams on a hanger, 1 spring, stop watch or clock, metre rule, pointer.

1.07 Experiment 07

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

(a) Suspend the pendulum bob from a retort stand as shown in Fig. 10 below.

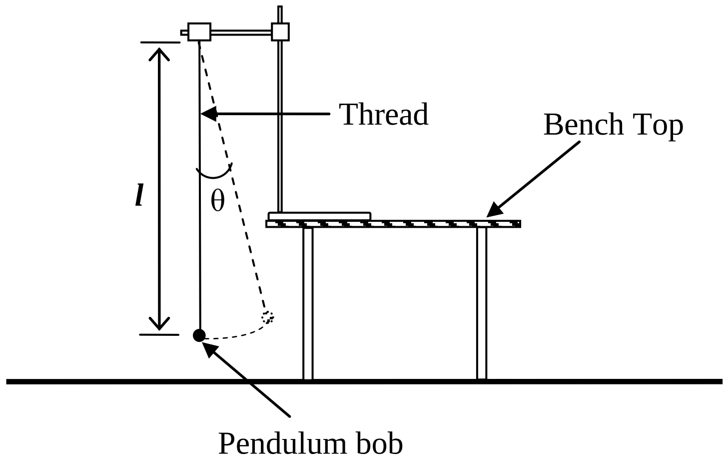


Fig. 7

(b) Adjust the length of the pendulum, ***l***, so that it is equal to 1.00m.

(c) Displace the bob through a small angle θ as shown in Fig. 7 above. Release it to oscillate in a vertical plane.

(d) Determine the time, t, for 20 oscillations.

(e) Find the time, T, for one oscillation.

(f) Repeat procedures (b) to (e) for values of ***l*** = 0.90, 0.80, 0.70, 0.60, 0.50 and 0.40 m.

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

(h) Plot a graph of T^2 against ***l***.

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

(j) Calculate the acceleration due to gravity, g, from the expression;

$$s = \frac{4\pi^2}{g}.$$

Apparatus
A pendulum bob, a string about 120 cm, a stop clock, metre rule and retort stand with a clamp.

1.08 Experiment 8

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

Procedure:

(a) Suspend the pendulum bob by means of a thread from a retort stand as shown in figure 8(a) below.

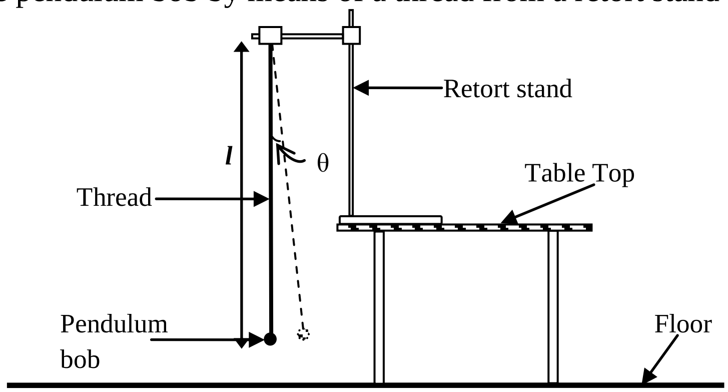


Fig. 8(a)

(b) Adjust the length of the pendulum bob, ***l*** to 1.20m.

(c) Displace the pendulum bob through a small angle θ and let it oscillate.

(d) Measure and record the time $\mathbf{20T_o}$ for 20 complete oscillations.

(e) Determine the time for one oscillation, $\mathbf{T_o}$**.**

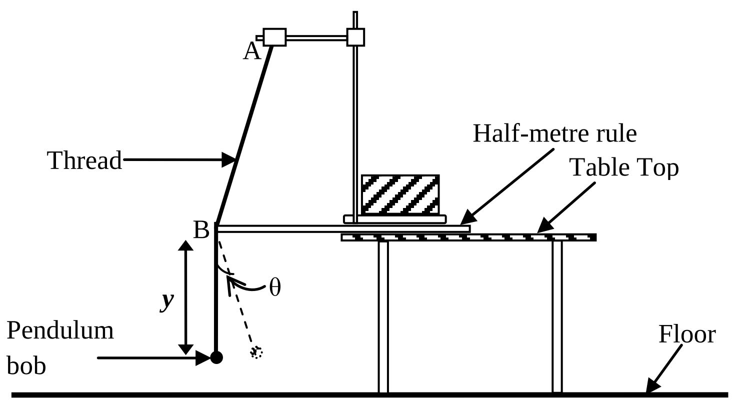


Fig. 8(b)

(f) Adjust the retort stand away from the edge of the table as shown in figure, 8(b) until $y = 60.0$ cm.

(g) Displace the pendulum bob through a small angle θ and let it oscillate with AB stationary.

(h) Measure and record the time, **20T** for 20 complete oscillations.

(i) Determine the time, **T** for one oscillation**.**

(j) Repeat procedures (f) to (j) for values of $y = 50.0, 50.0,\ 40.0,\ 30.0,\ 25.0,$ and 15.0 cm.

(k) Record your results in a suitable table including values of $(\mathrm{T_0} - \mathrm{T})$ and $(\mathrm{T_0^2} - \mathrm{T^2})$.

(l) Plot a graph of $(\mathrm{T_0^2} - \mathrm{T^2})$ against y.

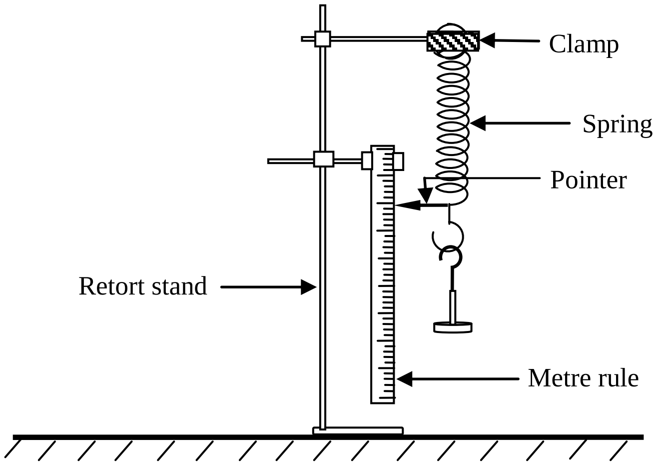
(m) Calculate the slope, **S** of the graph.

(n) Calculate the acceleration due to gravity, $\boldsymbol{g}$, from $\boldsymbol{g = -\frac{4\pi^2}{S}}$.

1.09 Experiment 9

In this experiment you are required to determine the acceleration due to gravity, g.

(a) Clamp the spring provided with a pointer attached and a metre rule as shown in Fig. 9 below.



(b) Read and record the initial position P_o of the pointer on the metre rule.

(c) Attach a mass, m, equal to 0.100 kg on the spring and record the new position P_1 of the pointer. Hence, find the extension, x, in metres.

(d) Pull the mass downwards through a small distance and release it.

(e) Measure and record the time for 20 oscillations.

(f) Calculate the time, T, for one oscillation.

(g) Repeat the procedures (d) to (f) for values of m equal to 0.200, 0.300, 0.400 and 0.500 kg

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

(i) Plot a graph of T^2 against m.

(j) Find the slope, s of the graph.

(k) Calculate g from the expression;

$$g = \frac{40\pi^2 x}{s}$$

Apparatus
A spring with a pointer, five 100 g masses on a mass hanger, stop clock, and a metre rule (or half metre rule); and retort stand with a clamp.

1.10 Experiment 10

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

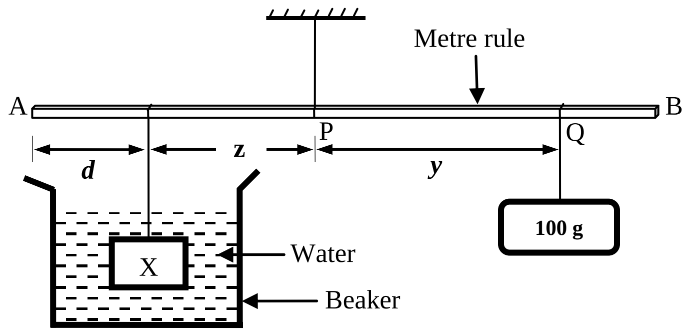


Fig. 10

(a) Record the mass, *M*, of the solid X provided.

(b) Suspend a metre rule from a clamp using a piece of thread and adjust it until it balances horizontally.

(c) Read and record the distance of the balance point, P, of the rule from end A.

(d) Suspend the solid, X at a distance d = 10 cm from end A of the metre rule and immerse it completely in water in the beaker.

(e) Suspend a 100 g mass from a point, Q, between P and B and then adjust the position of Q until the metre rule balances horizontally, with X completely immersed and not touching the beaker as shown in Fig. 10 above.

(f) Measure and record distances z and y.

(g) Repeat procedure (d) to (i) for values of d = 15, 20, 25, 30 and 35 cm.

(h) Enter your results in a suitable table.

(i) Plot a graph of z against y.

(j) Find the slope, s, of the graph.

(k) Calculate the relative density,ρ, of the material from the expression;

$$\rho = \frac{M}{M - 100S}$$

Apparatus: *Plastic Beaker, Metre rule, 100 g mass, 3 pieces of thread of 30 cm each, solid x, with its mass M indicated, water.*

1.11 Experiment 11

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

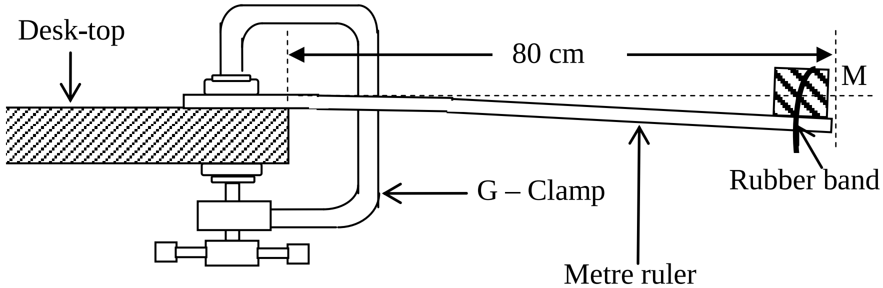


Fig. 11

(a) Record the thickness, d, of the metre rule.

(b) Clamp the metre rule provided with the graduated face upwards such that the free length equals 80 cm as shown in Fig. 11 above.

(c) Attach a mass, M equal to 0.05 kg at the end of the metre rule using a rubber band or 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 period, T.

(f) Repeat the procedures (c) to (e) for M equal to 0.10, 0.15, 0.20, 0.25 and 0.30 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;

$$\mathbf{Y = \frac{1590}{sd^3}}$$

Apparatus: *G-Clamp; Wooden metre rule with its thickness, d indicated; one 50 g mass; Three 100 g masses; Rubber band; Stop clock*

1.12 Experiment 12

In this experiment, you will determine the spring constant of the spiral spring provided.

(a) Clamp the spring using the two pieces of wood provided and make sure that the spring is vertical as shown in Fig. 12(a) below.

(b) Attach a pointer to the free end of the spring. Read and record the pointer position x_o on a vertical metre rule.

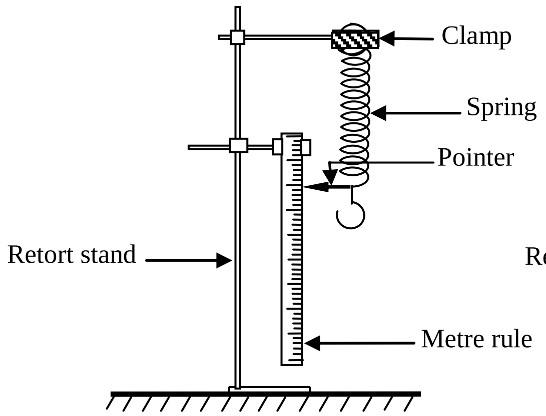


Fig.12 (a)

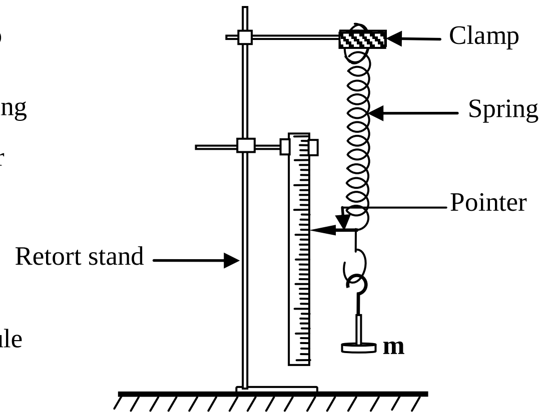


Fig.12 (b)

(c) Suspend a mass, m = 0.100 kg from the lower end of the spring as shown in Fig.12 (b) above.

(d) Read and record the new position of the pointer $\boldsymbol{x_1}$.

(e) Repeat procedures (c) and (d) above for the values of m = 0.200, 0.300, 0.400, 0.500 and 0.600 kg.

(f) Record your results in a suitable table including values of the extension, **e** in metres.

(g) Plot a graph of e against m.

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

(i) Determine the elastic constant, k from $k = \frac{1}{S}$

Apparatus
A spring with a pointer; Six 100 g masses on a mass hanger; and a metre rule; and retort stand with a clamp.

2.00 LIGHT EXPERIMENTS

Precautions in Light experiments.

(i) Using pins

- ✓ The two pins used to locate the path of light should be relatively spaced to minimize errors. (Check the pin-pricked points are clearly marked and labeled)
- ✓ The pins should be fixed vertically upright.
- ✓ View the base of the pins when aligning them as the pins may not be perfectly upright

(ii) Using lenses and mirrors

- ✓ The lens must be upright and parallel to the screen.
- ✓ The illuminated object should be placed at the same height as the optical centre of the lens.
- ✓ **Mirrors and Lenses:** The suitable focal length of a mirror or lens should be smaller than the smallest value of the object distance.
- ✓ Eg in experiment 16, the smallest object distance **d=15 cm**, the suitable mirror is that of **f =10, or 5 cm**. In experiment 24, the smallest object distance **u = 30 cm**, the suitable lens is that of **f = 25, 20, 15, 10 or 5 cm**.

(iii) Glass blocks: Glass blocks of any dimensions can be used. However, that of $100\text{mm} \times 60\text{mm} \times 18\text{mm}$ is preferred.

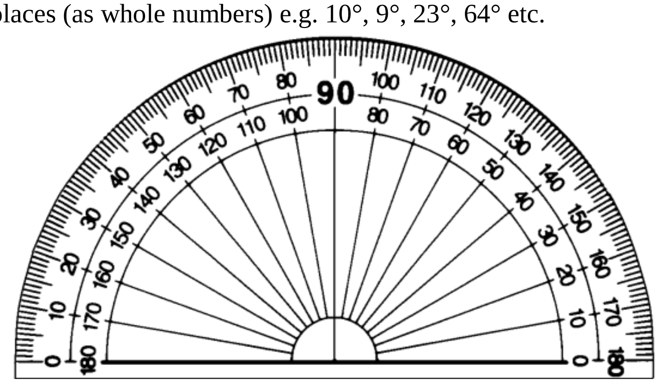
(iv) Glass Prisms: Equilateral triangular prisms should be used unless stated otherwise.

MEASUREMENT OF ANGLES

THE PROTRACTOR

- A Protractor measures angles in degrees (°)
- A small division on a protractor is an angle of 1° (0 d.p)
- Since 1° has no decimal place angles measured with a protractor should be recorded without a decimal place e.g. $19°, 50°, 87°\,and\,32°$.

A protractor measures angles between two intersecting lines in degrees (°) to zero decimal places. All values of angles obtained using a protractor must be recorded to zero decimal places (as whole numbers) e.g. 10°, 9°, 23°, 64° etc.



(i) How to Measure an Angle with a Protractor?
Angles are measured in degrees.

Step 1. The zero line of the protractor needs to be lined up with one side of the angle.

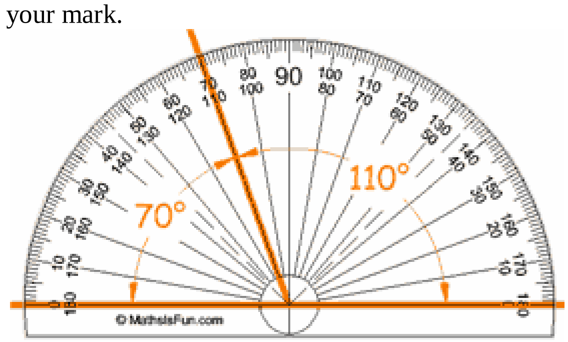
Step 2. You read the set of numbers from your zero line to the line where the angle stops..

