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PHYSICS PACTICAL WORK BOOK FOR NEW LOWER SECONDARY CURRICULUM S3 AND S4 2025 EDITION

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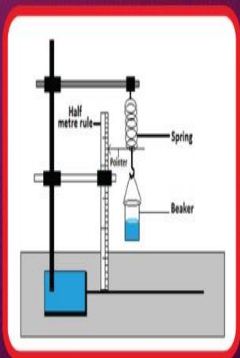
FOR NEW LOWER SECONDARY CURRICULUM

2025 EDITION



S3 AND S4

PHYSICS PRACTICAL WORK BOOK FOR NEW LOWER SECONDARY CURRICULUM

S3 AND S4

In case of any technical reaction inform of suggestion, criticism etc.

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2025 EDITION

STUDENT’S PARTICULARS

Student’s name

Class

Stream

Year

Facilitator’s name

PREFACE

This book is intended to help leaners who are preparing to sit for their final ordinary level examination particularly in physics practical under new lower secondary level curriculum.

The book is written basing on the content of physics in new lower secondary level curriculum as guided by NCDC physics syllabus and UNEB

The book contains worked examples, test items from mechanics, light and electricity. All the content is condensed to enable self-study.

The book contains theory and possible diagrams of most common experiments in ordinary level physics. An updated physics practical score grid (marking guide-2024) format is also provided in this book.

There is no doubt that this book will be helpful to all suitable users across the country.

ACKNOWLEDGMENT

I am thankful to the almighty God for giving me the gifts of life, knowledge and wisdom that have enabled me to come up with this book.

Thanks to the physics department members of the following schools whom I served with at some point. St Joseph's Girls senior secondary school Nsambya, St Noa girls secondary school Zana, Maryland high school-Entebbe (Kigungu main campus), King's way high school - kitende, Kairos high school Muyenga, Central college high school - Bulenga campus and Ebenezer Christian high school -Bulenga. You added a brick in my career development.

Thanks to all senior physics facilitators across the country especially those who have reviewed and edited this book. May God bless you.

DEDICATION

This book is dedicated to all physics facilitators across the country

This book is also dedicated to all our dear learners of physics across the country. You are the main reason as to why we wrote this book.

TABLE OF CONTENTS

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INTRODUCTION

Ordinary level physics practical (535/2 and 353/3) has been revised under new lower secondary curriculum as follows

Structure

The paper consists of ***two scenario-based*** items set from either mechanics and light or, light and electricity or mechanics and electricity. A candidate will be required to answer ***only one item.***

Duration.

The time allocated to this paper is strictly two hours. Candidates are advised to use the first 15 minutes for planning which may include;

i. Reading and understanding the scenario items asked. (Each scenario should be read at least twice). Make sure you fully understand the items before making a choice on the item you are to answer.
ii. Checking and making the choice of the apparatus you are going to use in your set up and procedures.
iii. Understanding the aim, hypothesis and variables involved in the experiment to be under taken
iv. Understanding on how data will be presented.
   For example, which quantities are to be included in the table of results, how will data be analysed (do you need a graph, then slopes, then intercepts etc.?).
v. Drawing conclusion from data analysed to prove your hypothesis and give appropriate advice.

PRESENTATION OF PHYSICS PRACTICAL WORK (PRACTICAL REPORT) BASED ON A SCIENTIFIC INVESTIGATION.

Aim of the experiment.

This is a general statement that guides your steps throughout the experiment. It brings out the main objective as to why you are carrying out the experiment. It is derived from the scenario item at hand. At the end of the experiment, make sure that you have achieved the aim of the experiment. For example, if the aim of your experiment was

‘’A scientific investigation to determine the mass of the metre rule”. At the end of the experiment, you should come up with the mass of given metre rule.

Variables.

These are quantities whose values may vary during the experiment. These variables are divided into three. That is;

Independent variable.

This is a variable which when changed causes a variation in another quantity. An independent variable is varied (changed or altered) so that we can notice how it affects another quantity (or variable).

For example; when the length of string of a pendulum is adjusted, the period of oscillation changes.

As the length of the string is increased from 10.0cm to 20.0,30.0,40.0cm etc., the period of oscillation keeps on increasing. This means that the period of oscillation of the pendulum depends on the length *l* of the string. In this case, the period of oscillation becomes the dependent variable (because it depends on the length of the string) while the length of the string becomes independent variable.