(ii) **How to draw angles using a protractor**

Step 1. To draw an angle of 50 degrees first draw a line segment that is to be the one side of the angle.

Step 2. Then put the protractor so that its zero line matches with your line segment and that the vertex is in place.

Step 3. Now put a mark at the 50 degree point.
Step 4. Then take the protractor off and draw a line through your mark.



Protractors usually have two sets of numbers going in opposite directions. Be careful which one you use!

When in doubt think "should this angle be bigger or smaller than 90° .

2.01: Experiment 13:

In this experiment, you will investigate the relationship between the number of images n formed by two plane mirrors inclined to each other and the angle between the mirrors.

(a) Draw two lines such that they make an angle $\boldsymbol{\theta = 90^0}$ at the point of intersection as shown in the figure 13 below.

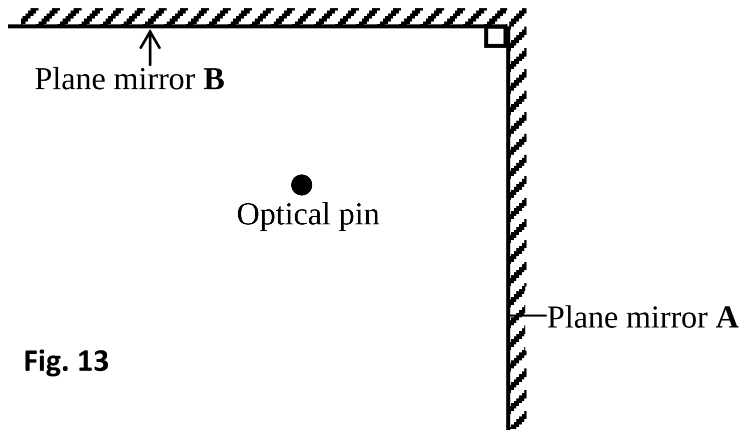


Fig. 13

(b) Place mirrors **A** and **B** as shown above on the lines drawn

(c) Place an optical pin at a distance of about 6cm in front of the point of intersection of the two mirrors such that it is equidistant from the two mirrors.

(d) Count and record the number of images, **n** observed. (place the eye at a distance of more than half a metre away from the mirrors)

(e) Keeping mirror **A** on the line, repeat procedures **(c)** and **(d)** adjusting the position of **B** such that it makes the angle $\boldsymbol{\theta = 70^0, 60^0, 40^0}$ and $\boldsymbol{30^0}$.

(f) Enter your results in a suitable table including values of $\frac{1}{\theta}$

(g) Plot a graph of **n** against $\frac{1}{\theta}$

(h) Find the intercept, **C**, on the **n**-axis

(i) Find the slope of the graph.

Note: ***Hand in your working sheet.***

Apparatus: 2 mounted plane mirrors, 4 drawing pins, 1 optical pin, and Complete Mathematical set.

2.02 Experiment 14

In this experiment, you will be required to verify that the angle of incidence is equal to the angle of reflection.

(a) Fix a white sheet of paper, provided on the soft board and place the plane mirror vertically on it.

(b) Put the plane mirror on the white sheet of paper and trace the mirror line with a sharp pointed pencil as shown in Fig.14 below.

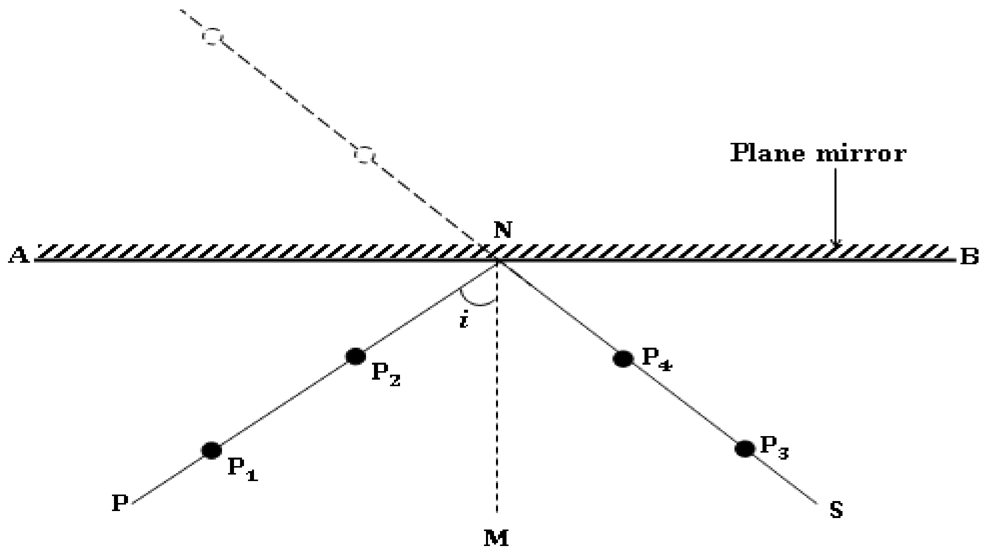


Fig. 14

(c) Remove the mirror from the paper. Label the traced line as AB.

(d) Draw a normal MN bisecting the mirror line AB

(e) Draw a line PN at angle $i = 10^o$ to MN.

(f) Fix pins P_1 and P_2 along the line PN.

(g) Place the mirror back on the paper so that it's reflecting surface coincides exactly with the mirror lining AB you have drawn.

(h) View the images of P_1 and P_2 in the mirror.

(i) Fix pins P_3 and P_4 such that they are in line with images of P_1 and P_2.

(j) Remove the pins P_1, P_2, P_3 and P_4 and the mirror from the white sheet of paper.

(k) Draw a line NS passing through the marks of pins P_3 and P_4.

(l) Measure and record the angle ***r***, between MN and NS.

(m) Repeat procedures (e) to (l) for angles $i = 20^o, 30^o, 40^o, 50^o, 60^o$ and 70^o.

(n) Record your values of ***i*** and ***r*** in a suitable table.

(o) Draw a graph of ***i*** against ***r*** and find its slope.

2.03 Experiment 15

In this experiment, you will verify that the angle of incidence, reflected ray and the normal line at the point of incidence, all lie in the same plane.

Procedures

a) Fix the plain sheet of paper on the soft board provided
b) Draw a line RS in the middle of the white sheet of paper provided.
c) Draw a normal ANM on RS as shown in Fig. 15.

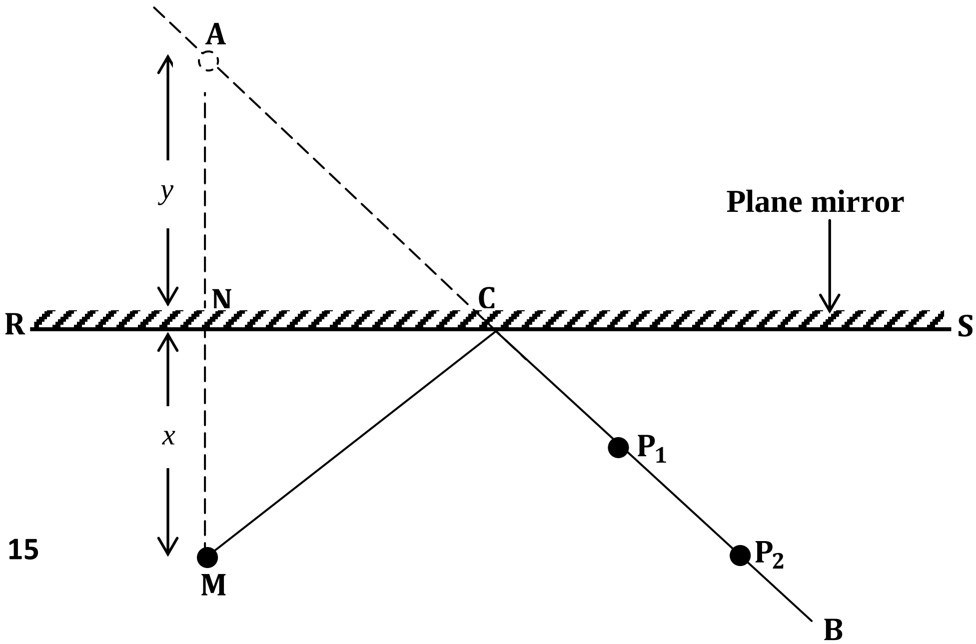


Fig. 15

d) Measure the distance NM, x = 1.5cm and fix a pin at M
e) Place the mirror along the mirror line RS as shown in Fig. 15 above
f) View the image of the pin at M from the right hand side of the normal ANM and fix pin P_1, and P_2 such that they are in the line with the image of the pin at M
g) Remove the pins P_1 and P_2 and the mirror from the white sheet of paper
h) Draw a line BCA passing through the marks of pin 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 = 2.0cm, 3.0cm, 4.0cm, 5.0cm 6.0cm 7.0cm and 8.0cm
k) Record your results in 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.

N.B: Staple your working sheet inside the work book.

Apparatus: A place mirror, soft board, white sheet of paper, 3 optical pins, 4 drawing pins and complete geometry set.

2.04 Experiment 16:

In this experiment, you will determine focal length, *f*, of a concave mirror.

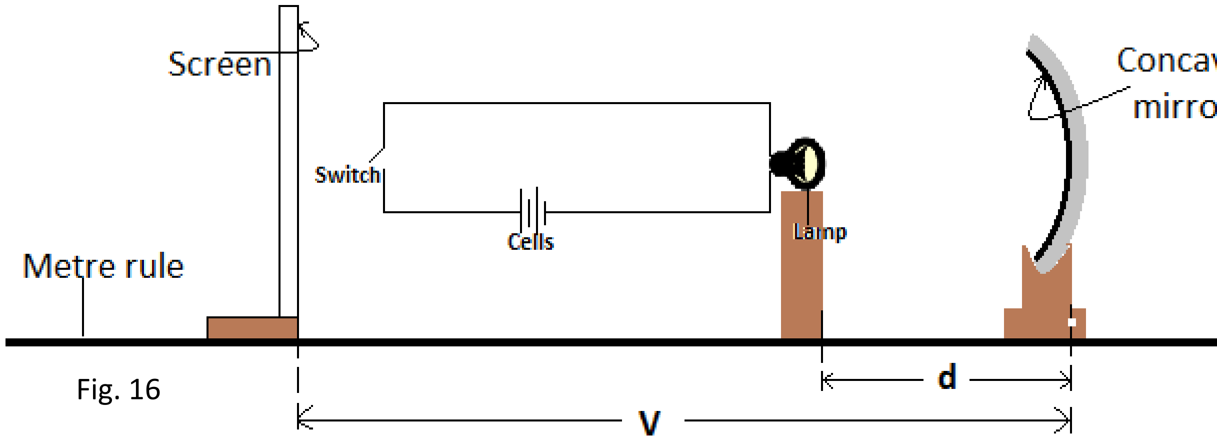


Fig. 16

Procedure

a) Set up the apparatus as shown in fig. 16 above.

b) Adjust the distance, $\boldsymbol{d} = \mathbf{15\ cm}$ and close the switch.

c) Adjust the position of the screen to and fro until a sharp image of the filament of the bulb is seen on the screen.

d) Open switch.

e) Measure and record the distance, **V** from the mirror to the screen.

f) Repeat the procedures (b) to (e) for values of, $\boldsymbol{d} = \mathbf{20, 25, 30, 35}$ and $\mathbf{40\ cm}$.

g) Enter your results in a suitable table including values of $\frac{V}{d}$

h) Plot a graph of $\frac{V}{d}$ against **V**.

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

j) Calculate the focal length, ***f*** from the expression;

$$f = \frac{1}{S}$$

Apparatus:
2 cells, Torch bulb (lamp), Concave mirror, White screen, Switch, Mirror holder, Metre rule, paper

2.06 Experiment 17

In this experiment, you will determine the focal length of a concave mirror.

(a) Align the torch bulb, the concave mirror and the screen as shown in Fig. 17 below.

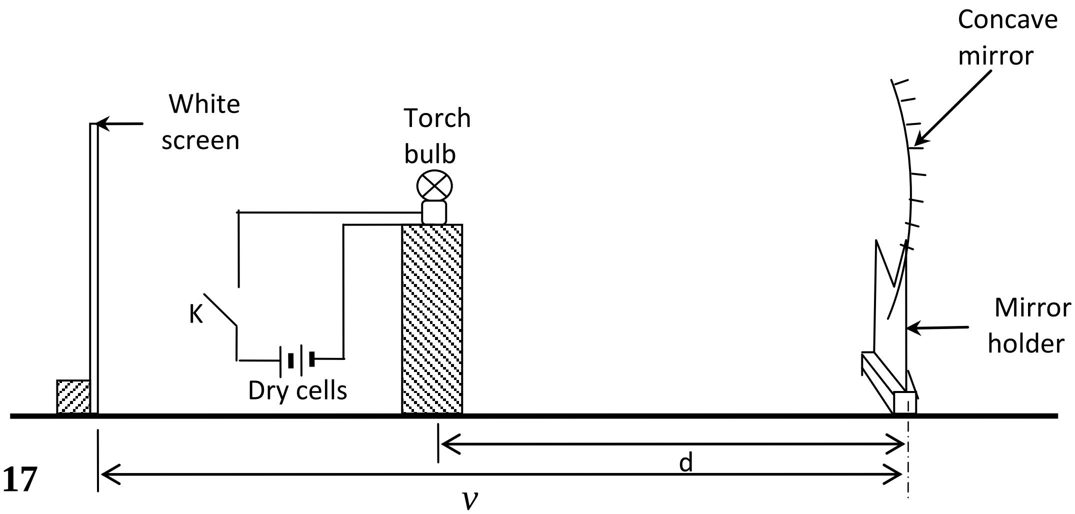


Fig. 17

(b) Adjust the distance, d to 15 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) Open the switch K.

(f) Measure the distance, v, of the screen from the mirror.

(g) Repeat the procedures (b) to (f) for values of d = 20, 25, 30 35 and 40 cm.

(h) Record your results in a suitable table including values of $\frac{v}{d}$.

(i) Plot a graph of $\frac{v}{d}$ against v.

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

(k) Calculate the focal length, f, from the expression ;

$$f = \frac{1}{S}$$

Apparatus: *Switch, 2 dry cells, torch bulb on its holder, connecting wires, mirror or lens holder, concave mirror focal length = 10 cm and a white screen.*

2.07 Experiment 18

In this experiment, you will determine the focal length, f, of concave mirror provided.

(a) Fix the mirror in the holder.

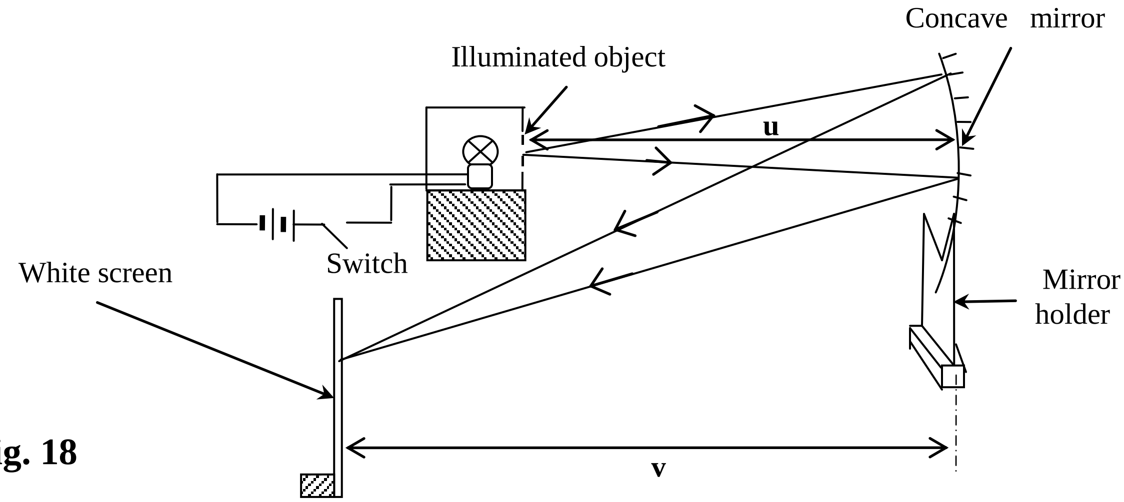


Fig. 18

(b) Focus light from a window onto the screen.

(c) Measure and record the distance, x, between the screen and the mirror.

(d) Arrange the mirror, the mounted bulb and the screen as shown in **Fig. 18** above.

(e) Adjust the object distance **u** = 2.4x

(f) Close the switch and move the screen until a sharp image of the object is formed on it.

(g) Measure and record the image distance, **v**.

(h) Repeat the procedures (e) to (g) for values of **u** = 3.2x, 4.0x, 4.8x, 5.6x and 6.4x.

(i) Enter your values in a suitable table including values of (**u + v**) and **uv**.

(j) Plot a graph of **uv** against (**u + v**).

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

(l) Calculate the difference between f and x.

Apparatus: *Switch, 2 dry cells, torch bulb on its holder, connecting wires, mirror or lens holder, concave mirror focal length = 10 cm and a white screen.*

2.08 Experiment 19

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

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

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

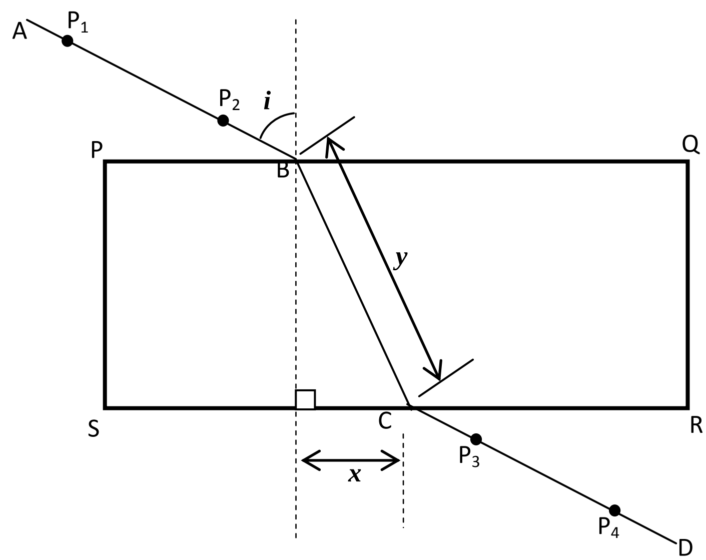


Fig. 19

(c) Remove the glass block and draw a perpendicular to PQ at B.

(d) Draw a line AB such that angle, $i = 10^o$ and replace the glass block.

(e) Stick two pins P_1 and P_2 along AB.

(f) 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 pins P_1 and P_2.

(g) Remove the glass block and draw a line through P_3 and P_4 to meet SR at C.

(h) Join C to B, measure and record distances *x* and *y*.

(i) Repeat procedures (f) to (g) for values of ***i*** equal to 20^o, 30^o, 40^o, 50^o and 70^o.

(j) Enter your results in a 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 the graph.

NOTE: Hand in the tracing Paper

Apparatus: *Glass block; Soft board; 2 Thumb pins; 4 Optical pins; Plain sheet of paper*

2.09 Experiment 20

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

(a) Fix the plane sheet of paper on a soft board using drawing pins.

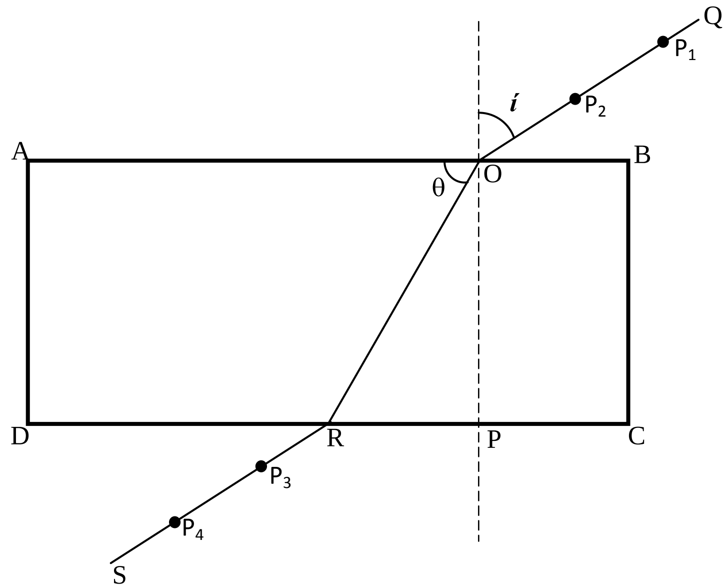


Fig. 20

(b) Place the glass block on the sheet of paper so that it rests on its broader face and trace its outline ABCD.

(c) Remove the glass block.

(d) Measure angle i equal to 20^o and draw line QO.

(e) Fix pins P_1 and P_2 on line QO and then replace the glass block onto its outline.

(f) Looking through the opposite face of the block fix pins P_3 and P_4 along RS such that they appear to be in line with the images of pins $P_1$and P_2.

(g) Remove the pins and the glass block and draw a line through P_3 and P_4 to meet the glass block at R.

(h) Join R to O and measure angle θ.

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

(j) Record your results in a suitable table including values of $\sin i$ and $\cos \theta$.

(k) Plot a graph of $\sin i$ against $\cos \theta$.

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

HAND IN THE WHITE TRACING PAPER

Apparatus: *Glass block; Soft board; 2 Thumb pins; 4 Optical pins; Plain sheet of paper.*

2.10 Experiment 21

In this experiment, you will determine the refractive index, n, of the material of glass block given.

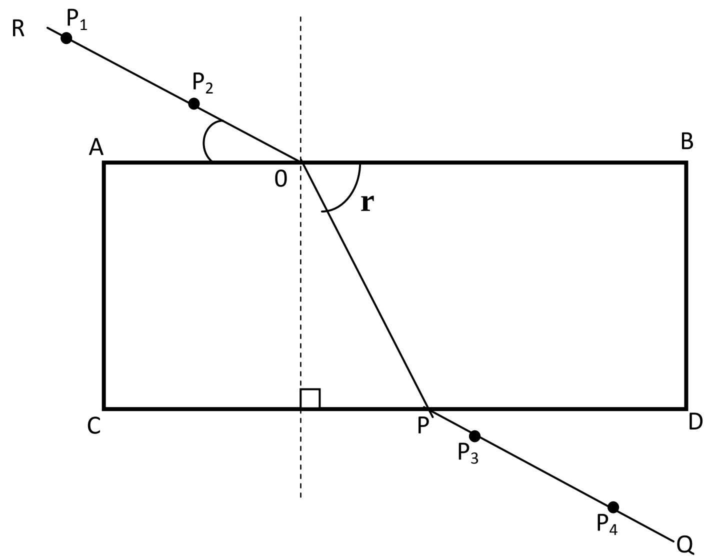


Fig. 21

(a) Fix the plane 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 its broader face and trace its outline ABCD.

(c) Remove the glass block.

(d) At point O about 2 cm from A, draw a line RO at an angle $\theta = 80^o$ 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 the images of P_1 and P_2 as shown in Fig. 21 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 **r**.

(j) Repeat procedures (d) to (i) for $\theta = 70, 60, 50, 40$ and 30^o.

(k) Record your results in a suitable table including values of cos θ and cos r.

(l) Plot a graph of cos θ against cos r.

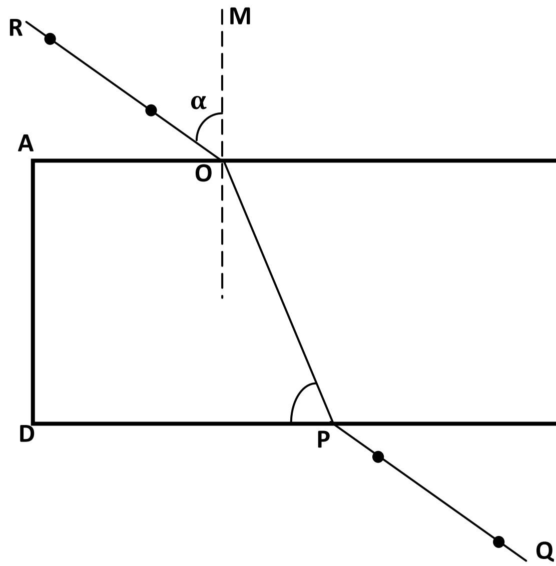
(m) Find the slope, n, of the graph.

HAND IN THE TRACING PAPER

Apparatus: *Glass block; Soft board; 2 Thumb pins; 4 Optical pins; Plain sheet of paper.*

2.11 Experiment 22.

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



22(b)F

Procedures

a) Fix the plain sheet of paper on the soft board using drawing pins.
b) Place the glass block provided in the middle of the paper. Make sure that the glass block rests on its broad face as shown in figure 22.
c) Trace the outline ABCD of the glass block.
d) Remove the glass block.
e) Mark a point N on AB such that AN is a quarter of AB.
f) Draw a line MN perpendicular to AB.
g) Draw a line RN at an angle $\boldsymbol{\alpha = 10^o}$ to MN.
h) Fix two pins P_1 and P_2 on line RN.
i) Place the glass block on its outline.
j) Looking through the glass block from side CD, fix two pins, P_3 and P_4 so that they appear to be in line with the images of P_1 and $P_{2.}$
k) Remove the glass block and the pins and draw lines TS and SN.
l) Measure and record angle **θ**
m) Repeat procedures (g) to (l) for values of $\boldsymbol{\alpha = 20^o, 30^o, 40^o, 50^o}and\boldsymbol{60^o}$.
n) Record your results in a suitable table including values of sin **α** and cos**θ**.
o) Plot a graph of sin **α** against cos**θ**
p) Find the slope $\boldsymbol{n}$ of the graph.

Note: Hand in you tracing paper

Apparatus: Plain sheet of paper, rectangular glass block, soft board, 2 optical pins, 4 drawing pins, complete mathematical set.

2.11 Experiment 22(b).

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

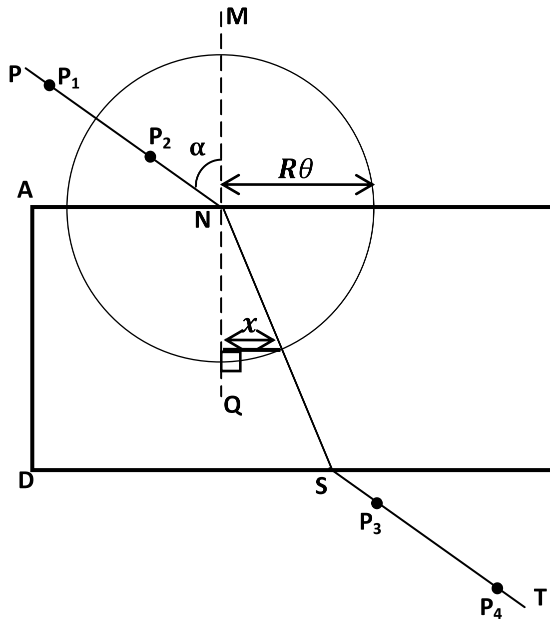


Fig. 22(b)

Procedures

a) Fix the plain sheet of paper on the soft board using drawing pins.
b) Place the glass block provided in the middle of the paper. Make sure that the glass block rests on its broad face as shown in figure 22(b).
c) Trace the outline ABCD of the glass block.
d) Remove the glass block.
e) Mark a point N on AB such that AN is a quarter of AB.
f) Draw a line MN perpendicular to AB.
g) Draw a line RN at an angle $\boldsymbol{\alpha = 20^o}$ to MN.
h) Fix two pins P_1 and P_2 on line PN.
i) Place the glass block on its outline.
j) Looking through the glass block from side CD, fix two pins, P_3 and P_4 so that they appear to be in line with the images of P_1 and P_2.
k) Remove the glass block and the pins and draw lines TS and SN.
l) Repeat procedures (g) to (k) for values of $\boldsymbol{\alpha = 30^o, 40^o, 50^o}$ and $\boldsymbol{60^o}$.
m) With N as the centre, draw a circle of radius, R = 4.0 cm.
n) From the intersection of NS with the circle, draw a perpendicular to MQ.
o) Measure and record the perpendicular distance $\boldsymbol{x}$ for each value of angle, $\boldsymbol{\alpha}$**.**
p) Record your results in a suitable table including values of sin $\boldsymbol{\alpha}$ and $\boldsymbol{\frac{x}{R}}$.
q) Plot a graph of sin $\boldsymbol{\alpha}$ against $\boldsymbol{\frac{x}{R}}$
r) Find the slope $\boldsymbol{n}$ of the graph.

Note: Hand in you tracing paper

Apparatus: Plain sheet of paper, rectangular glass block, soft board, 2 optical pins, 4 drawing pins, complete mathematical set.

2.12 Experiment 23

In this experiment, you are required to determine the refractive index n, of the glass using glass prism.

Procedure:

(a) Place the glass prism on a plain sheet of paper on a soft board and draw its outline. Label the vertices PQR as seen in fig. 23 below.

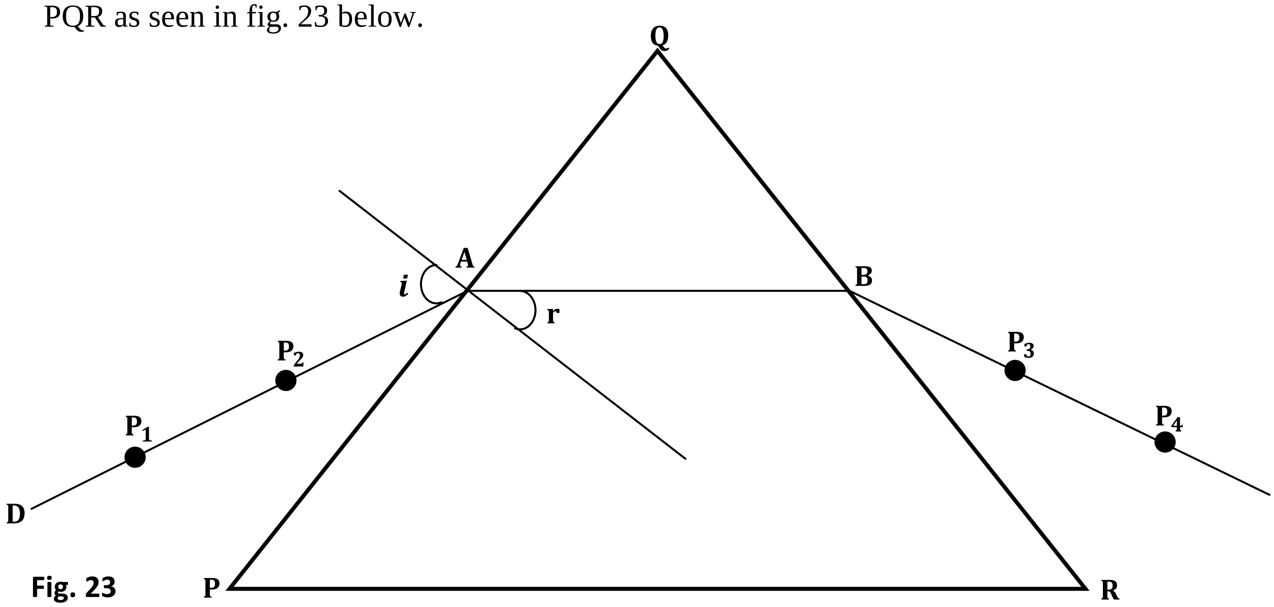


Fig. 23

(b) At point A, 2cm from vertex Q, draw a normal to the line PQ.

(c) Draw a line DA at an angle of incidence, $i = 30^0$ with the normal.

(d) Stick pins P_1 and P_2 about 4cm apart on the line DA.

(e) Replace the glass prism on its outline such that its vertices exactly match those on the outline.

(f) Stick pins, P_3 and P_4 such that they are collinear with the image of P_1 and P_2.

(g) Remove the prism and the pins. Draw a line through the position of the pins P_3 and P_4 to meet RQ at B.

(h) Join B to A measure and record angle r.

(i) Repeat procedure (c) to (h) for values of $i = 40^0, 50^0, 60^0$ and 70^0.

(j) Enter your results in a suitable table including values of sin i and sin r.

(k) Plot graph of sin$i$ (along the vertical axis) against sin$r$ (a long the horizontal).

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

Note: Hand in your tracing paper

Apparatus: Plain sheet of paper, rectangular glass block, soft board, 2 optical pins, 4 drawing pins, complete mathematical set.

2.13 Experiment 24.

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

(a) Arrange the cross wires, the lens, L and the screen in a straight line as shown in Fig. 24 below.

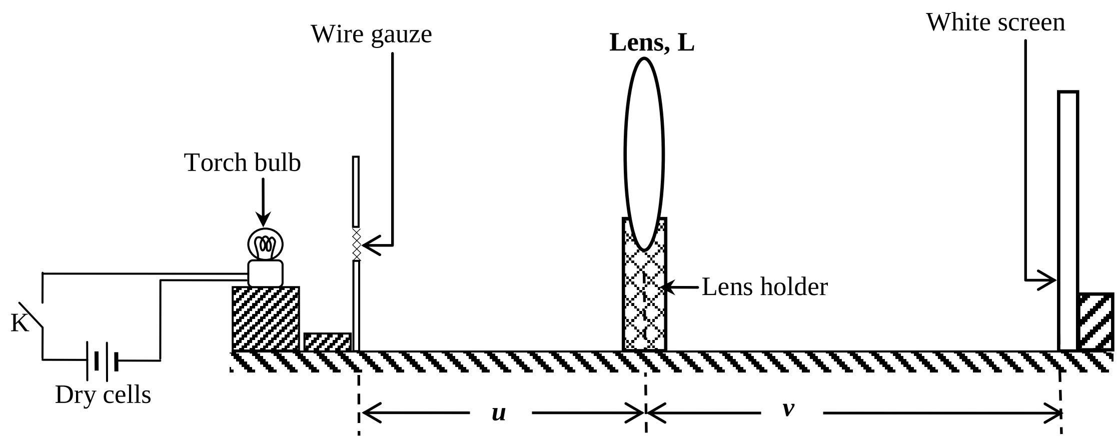


Fig. 24

(b) Adjust the distance, u between the cross wires and the lens to 30 cm.

(c) Close the switch, K so that the bulb lights.

(d) Move the screen to and fro until a sharp image of the cross wires is formed on the screen.

(e) Read and record the image distance, v, between the lens and the screen.

(f) Repeat procedures (b) to (e) for values of u equal to 40, 50, 60 and 70 cm.

(g) Record your results in a suitable table including values of $\frac{v}{u}$.

(h) Plot a graph of $\frac{v}{u}$ against v.

(i) Find the intercept, f_1, on the v – axis.

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

(k) Calculate, $\boldsymbol{f_2}$, from, $\boldsymbol{f_2} = \frac{1}{S}$.

(l) Find $\boldsymbol{f}$ from the expression; $f = \frac{f_1 + f_2}{2}$.

Apparatus: *Switch, 2 dry cells, torch bulb in its holder, connecting wires, cross wires, lens holder, convex lens focal length = 10 cm and a white screen.*

2.14 Experiment 25.

In this experiment, you will determine the focal length of a converging lens.

(a) Mount the lens provided and place it facing the window.

(b) Place the screen behind the lens and adjust it until a clear image of the distant object is obtained.

(c) Measure and record the distance, **d**, between the lens and the screen.

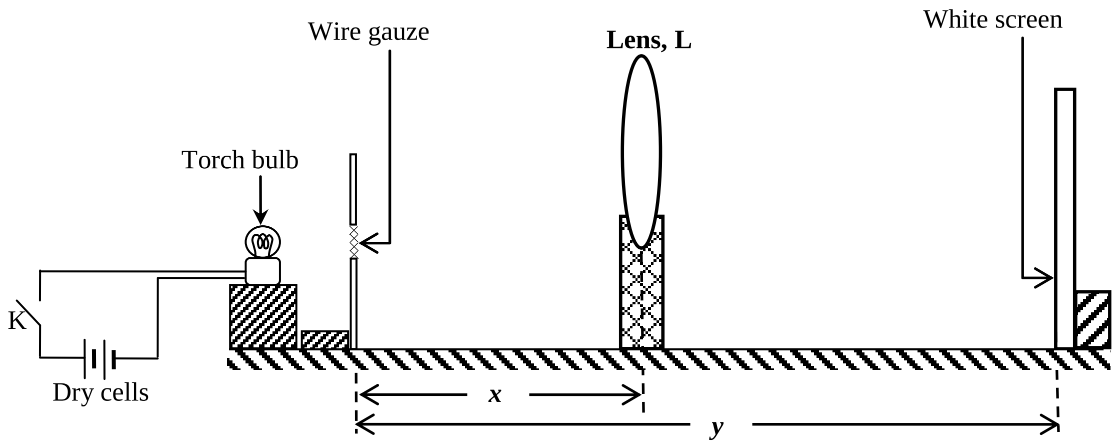


Fig. 25

(d) Arrange the bulb, wire gauze, lens and screen as shown in Fig. 25 above.

(e) Adjust the lens so that the distance, x between the wire gauze and the lens is equal to 2.5d.

(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, y, between the wire gauze and the screen.

(h) Repeat procedures (e) to (g) for values of x = 3.0d, 3.5d, 4.0d and 4.5d.

(i) Record your results in a suitable table including values of $(y - x)$ and $x(y - x)$.

(j) Plot a graph of $(y - x)$ against $x(y - x)$.

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

(l) Calculate f from the relation:

$$S = \frac{1}{f}.$$

Apparatus: *Switch, 2 dry cells, torch bulb on its holder, connecting wires, cross wires, lens holder, convex lens of focal length = 10 cm and a white screen.*

2.15 Experiment 26

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

(a) Focus the image of a distant object onto the screen provided.

(b) Measure and record the length, **F**, between the screen and the lens.

(c) Connect the bulb, the dry cells and switch, K, in series as shown in figure 26 below.

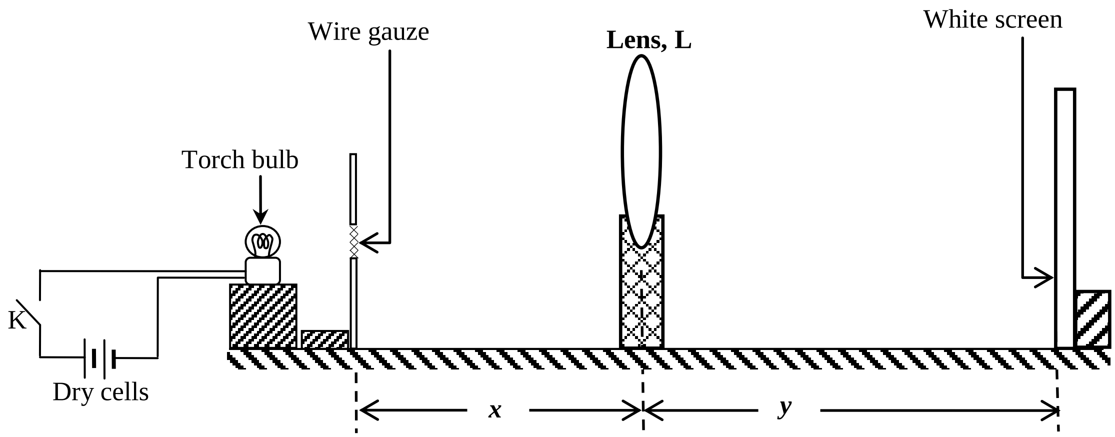


Fig. 26

(d) Arrange the bulb, lens and the screen as shown in Fig. 26 above.

(e) Adjust distance, ***x***, between the bulb and the lens to 1.5**F**

(f) Close the switch, K.

(g) Adjust the position of the screen to obtain a clear image on it.

(h) Measure the distance, y, between the lens and the screen.

(i) Repeat procedures (e) to (h) for ***x*** = 2.0F, 2.5F, 3.0F and 4.0F.

(j) Tabulate your results including values of ***xy*** and ***x* + *y*.**

(k) Plot a graph of ***xy*** against ***x* + *y***.

(l) Find the slope, ***f***, of the graph.

Apparatus: *Switch, 2 dry cells, torch bulb in its holder, a wooden small piece of block, connecting wires, cross wires, lens holder, convex lens of focal length = 15 cm or 20 cm and a white screen.*

3.16: Experiment 27(a).

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

(a) Mount the lens in the holder provided and place it facing a window.

(b) Place a white screen behind the lens.

(c) Adjust the position of the white screen until a clear image of a distant object is obtained on it.

(d) Measure and record the distance, f, between the lens and the white screen.

(e) Connect the bulb, dry cells and the switch, K in series.

(f) Arrange the bulb, wire gauze, lens and the white screen as shown in figure 27 (a) below.

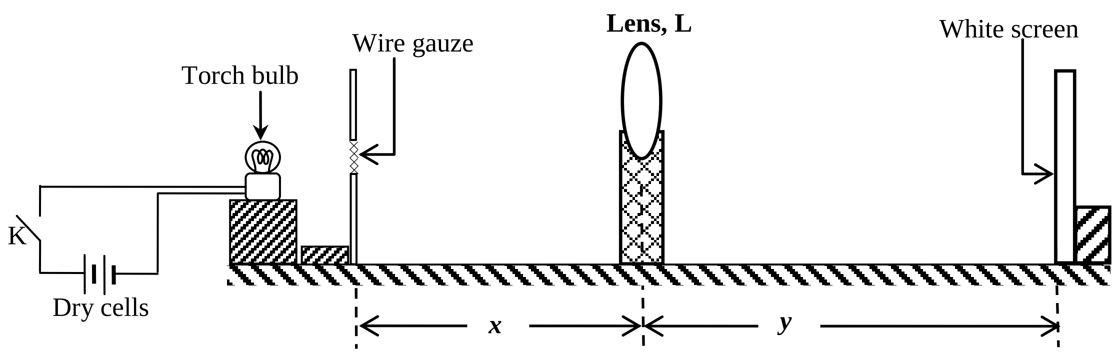


Fig. 27(a)

(g) Adjust the lens so that the distance, $\boldsymbol{x}$, between the wire gauze and the lens is equal to $2.0f$.

(h) Close switch, K, and move the white screen until a clear image of the wire gauze is obtained on the white screen.

(i) Measure and record the distance, y, between the lens and the white screen.

(j) Open switch, K.

(k) Repeat procedures (g) to (j) for values of $\boldsymbol{x} = 2.4f$, $2.8f$, $3.2f$ and $3.6f$.

(l) Record your results in a suitable table including values of $\boldsymbol{xy}$ and $(\boldsymbol{x} + \boldsymbol{y})$.

(m) (i) Plot a graph of $\boldsymbol{xy}$ against $(\boldsymbol{x} + \boldsymbol{y})$.

(ii) Determine the slope, **F**, of the graph, where **F** is the focal length of the lens.

(iii) Find the value of : $\dfrac{F - f}{f}$.

(n) (i) Plot a graph of $(\boldsymbol{x} + \boldsymbol{y})$ against $\boldsymbol{x}$.

(ii) Find the minimum value W of $(\boldsymbol{x} + \boldsymbol{y})$.

(iii) Find the focal length, F of the lens from the expression, W = 4F.

Apparatus: *Switch, 2 dry cells, torch bulb on its holder, a wooden small piece of block, connecting wires, lens holder, convex lens of focal length = 15 cm and a white screen.*

3.16: Experiment 27 (b).

In this experiment, you will determine the focal length of the two lenses, L_1 and L_2

Procedure:

(a) Arrange the experiment as shown, when x = 40cm.

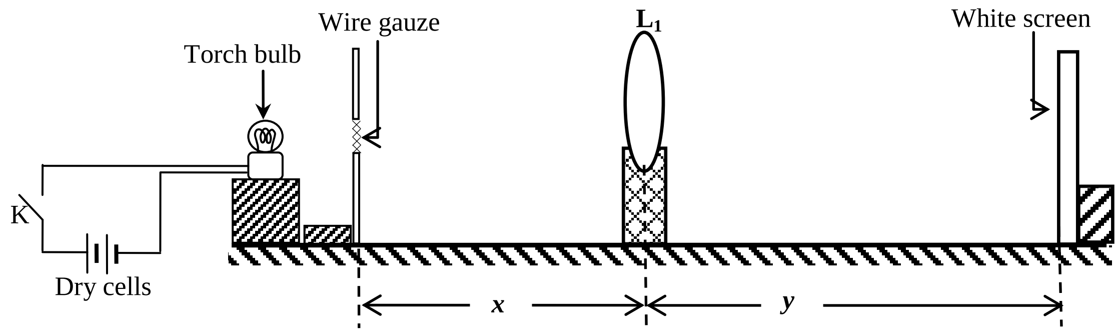


Fig. 27(b)

(b) Move the screen to and from the lens L_1 to obtain a sharp focused image of the wire gauze.

(c) Measure and record the distance y.

(d) Calculate the focal length f_1 of L_1 from $f_1 = \frac{xy}{x+y}$.

(e) Place L_1 and L_2 in the contact as shown below.

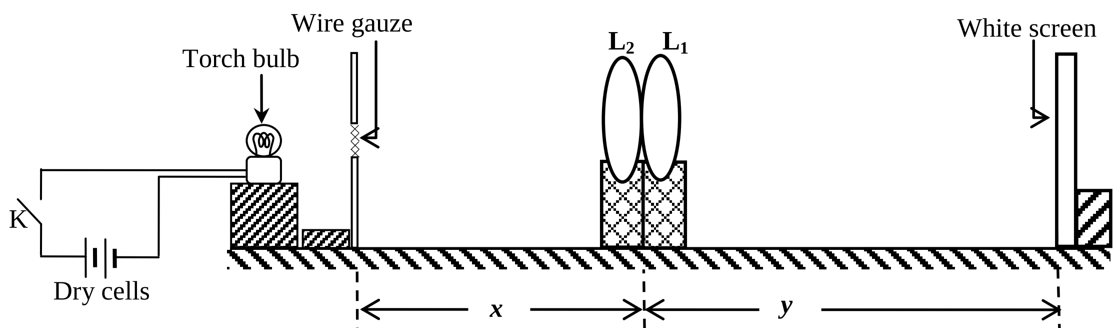


Fig. 27(c)

(f) Starting with x = 40 cm, adjust the position of the screen to obtain a sharp image of the wire gauze.

(g) Measure and record the distance y.

(h) Repeat procedures (f) and (g) for values of x = 35, 30, 20 and 15cm.

(i) Tabulate your results including values of $\frac{y}{x}$.

(j) Plot a graph of $\frac{y}{x}$ against y.

(k) Find the slope S of your graph and calculate the value of f from $f = \frac{1}{S}$.

(l) Find the value of f_2 from the expression; $f = \frac{f_1 f_2}{f_1+f_2}$

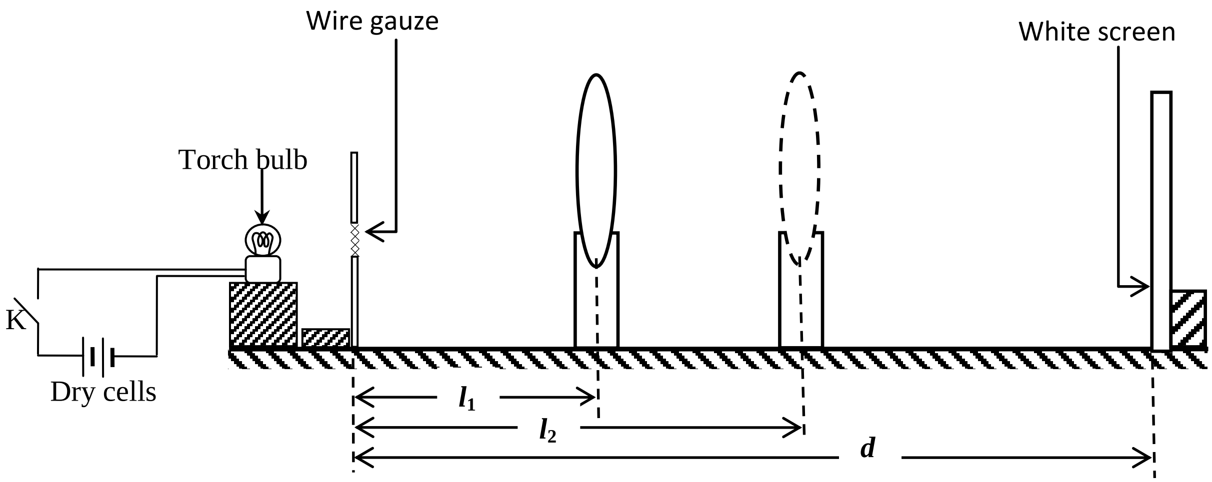
Apparatus: *Switch, 2 dry cells, torch bulb on its holder, a wooden small piece of block, connecting wires, lens holder, 2 convex lenses of focal length, L_1 = 20 cm and L_2 = 15 cm screen with a hole covered with cross wires and a white screen.*

3.16: Experiment 27 (c).

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

Procedure:

(a) Arrange the bulb, wire gauze, lens and screen as shown in the figure below.



(b) Adjust the screen so that distance, d =70cm.

(c) Place the lens between the screen and wire gauze and move it near the gauze to obtain a magnified image on the screen.

(d) Measure and record the distance, l_1.

(e) Keeping the gauze and screen fixed move the lens towards the screen to obtain a sharp diminished image on the screen. Measure and record distance, l_2.

(f) Repeat procedures (b) to (e) for values of d = 65, 60, 55, 50 and 45cm.

(g) Record results in a suitable table including values of d^2, $x = (l_2 - l_1)$, x^2, and $y = (d^2 - x^2)$.

(h) Plot a graph of y against d.

(i) Find the slope S.

(j) Find f from; $4f = S$

Apparatus: *Switch, 2 dry cells, torch bulb on its holder, a wooden small piece of block, connecting wires, lens holder, convex lens of focal length = 20 cm screen with a hole covered with cross wires and a white screen.*

3.16: Experiment 27(d).

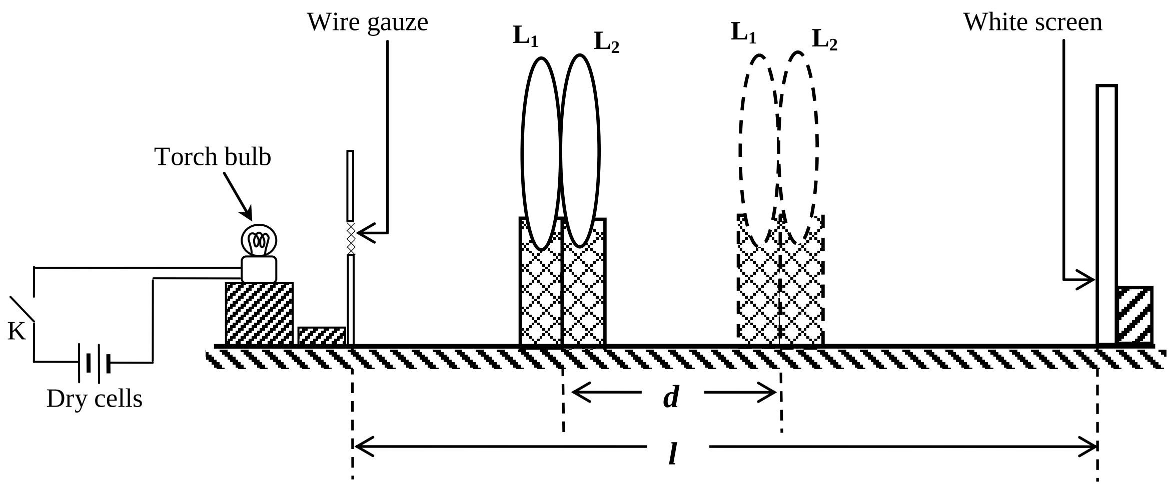
In this experiment, you will determine the focal length, f_2, of the lens, L_2

Procedure:

(a) Determine the focal length f_1 of lens L_1 using a distant object.

(b) Combine L_1 and L_2 together to form a lens combination of two lenses.

(c) Arrange the screen, lens combination and illuminated object such that they are a distance, $l = 0.30$ m apart as shown in the figure below.



(d) Move the lens combination until a sharp image of the illuminated object is formed on the screen.

(e) Displace the lens combination through a distance, *d*, to obtain another image on the screen.

(f) Measure and record the displacement, *d* of the lens combination.

(g) Repeat procedures (c) to (f) for values of *l* = 0.35, 0.40, 0.45, 0.50 and 0.55m.

(h) Tabulate your results including values of $l^2 - d^2$

(i) Plot a graph of $l^2 - d^2$ against *l*.

(j) Find the slope S of your graph and

(k) Calculate the value of ***f*** from $f = \frac{S}{4}$.

(l) Find the value of f_2 from the expression; $f_2 = \frac{f_1 f}{f_1 - f}$

3.17 Experiment 28

In this experiment, you will determine the power, P of a cylindrical water lens using two methods.

Procedure

METHOD I

a) Measure and record the external diameter, D, of the 250ml glass beaker provided.

b) Draw using a pen, a vertical line along the strip of the paper provided.

c) Stick the strip of paper vertically on the side of the glass beaker using the pieces of cello tape provided.

d) Place the beaker containing water between the screen and the illuminated object such that the vertical line on the beaker faces you as shown in the figure 28 (a) below.

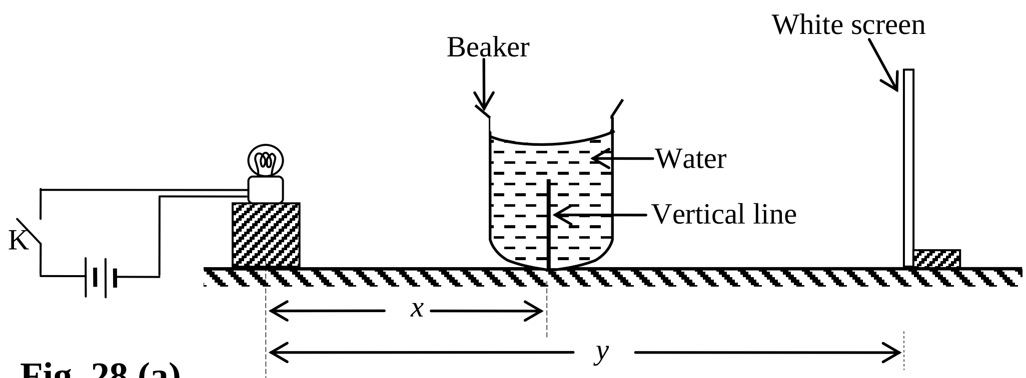


Fig. 28 (a)

e) Pour water into the beaker up to the 250 ml mark.

f) Adjust the distance, x, to 20.0 cm.

g) Adjust the position of the screen until a sharp vertical line image of the bulb is formed on it.

h) Measure and record the distance, **y**, of the screen from the bulb.

i) Calculate the value of, **P,** from the expression;

$$P = \frac{y}{x(y - x)}$$

j) Repeat the procedure (f) to (i) for x = 30.0 cm.

k) Calculate the average value of **P**.

DO NOT DISMANTLE THE SET UP

METHOD II

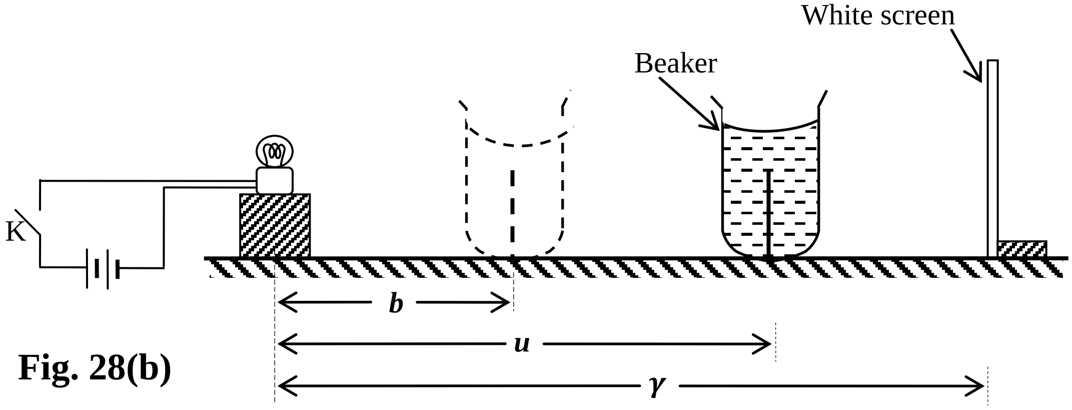


Fig. 28(b)

a) Adjust the distance between the bulb and the screen to ,$\boldsymbol{\gamma} = 5\text{D}$cm as shown in the fig.28(b) above.

b) Starting with the beaker near the screen, move the beaker towards the bulb until a sharp diminished vertical line image of the bulb is formed on the screen.

c) Measure and record the distance, **u**, of the beaker from the bulb.

d) Keeping $\boldsymbol{\gamma}$**,** constant, move the beaker further towards the bulb until another sharp magnified image is formed on the screen.

e) Measure and record the new distance, **b**, of the beaker from the bulb.

f) Repeat procedure (a) to (e) for values of $\boldsymbol{\gamma} = 6\text{D},\ 7\text{D},\ 8\text{D},\ 9$ D and 10D cm.

g) Tabulate your results including values of γ^2 , $w = (u - b),\ w^2\ and\ z = (\gamma^2 - w^2)$.

h) Plot a graph of z against γ.

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

j) Calculate the value of, **P,** from the expression;

$$\boldsymbol{P = \frac{4}{S}}$$

Apparatus: 2 dry cells, 1 double cell holder, 1 torch bulb, a bulb holder, 1 switch, 1 250ml glass beaker, water, 1 screen, connecting wires, 1 meter rule, wooden block, 1 piece of paper 2cm X 4cm and 2 pieces of transparent cello tape, vernier calipers.

4. HEAT EXPERIMENTS

Precautions in Heat experiments.

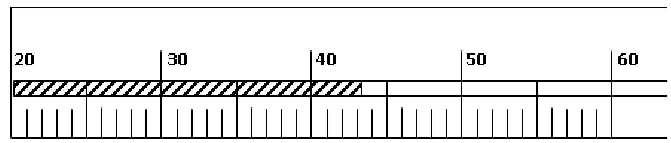
- ✓ The water or liquid in the vessel should be stirred constantly during the experiment so that the temperature is uniform throughout the water. Do not use a thermometer as the stirrer.
- ✓ The thermometer should not be placed at the bottom of the beaker when water is being heated. This is because the temperature of the beaker is always higher than that of the water. Over heating may lead to over expansion of the mercury thread thus breaking the thermometer.
- ✓ Temperature readings should be taken only when they are steady.
- ✓ When comparing heat loss due to a change in temperature by two experiments, make sure that the starting temperature for both experiments is the same.
- ✓ Disturbance due to wind can be avoided by switching off the fans and closing windows and doors.

- ✓ When a calorimeter is used,

(i) It should be covered with a lid to reduce heat loss by convection,

(ii) It should be placed in a shiny jacket lined with good insulating material (e.g wool, cotton) to minimize heat loss by radiation and conduction.

1 small division on a thermometer is 1℃ (0 d.p). The thermometer therefore measures temperature in degrees Celsius (°C) to zero or one decimal place. If the temperature is recorded to one decimal place, the last digit should be 0 or 5 e.g. 26.0°C, 32.5°C, 23.0°C etc



The reading of the thermometer above is 43^0C or 43.0^0C 0r 43.5^0C

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.

3.01 Experiment 29

In this experiment, you will determine the cooling constant of water.

(a) Record the room temperature, T_o.

(b) Heat 100 cm^3 of water to about 90^o C.

(c) Transfer the hot water quickly into the calorimeter.

(d) Place a thermometer in the hot water and start the stop clock when the temperature of water is 65^o C.

(e) Record the temperature, T, of the water every two minutes for 14 minutes.

(f) Record your results in a suitable table including values of $(T - T_o)$ and $\log_{10}(T - T_o)$

(g) Plot a graph of $\log_{10}(T - T_o)$ against time.

(h) Find the slope, s, of the graph.

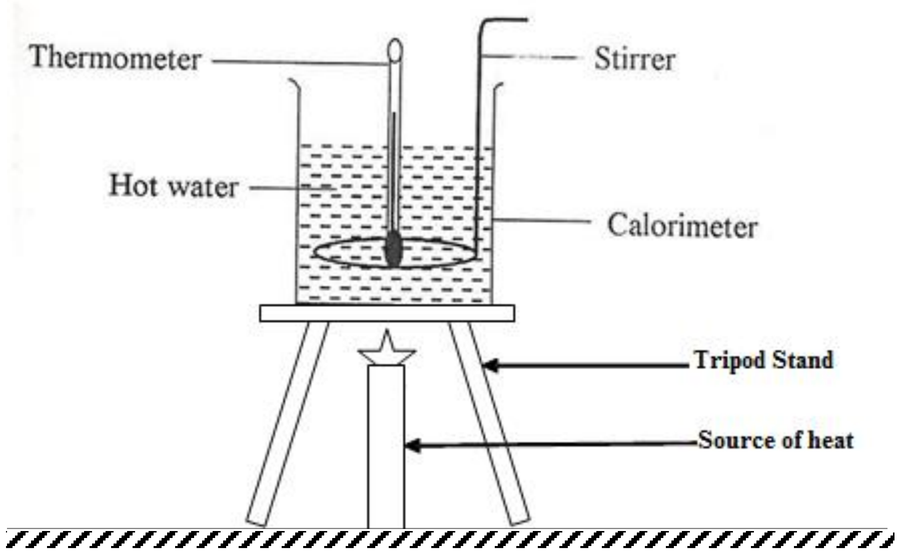
(i) Calculate the cooling constant, k, from the expression;

$$S = 26.06\ k$$

Apparatus: *Thermometer; Glass beaker 100 cm^3; Stop clock or stop watch; Source of heat, Calorimeter with its mass markedon it and Water.*

3.02 Experiment 30

In this experiment, you will determine the room temperature, θ_R.



(a) Measure the room temperature θ_o.

(b) Heat 100 cm^3 of water in a beaker to a temperature of about 90^oC.

(c) Transfer the hot water quickly into a calorimeter.

(d) Place the thermometer in the hot water and start the stop clock when the temperature of the water is 65^oC.

(e) Record the temperature, θ, of the water after every two minutes for 14 minutes.

(f) Record your results in a suitable including values of $(\theta - \theta_0)$ and $log_{10}(\theta - \theta_0)$.

(g) Plot a graph of $log_{10}(\theta - \theta_0)$ against time, t.

(h) Find the value, I, of $log_{10}(\theta - \theta_0)$ when t = 0.

(i) Find the **antilog of I**.

(j) Calculate the temperature of the surroundings, θ_R, using the expression;

$$\textbf{Antilog of I} = 65 - \theta_R.$$

Apparatus: Thermometer; Glass beaker 100 cm^3; Stop clock or stop watch; Source of heat, Water, Calorimeter.

3.03 Experiment 31

In this experiment, you will determine the specific heat capacity of water.

(a) Record the mass, M, of the calorimeter.

(b) Measure out 100 ml of the hot water provided (temperature more than 80^oC) and pour it in the calorimeter.

(c) Place the thermometer in the hot water and start the stop clock /watch when the temperature of the water is 70^oC.

(d) Record the temperature, θ, of the hot water after every time interval, t of two minutes as the water cools from 70^oC to 40^oC.

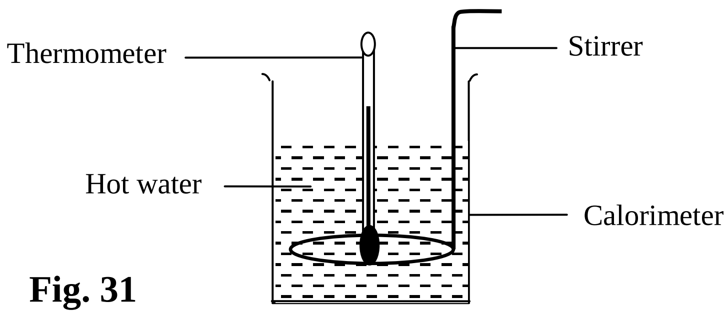


Fig. 31

(e) Tabulate your results in a suitable table.

(f) Plot a graph of θ against t.

(g) Obtain the time, t for the water to cool from 60^oC to 50^oC.

(h) Calculate the specific heat capacity of water, S, from the expression; $\mathbf{(3.81 \times 10^2)M + 0.1S = t}$

Apparatus: Thermometer; Glass beaker 100 cm^3; Stop clock or stop watch; Source of heat, Water, calorimeter

4.ELECTRICITY EXPERIMENTS

Precautions in Electricity experiments.

- **Reading the meters**

The meters (voltmeter and ammeter) must be read with the eye directly opposite the pointer such that the image of the pointer in the meter cannot be seen, to avoid parallax error.

- **Connecting the components in the circuit.**

The contacts between the wires and the components and the plug of the switch must be tightened to reduce contact resistance in the circuit.

- **Measuring the length of resistance wire**

Make sure that there is no kink in the bare resistance wire especially when you have to measure the length of the wire accurately.

- **Using a jockey to determine balance the length.**

✓ The jockey should be held vertically so that the readings obtained are more precise. Do not exert too much pressure on the resistance wire as this may deform the wire and the cross – sectional area will no longer be uniform.

✓ Switch on the circuit for a few seconds before taking a reading and then switch it off immediately. This is to avoid unnecessary heating in the resistance wire as a change in temperature can affect resistance of the wire.

✓ If the connecting wires are not long enough, do not join up two pieces of wires because, the contact resistance at the joint can be quite significant. Instead, ask for a longer piece of wire.

Constantine wire SWG 28 and SWG 30: For experiments that have only the ammeter, SWG 30 is preferred because it has a smaller resistance leading to bigger values of current, I that are easier to read.

Similarly, for experiments that have only the Voltmeter, SWG 28 is preferred because it has a higher resistance leading to bigger values of potential difference, V that are easier to read.

Bulbs, 2.5V. A 2.5V bulb in a circuit will give light only if the P.d across it 2.5V or more. This therefore means that a bulb in a circuit may light or may not. As long as the connected Ammeters and Voltmeters deflect, the student should continue with the experiment regardless of whether the bulb lights or not.

In some experiments, the bulb may not give light at first but as the experiment progress, it gives light. This means that initially, the pd across the bulb was far below 2.5V. In other experiments, the bulb may give light at first but as the experiment progress, it goes off. This means that the P.d across the bulb has fallen below 2.5V.

The connections should be firm enough and the circuits should be connected from the positive of the battery to the negative of the battery.

To make the connections easily, first place the instruments as they appear in the circuit diagram. The terminals must correspond i.e,

❖ The positive **(RED)** knobs (terminals) of the ammeters or voltmeters must be connected to the positive side of the cell(s) in the circuit.

❖ The negative **(BLACK)** knobs (terminals) of the ammeters or voltmeters must be connected to the negative side of the cell(s) in the circuit. In this way, the meters may be facing away from you, but after connecting, you can turn the meters to face you for easy reading.

❖ If the terminals are interchanged, (i.e when Positive is connected to negative), the meters will deflect in the opposite direction. The pointer will move to the left of the zero (0) mark. You may be tempted to think that the meter is not working because it deflects by a small amount to the left of zero. When it deflects this way, the student should inter change the terminal connections.

❖ All the connections should be firm. If not the meters may not deflect or if they do, the deflections will not be steady! This makes taking the reading hard.

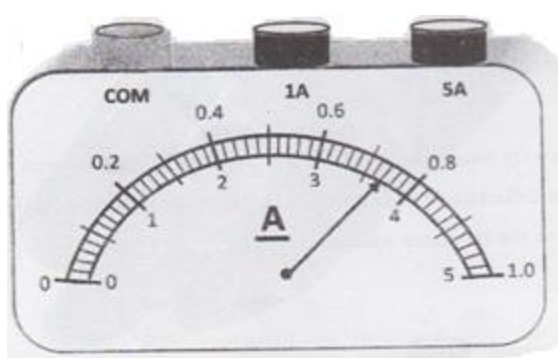
❖ After taking the reading the student should remember to switch off the circuit to avoid un necessary drop in the e.m.f of the cell(s) during the experiment.

❖ Voltmeters are calibrated differently e.g 0-3V, 0-5V. Some voltmeters have two scales; e.g 0-3V and 0-5V, 0-3V and 0-6V.
To use the scale of range **0-3V,** the knob (terminal) marked **3V** is used with the terminal marked **COM.**

MEASUREMENT OF CURRENT, (I) AND VOLTAGE (or Pd), (V)

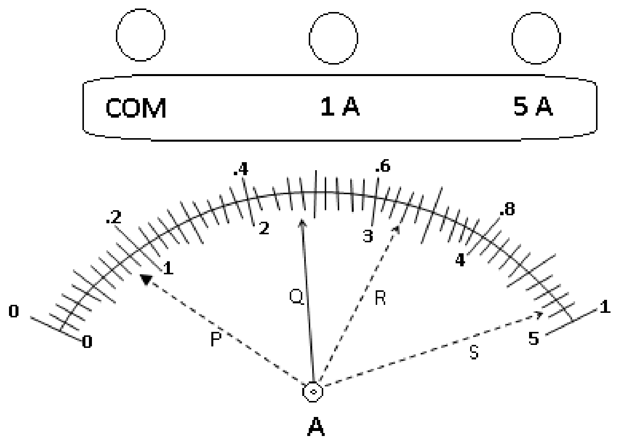
(a) Ammeter

Ammeters measure current (**I**), 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.



Consider the scale with range 0 – 1A
10 divisions $=$ 0.2A
1 division $=$ 0.02A
Ammeter reading $=$ 0.02 x 37
$=$ 0.74 A

Consider the scale with range 0 – 5A
10 divisions $=$ 1A
1 division $=$ 0.1A
Ammeter reading $=$ 0.1 x 37
$=$ 3.70 A



Position P:
In the figure above, taking the 0- 1A scale,
10 divisions $=$ 0.2A
1 division $=$ 0.02A
Ammeter reading $= 0 + (0.02 \text{ x } 8)$
$=$ 0.16A

In the figure above, taking the 0- 5A scale,
10 divisions $=$ 1 A
1 division $=$ 0.1 A
Ammeter reading $= 0 + (0.1 \text{ x } 8)$
$=$ 0.80 A

Position Q:
In the figure above, taking the 0- 1A scale,
10 divisions $=$ 0.2A
1 division $=$ 0.02A
Ammeter reading $= 0.4 + 0.02 \text{ x } 4$
$= 0.4 + 0.08$
$=$ 0.48A

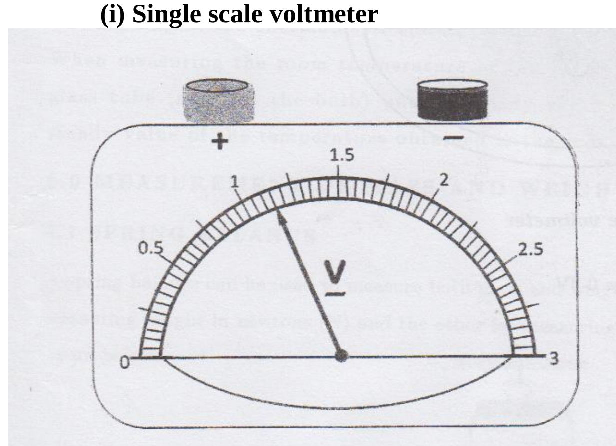
In the figure above, taking the 0- 5A scale,
10 divisions $=$ 1 A
1 division $=$ 0.1 A
Ammeter reading $= 2 + 0.1 \text{ x } 4$
$= 2 + 0.4$
$=$ 2.40A

Position R:
In the figure above, find the reading of the ammeter.
(i) taking the 0- 1A scale, ……………………………………
(ii) taking the 0- 5A scale ……………………………………

Position S:
In the figure above, find the reading of the ammeter.
(i) taking the 0- 1A scale, ……………………………………
(ii) taking the 0- 5A scale ……………………………………

(b) Voltmeter
A voltmeter measures voltage (p.d), (**V**) 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 but in parallel with the cell or any other component.

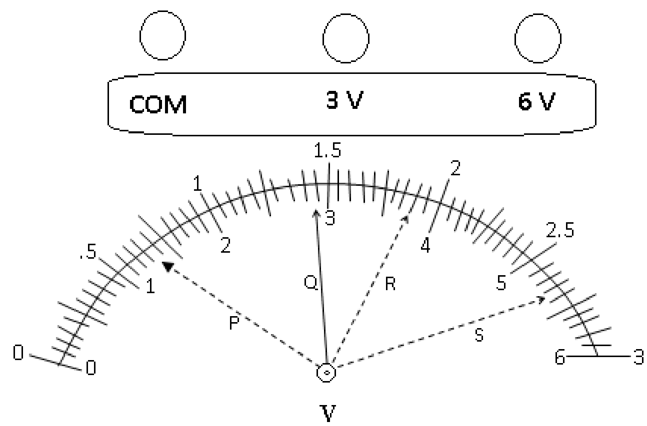
(i) Single scale voltmeter



In the diagram above;

10 divisions $=$ 0.5V 1 division $=$ 0.05V Voltmeter reading $=$ 0.05 x 23 $=$ 1.15V	OR, $= 1 + 0.05 \times 3$ $= 1 + 0.15$ $=$ 1.15V

(ii) Double scale voltmeter



Position P:
In the figure above, taking the 0- 3V scale,
10 divisions $=$ 0.5 V
1 division $=$ 0.05 V
Voltmeter reading $= 0.5 + (0.05 \text{ x } 3)$
$= 0.5 + 0.15$ V
$=$ 0.65 V
In the figure above, taking the 0- 6V scale,
10 divisions $=$ 1 V
1 division $=$ 0.1 V
Voltmeter reading $= 1 + (0.1 \text{ x } 3)$
$=$ 1.30 V
Position Q:
In the figure above, taking the 0- 3V scale,
10 divisions $=$ 0.5 V
1 division $=$ 0.05 V

Voltmeter reading $= 1 + 0.05 \times 8$
$= 1 + 0.40$
$= 1.40$ V

In the figure above, taking the 0- 6V scale,
10 divisions = 1 V
1 division = 0.1 V
Voltmeter reading $= 2 + 0.1 \times 8$
$= 2 + 0.8$
$= 2.80$ V

Position R:
In the figure above, find the reading of the voltmeter.
(i) taking the 0- 3V scale, ……………………………………
(ii) taking the 0- 6V scale ……………………………………

Position S:
In the figure above, find the reading of the voltmeter.
(i) taking the 0- 3V scale, ……………………………………
(ii) taking the 0- 6V scale ……………………………………

4.01: Experiment 32.

In this experiment, you will determine a constant of the wire provided.

(a) Connect the circuit shown in the figure 32 below starting with a length of the wire, y, equal to 30 cm.

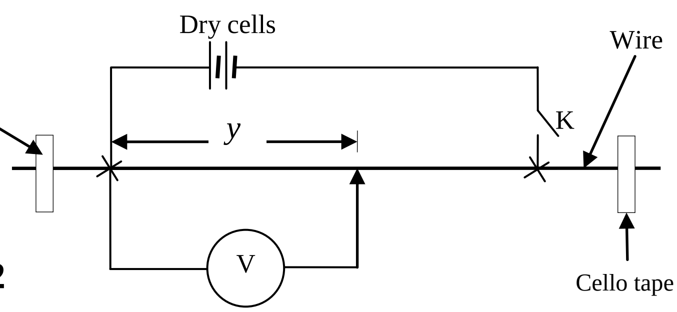


Fig. 32

(b) Close switch K.

(c) Read and record the reading, V , of the voltmeter

(d) Open switch K.

(e) Repeat procedures (c) to (e) for the values of y = 40, 50, 60 and 70 cm.

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

(g) Plot a graph of $\frac{1}{V}$ against $\frac{1}{y}$.

(h) Find the slope, s, of the graph.

(i) Determine the intercept, c, on the $\frac{1}{V}$ axis.

(j) Calculate the constant of the wire, Φ , from the expression;

$$\Phi = \frac{100c}{s}$$

Apparatus: *Voltmeter (0-3 V); 2 Dry cells; Jockey; Cello tape; 5 pieces of connecting wires; Metre rule; Switch; Nichrome (28SWG).*

4.02 Experiment 33

In this experiment, you will determine the resistivity, ρ, of the bare wire, W.

(a) Connect the ammeter A, switch K, dry cell E and wire W as shown in figure 33 below.

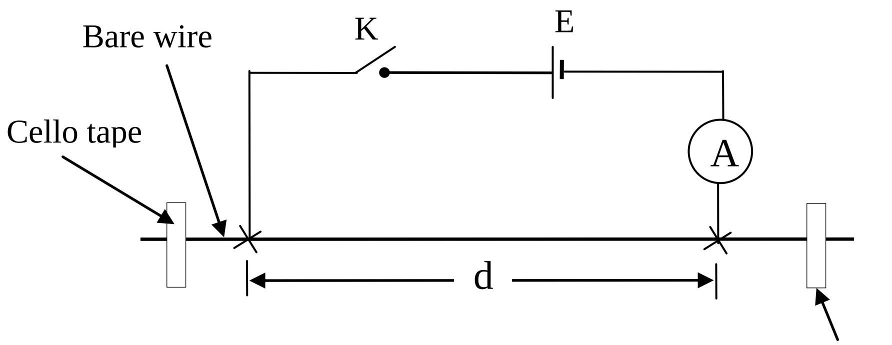


Fig. 32

(b) Adjust distance, d, of the wire to 20 cm.

(c) Close the switch, K, and record the reading, I, of the ammeter.

(d) Repeat the procedures (b) and (c) for values of d equal to 30, 40, 50, 60, 70 and 80 cm.

(e) Record your results in a suitable table including values of $\frac{1}{I}$ against d.

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

(g) Calculate the resistivity, ρ, of the wire from; $\boldsymbol{\rho = 1.6 \times 10^{-5}\ S}$.

Apparatus: *Ammeter (0 – 1 A); 1 Dry cell (Size D); Jockey; Cello tape; 5 pieces of connecting wires; Metre rule; Switch; Constantan (28 SWG) .*

4.03: Experiment 34.

In this experiment, you will determine the resistivity, ρ, of the material of the material of the wire provided.

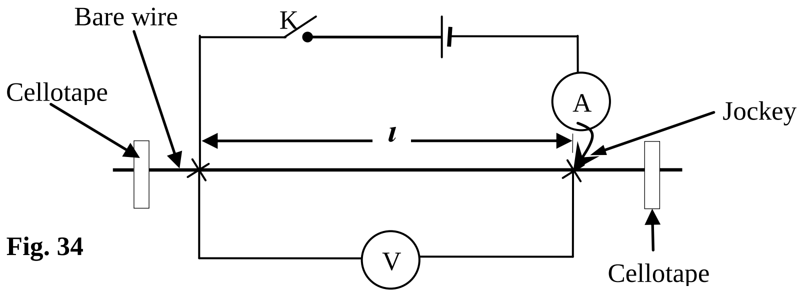


Fig. 34

(a) Connect the circuit as shown in figure 34 above.

(b) With the switch, K, open, adjust the position of the jockey along the bare wire such that $l = 0.2$ m.

(c) Close the switch K.

(d) Note the ammeter reading, I and voltmeter reading V.

(e) Open the switch K.

(f) Repeat procedures (b) to (e) for values of $l = 0.30, 0.40, 0.50, 0.60$ and 0.70m.

(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,

$$\rho = 2.04 \times 10^{-7} S.$$

Apparatus: *Voltmeter (0-3 V); Ammeter (0 – 1 A); 1 Dry cell; Jockey; Cello tape; 5 pieces of connecting wires; Metre rule; Switch; Nichrome (28SWG)*

4.04 Experiment 35

In this experiment, you will determine the internal resistance of a dry cell provided.

(a) Stretch and fix wire P on a metre rule with a cellotape.

(b) Connect the dry cell, 2Ω resistor and a voltmeter as shown in figure 34 below.

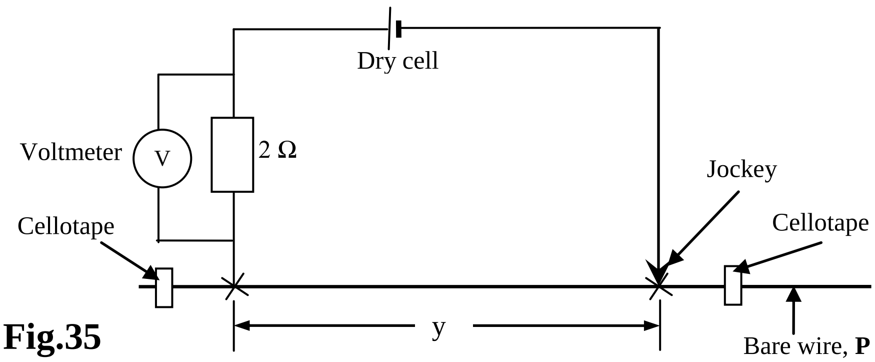


Fig.35

(c) Place the jockey on wire P such that y is equal to 30 cm. Record the voltmeter reading *v*.

(d) Repeat procedure (c) above for values of y equal to 40, 50, 60, 70 and 80 cm

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

(f) Plot a graph of $\frac{y}{V}$ (on vertical axis) against y(on horizontal axis)

(g) Find the slope, s, of the graph.

(h) Find the value **n** of $\frac{y}{V}$ when y = 0 cm.

(i) Calculate the e.m.f, E of the dry cell from;

$$E = \frac{3\times10^{-2}}{S}$$

(j) Calculate the internal resistance, **r** of the dry cell from;

$$\mathbf{r = 2nE - 1}.$$

Apparatus: *Voltmeter (0-3 V); Resistor 2 Ω; Dry cell; Jockey; Cello tape; 5 pieces of connecting wires; Metre rule; Nichrome (28 SWG).*

4.05 Experiment 36:

In this experiment, you will determine the internal resistance, *r* of a pair of dry cells.

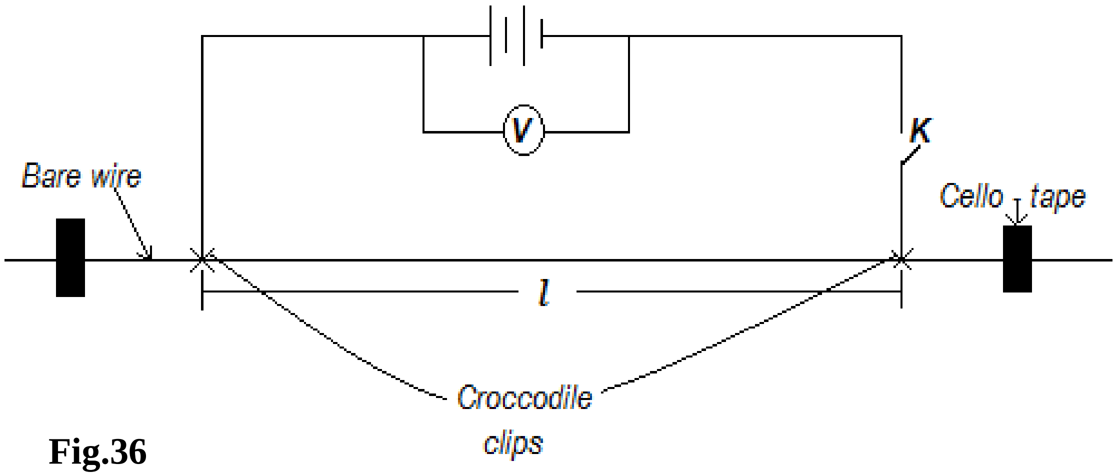


Fig.36

Procedure

(a) Connect your apparatus as shown in the figure 36 above.

(b) Adjust the distance $\boldsymbol{l} = 20\ cm$

(c) Read and record the voltmeter reading, $\mathbf{V_o}$.

(d) Close Switch K

(e) Read and record the reading of the voltmeter, $\mathbf{V_1}$

(f) Open switch K

(g) Repeat procedures (d) to (e) with values of $\boldsymbol{l} = \mathbf{30},\ \mathbf{40},\ \mathbf{50},\ \mathbf{60}$ and $\mathbf{70}\ \boldsymbol{cm}$.

(h) Record your values in a suitable table, including values of $\mathbf{V} = (\mathbf{V_0} - \mathbf{V_1})$ and $\frac{\mathbf{V_1}}{\boldsymbol{l}}$

(i) Plot a graph of **V** against $\frac{\mathbf{V_1}}{\boldsymbol{l}}$

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

(k) Calculate the resistance per metre, ***r***, from the expression;

$$\boldsymbol{r} = 420\boldsymbol{S}$$

Apparatus: 2 cells, 2 single cell holders, switch, K, bare wire 110 m long (Constantine wire SWG 28),Voltmeter (0 – 3) V, Cello – tape, metre rule, 2 crocodile clips, 6 Pieces of connecting wires of about 30 cm each.

4.06 Experiment 37:

In this experiment, you will determine the diameter, *D* of the bare wire given.

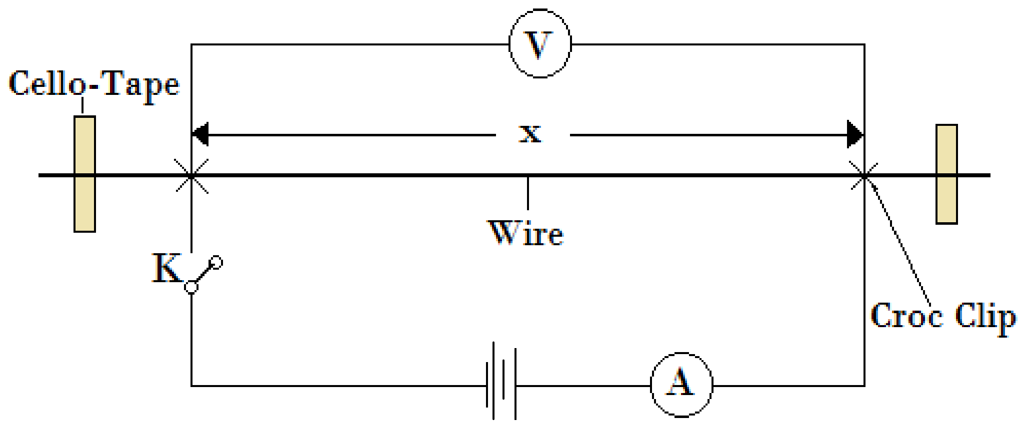


Fig.37

Procedure

a) Fix the bare wire on the metre rule using the cello – tape.

b) Connect the circuit as shown in the figure 36 above.

c) Adjust the position of the length, $\boldsymbol{x} = \mathbf{0.90}\ \boldsymbol{m}$.

d) Close the switch, **K**.

e) Read and record the ammeter reading, $\boldsymbol{I}$ and voltmeter reading, $\boldsymbol{V}$.

f) Open the switch, **K**.

g) Repeat the procedures c) to f) for values of $\boldsymbol{x} = \mathbf{0.80, 0.70, 0.60, 0.5}\ \boldsymbol{and}\ \mathbf{0.40}\ \boldsymbol{cm}$.

h) Record your results in a suitable table including values of $\boldsymbol{Ix}$.

i) Plot a graph of $\boldsymbol{V}$ against $\boldsymbol{Ix}$.

j) Find the slope, $\boldsymbol{S}$ of the graph.

k) Calculate the diameter, $\boldsymbol{D}$ in metres of the bare wire from the expression.

$$\boldsymbol{D} = \left(\frac{\mathbf{8.0}\ \boldsymbol{x}\ \mathbf{10^{-4}}}{\boldsymbol{S}^{\frac{1}{2}}}\right)$$

Apparatus: 2 cells, 2 single cell holders, switch, K, bare wire 110 m long (SWG28) , Ammeter (0 – 1) A, Voltmeter(0 – 3) V, Cello – tape, metre rule, 2 crocodile clips, 5 Pieces of connecting wires of about 30 cm each.

4.07 Experiment 38:

In this experiment, you will determine the internal resistance, r and the electromotive force, E of the cell.

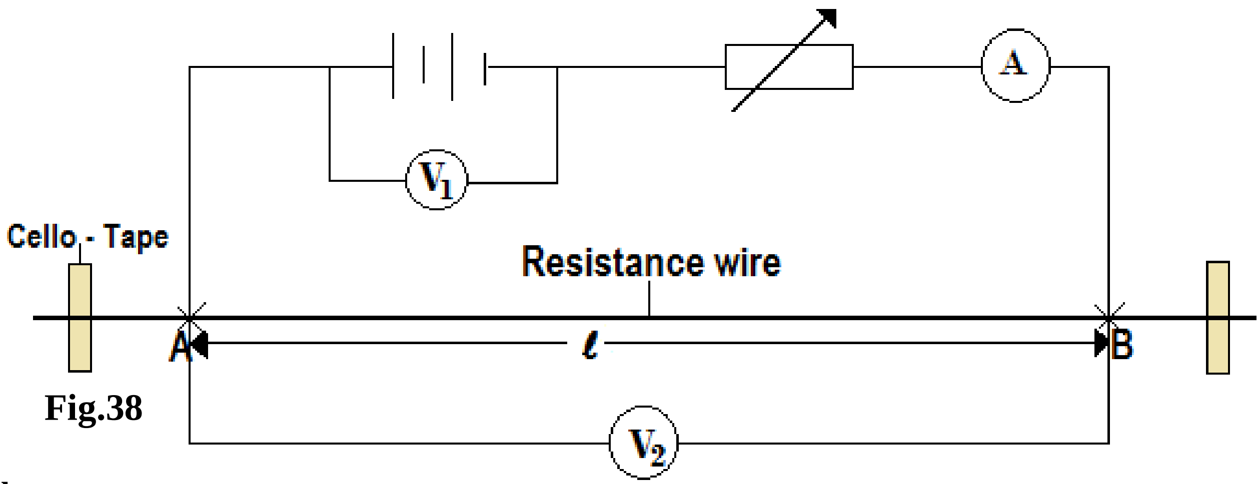


Fig.38

Procedure:

a) Fix the resistance wire on the metre rule using the cello – tape.

b) Connect the circuit as shown in the fig. 38 above such that AB = 15 cm.

c) Adjust the rheostat until the ammeter reading, $\boldsymbol{I = 0.80\ A}$.

d) Connect the voltmeter across the cells and record its reading, $\boldsymbol{V_1}$.

e) Disconnect the voltmeter and connect it across AB. Read and record its reading, $\boldsymbol{V_2}$

f) Repeat procedures c) to e) for values of $\boldsymbol{I = 0.70, 0.60, 0.50, 0.40\ and\ 0.30\ A}$.

g) Enter your result in a suitable table.

h) On the same axes,

   i. Plot a graph of $\boldsymbol{V_1}$ against. $\boldsymbol{I}$

   ii. Plot a graph of $\boldsymbol{V_2}$ against. $\boldsymbol{I}$

i) Read and record the value of current, $\boldsymbol{I_0}$ and voltmeter, $\boldsymbol{V_0}$where the two graphs intercept.

j) Calculate the value of resistance, **r** from the expression;

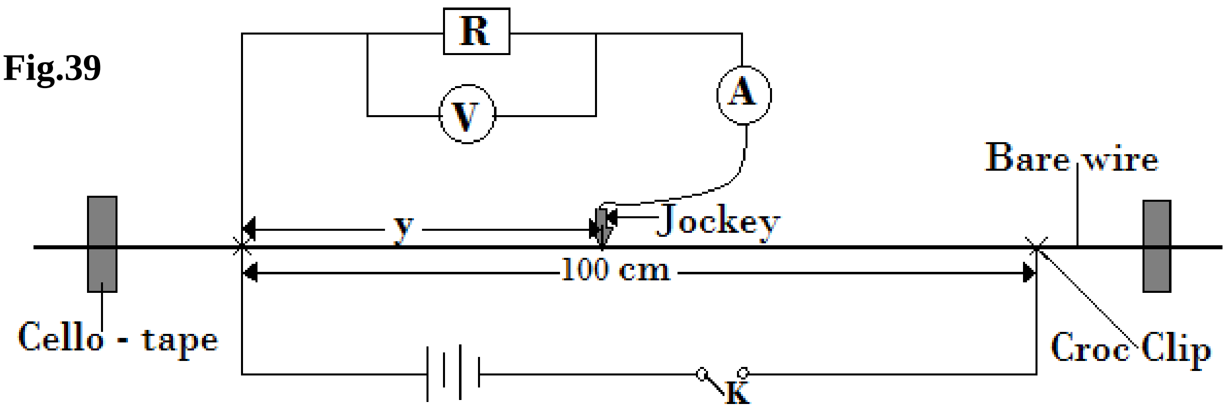
$$\mathbf{r = \frac{V_0}{I_0}}$$

Apparatus: 2 cells, 2 single cell holders, switch, K, bare wire 110 m long (SWG28) , Ammeter (0 – 1) A, Voltmeter (0 – 3) V, Rheostat (0 - 50Ω), Cello – tape, metre rule, 2 crocodile clips, 5 Pieces of connecting wires of about 30 cm each.

4.08 Experiment 39:

In this experiment, you will determine a constant, Ω of the resistor, R

Fig.39



Procedure

a) Connect the circuit as shown in the fig.39 above.

b) Beginning with length, $\mathbf{y = 0.200\ m}$, close the switch, **K**.

c) Read and record the voltmeter reading, **V** and the ammeter reading, **I**.

d) Open the switch, **K**.

e) Repeat the procedures (b) to (d) for the values of $\mathbf{y = 0.300, 0.400, 0.500, 0.600\ and\ 0.700\ m}$.

f) Record your values in a suitable table including the values of $\frac{1}{V}$ and $\frac{1}{I}$.

g) Plot a graph of $\frac{1}{I}$ against $\frac{1}{V}$

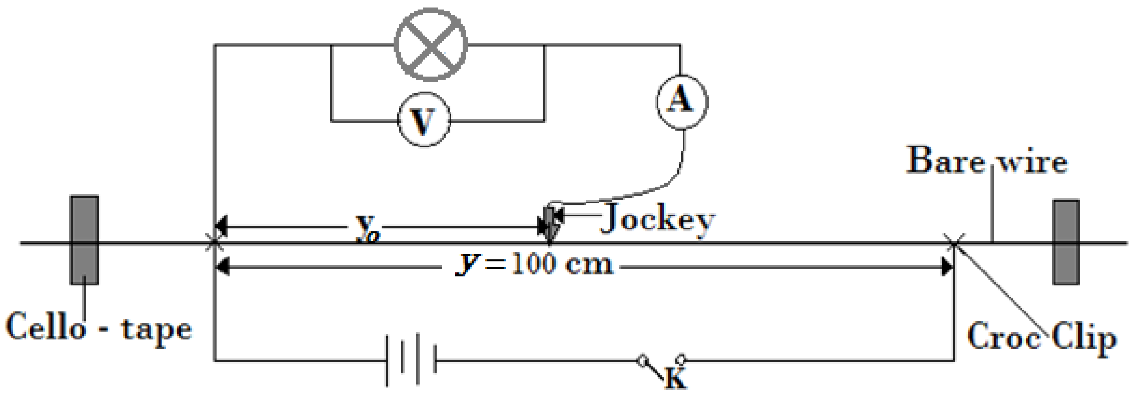
h) Determine the slope, Ω of the graph.

Apparatus: 2 cells, 2 single cell holders, switch, K, bare wire 110 m long SWG28 , Ammeter (0 – 1) A, Voltmeter (0 – 3) V, Resistor **R**, Cello – tape, metre rule, 2 crocodile clips, 5 Pieces of connecting wires of about 30 cm each.

4.09 Experiment 40:

In this experiment, you will determine resistance of the filament of the torch bulb provided.

Fig.40



Procedure

a) Connect the circuit as shown on the diagram above.

b) Starting with $\boldsymbol{y} = $ **100 cm** and $\boldsymbol{y_0} = \mathbf{20}$ **cm**, close the switch, K.

c) Read and record the voltmeter reading**, V** and the ammeter reading, **I.**

d) Open the switch, K.

e) Repeat the procedures (b) to (d) for values of; $\boldsymbol{y_0} = \mathbf{0.300}, \mathbf{0.400}, \mathbf{0.500}, \mathbf{0.600}$ and $\mathbf{0.700}$ **m.**

f) Enter your results in a suitable table.

g) Plot a graph of **V** against **I**.

h) Determine the slope, ***S*** of the graph**.**

Apparatus: 2 cells, 2 single cell holders, switch, K, bare wire 110 m(SWG28) , Ammeter (0 – 1) A, Voltmeter (0 – 3) V, Cello – tape, metre rule, Torch bulb, 2 crocodile clips, 5 Pieces of connecting wires of about 30 cm each.

4. 10: Experiment 41.

In this experiment, you will determine the ratio, p, of the internal resistance of a pair of dry cells to the resistance per centimetre of the wire labelled, W.

(a)Fix the bare wire labelled, W, on the bench using cello tape.

(b) Connect the circuit as shown in the figure 41 below.

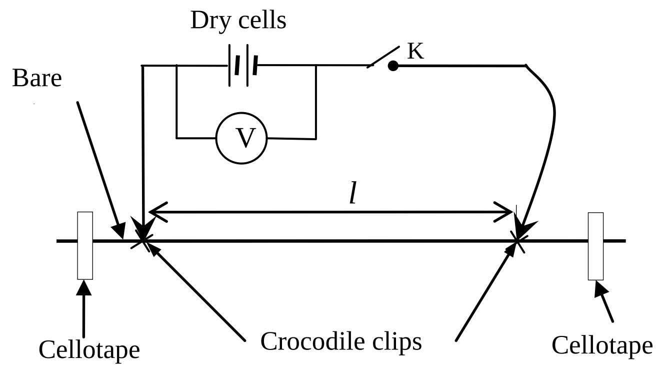


Fig. 41

(c)Starting with a length, l = 20 cm, read and record the voltmeter reading, V_0.

(d) Close the switch, K.

(e)Read and record the voltmeter reading, V_1.

(f) Open the switch, K.

(g) Repeat the procedures (c) to (f) for values of $\boldsymbol{l}$= 30, 40, 50, 60 and 70 cm.

(h) Record your values in a suitable table including values of $V = V_0 - V_1$.

(i) Plot a graph of V against l.

(j) Determine the slope, **p** of the graph.

Apparatus: *Voltmeter (0-3 V); 2 Dry cells; Jockey; Cello tape; 5 pieces of connecting wires; Metre rule; Switch, Constantan wire(28 SWG) labelled W.*

4.11 Experiment 42

In this experiment, you will determine the constant, L_o, of the bicycle spoke

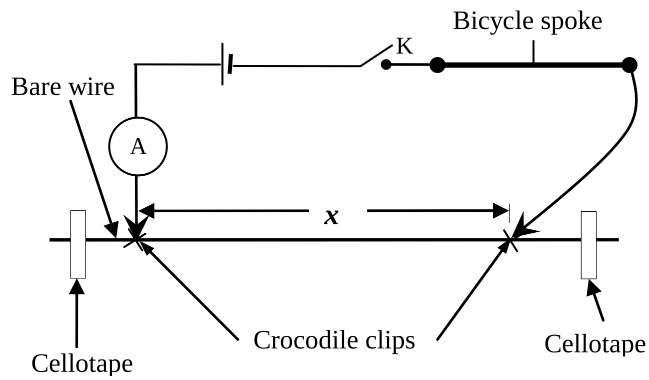


Fig. 42

(a) Connect the circuit as shown in figure 42.

(b) Starting with a length, x = 0.800 m, close the switch, K.

(c) Record the ammeter reading, I.

(d) Open the switch K.

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

(f) Record your results in a suitable table including values of $\frac{1}{I}$.

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

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

(i) Read the intercept, C, on the $\frac{1}{I}$ axis.

(j) Calculate the value of L_o from the expression: $\mathbf{S} = \frac{2C}{L_o}$

Apparatus: *Ammeter (0 – 1 A); 1 Dry cell; Jockey; Cello tape; 5 pieces of connecting wires; Metre rule; Switch; nichrome (28SWG); Bicycle spoke.*

4.12 Experiment 43

In this experiment, you will determine the resistance of a resistor.

(a) Connect the dry cells, resistance wire, resistor **R**, voltmeter **V** and ammeter **A** as shown in the figure 43 below.

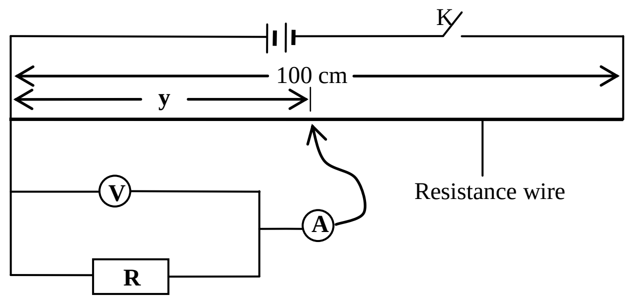


Fig. 43

(b) Adjust the length, y, of the resistance wire to 20 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) to (c) for values of y equal to 30, 40, 50, 60 and 70 cm.

(f) Record your results in a suitable table.

(g) Plot a graph of V against I.

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

Apparatus: *Voltmeter (0-3 V); Ammeter (0 – 1A); Resistor 5Ω; 2 Dry cells; Jockey; Cello tape; 5 pieces of connecting wires; Metre rule; Switch; Nichrome (28SWG).*

4.13 Experiment 44

In this experiment, you will determine the resistance of a resistance wire.

(a) Fix the resistance wire provided firmly on the bench.

(b) Connect the circuit as shown in figure 44 below with the length *PQ* = 20 cm.

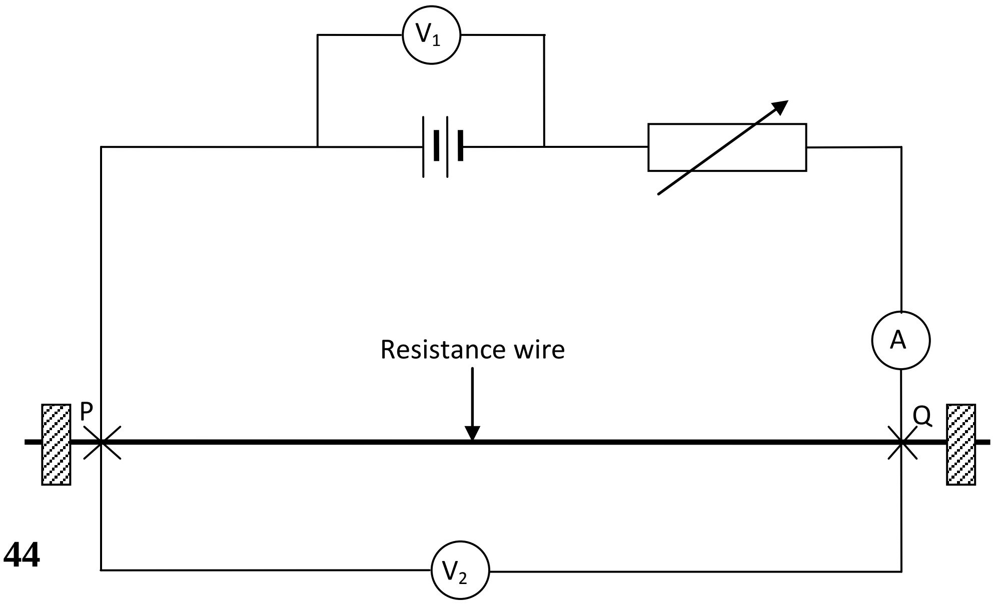


Fig. 44

(c) Adjust the rheostat so that the ammeter reading I = 0.6 A.

(d) Connect a voltmeter across the cells and record its reading V_1.

(e) Disconnect the voltmeter and connect it across PQ. Record its reading V_2.

(f) Repeat procedures (c), (d) and (e) for values of I = 0.5, 0.4, 0.3, 0.2 and 0.1 A.

(g) Record your results in a suitable table.

(h) On the same axes, plot a graph of

(i) V_1 against I.

(ii) V_2 against I.

(i) Read the values of current I_o and voltage V_o where the two graphs meet.

(j) Calculate the value of $\frac{V_o}{I_o}$.

Apparatus: *Voltmeter (0-3 V); ammeter (0 – 1 A); Rheostat (0 - 50Ω); 2 Dry cells; Jockey; Cello tape; 8 pieces of connecting wires; Metre rule; Switch; Nichrome (28SWG).*

4.15 Experiment 45.

In this experiment, you will determine the resistance, R, of the filament of the torch bulb provided.

(a) Fix the bare wire, P, on the bench using pieces of cellotape.

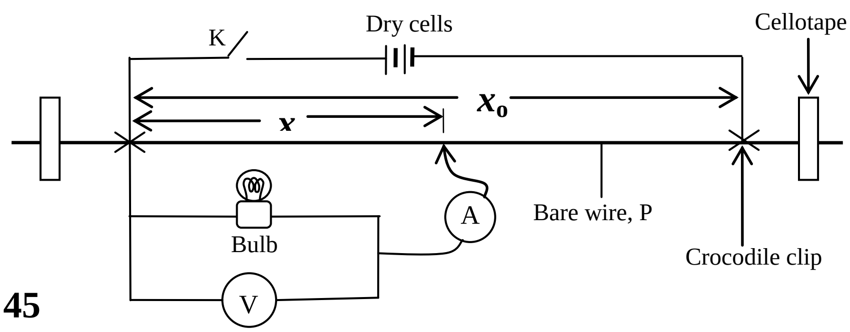


Fig. 45

(b) Connect the circuit as shown in the figure 45 above.

(c) Starting with length, x_o = 1.00 and x = 0.20 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 (c) to (e) for values of $\boldsymbol{x}$ = 0.30, 0.40, 0.50, 0.60 and 0.70 m.

(g) Record your results in a suitable table.

(h) Plot a graph of V against I.

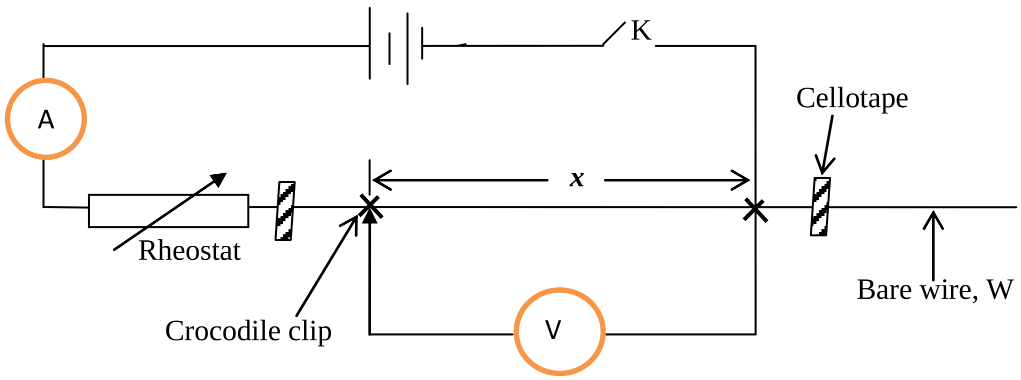
(i) Determine the slope, S, of the graph.

Apparatus: 1*Voltmeter (0-3 V);1 Ammeter (0 -1); 2 Dry cells; Jockey; 2 pieces of Cello tape; 10 pieces of connecting wire about 30cm long;1 Metre rule; Constantan (28 SWG); 1 bulb in a holder,1 switch.*

4.16 Experiment 46.

In this experiment, you will determine the constant, β of the bare wire labeled W. (20 marks)

(a) Connect the circuit shown in figure below



(b) Adjust the crocodile clip so that x = 0.300m.

(c) Close switch K, and adjust the rheostat until the ammeter reading, I= 0.40 A.

(d) Record the voltmeter reading, V.

(e) Open switch, K.

(f) Repeat procedures (b) to (e) for values of x = 0.400, 0.500, 0.600, 0.700 & 0.800 m.

(g) Tabulate your results including values of $\frac{V}{I}$

(h) Plot a graph of $\frac{V}{I}$ against x

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

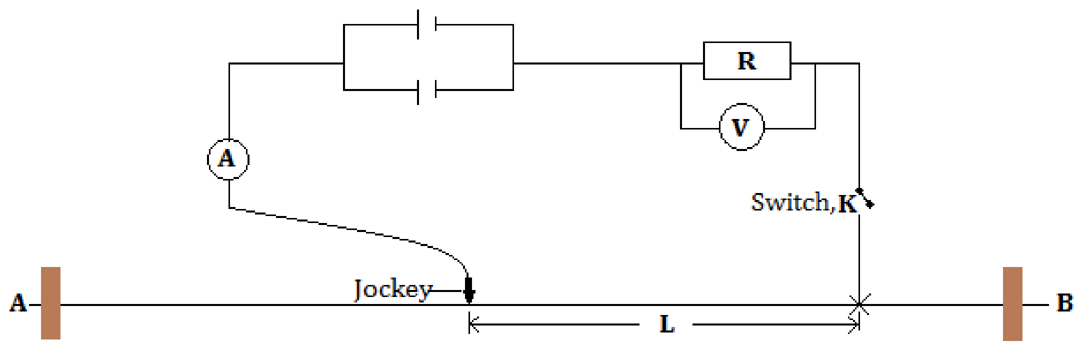
(j) Calculate the constant, β of the bare wire W from the expression,

$$\beta = 1.13\text{x}10^{-7}S$$

Apparatus: 1*Voltmeter (0-3 V);1 Ammeter (0 -1); 2 Dry cells; Jockey; 2 pieces of Cello tape; 10 pieces of connecting wire about 30cm long;1 Metre rule; 1 Switch; Constantan bare wire (28 SWG); 1Rheostat (0 - 50Ω).*

4.17: Experiment 47.

In this experiment, you will determine the constant, R of the resistor provided.



Procedure

a) Set up the apparatus as shown in the diagram above.

b) Starting with length, $\mathbf{L = 100\ cm}$, close the switch, K.

c) Record the voltmeter reading, **V** and the ammeter readings, **I.**

d) Repeat the procedures b) and c) for values of $\mathbf{L = 90, 80, 70, 60}$ and $\mathbf{50\ cm}$.

e) Enter your result in the suitable table including values of $\frac{1}{V}$ and $\frac{1}{I}$

f) Plot a graph of $\frac{1}{I}$ against $\frac{1}{V}$.

g) Determine the gradient, ***S*** of the graph.

Apparatus: Two cells, Nichrome wire SWG28 (about 110 cm), 8 pieces of connecting wires, a Carbon resistor, i.e. 5 Ω, ammeter (0 – 1)A, Voltmeter (0 – 3)V, Switch, K, 2 single cell holders.

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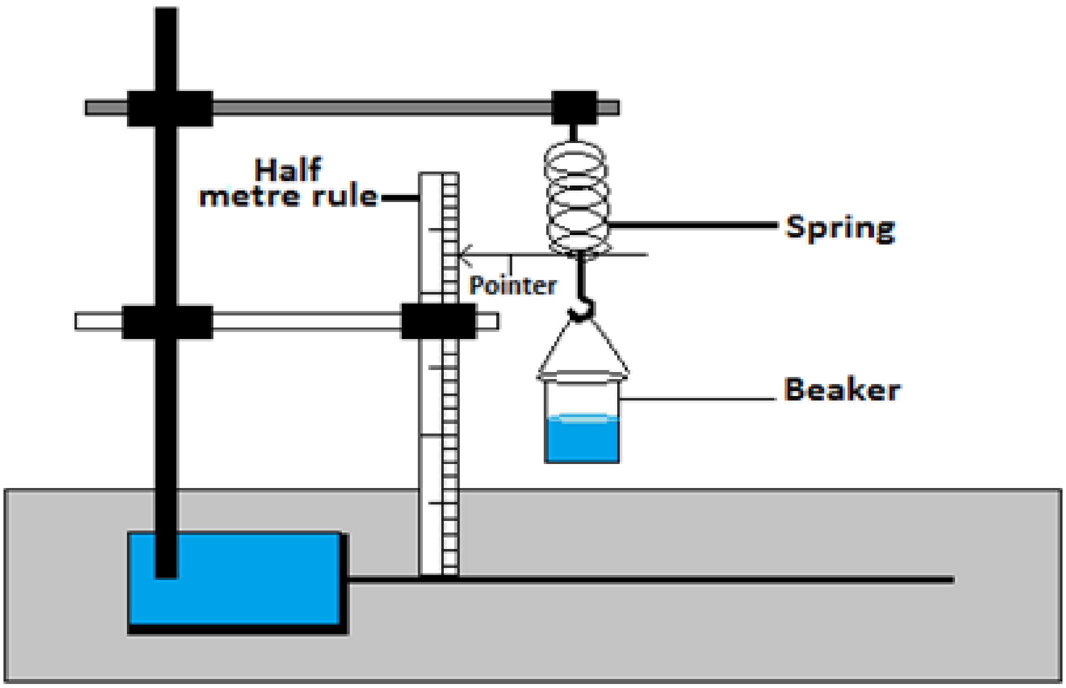

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