Dependent variable.

This is a variable whose values depend on values of the other physical quantity (independent variable).

Controlled (fixed) variable

This is a variable whose values may change as the experiment goes on but the effects of its variations are assumed to be constant since it not part of the experiment.

The most notable examples of such variable include; effect of blowing wind, sunlight intensity, temperature, etc.

Hypothesis.

This is a general statement that predicts the outcome of the experiment. At the end of the experiment, it can be proven correct or wrong. It is derived from given the situational (scenario) item.

For example,

When John, a camera man took his lens camera for repair, the technician (mechanic) advised him that the lens to be used in repairing the lens camera should be of focal length f, ranging from 10cm to 15cm.

Your hypothesis basing on this scenario may be

"The focal length, f of the lens is in the range $10cm\ to\ 15cm$ and the lens can be used to repair the lens camera of the camera man".

If at the end of the experiment, your focal length is let's say 13.5cm, then your hypothesis is proved correct (tested positive) and the lens can be used to repair the lens camera of the camera man.

However, if the value of focal length is 9.0cm or 20.0cm, then your hypothesis is tested negative since the obtained value of f does not lie in the expected range of

$10cm\ to\ 15cm$ and therefore the lens cannot be used to repair the lens camera of the camera man

List of apparatus.

This is a set of instruments or materials that you are going to use in the experiment. When stating the apparatus, specify the quantity of the apparatus needed e.g.,

- 1 metre rule,
- 1 stop clock,
- 3 pieces of thread each of length 50.0cm
- 1 pendulum bob
- 1 retort stand with a clamp, etc.

Experimental set up

Under this, you can sketch a simple diagram that is well labelled to show how your apparatus are to be arranged. The diagram guides the logical flow of your procedures.

Procedure or steps

Write the steps to be taken so as to come up with results. The procedures must be relevant, accurate and coherent (logically flowing). Present simple tense is recommended when writing these procedures.

You should properly number your steps.

Sources of errors and precautions.

Some times after running the experiment and analysing data, the outcome may not be exactly the same as what was expected.

In most cases this could be a result of the errors that may arise as we do the experiment. Sources of such errors depend on the experiment being carried out. They may include; parallax errors which arise due to poor positioning of your eye when taking a reading from a given scale of a measuring instrument, zero errors in some measuring instruments especially the stop clocks, ammeters, voltmeters, galvanometers, wind effects and air resistance etc.

Once those errors are specified, go ahead and suggest how they can be minimised or avoided.

Data presentation

Record the single measurements first if necessary for example, the initial position of the pointer $P_O = 45.6cm$, The balancing point $G = 49.5cm$

After this, design a suitable table where results are to be tabulated. In the table of results,

- ❖ Independent variables should be entered first. Then after, depended variables (measured and calculated values should follow in the next columns).
- ❖ The symbol of the quantity and its unit in brackets () should be written once at the top of each column.
- ❖ Related columns should be next to each other

Data analysis

Data recorded in your table has to be analysed so as to accomplish the aim the experiment and test the hypothesis. Data is analysed by plotting relevant graph(s) or using pie chart, line graphs, bar graphs, statistical tables etc. depending on the nature of the data to be analysed. Graph is highly recommended when analysing data from a physics practical.

Conclusion and advice

Data analysis may include drawing a graph, finding the slope of the graph, and using the slope to make a conclusion.

The conclusion may also be made after substituting the value of the slope in the appropriate formula.

You are expected to use the value of the slope or value obtained after substituting the slope in the appropriate formula or the ***trend of the graph*** to prove your hypothesis, make conclusions in relation to your aim and give appropriate advice

For example,

Given the hypothesis which states that

"The value of focal length, f of a lens is in the range $8\text{cm} < \text{f} < 15\text{cm}$ and the lens can be used to repair the lens camera of the camera man".

When a graph of $(\text{u} + \text{v})$ against uv is plotted, the slope s of this graph will be $\boldsymbol{\frac{1}{f}}$. That is $s = \frac{1}{f}$, $thus\ \boldsymbol{f = \frac{1}{s}}$. If slope $s\ =\ 0.5cm^{-1}$, then by substitution in $\boldsymbol{f = \frac{1}{s}}$

$$\boldsymbol{f = \frac{1}{0.5\ cm^{-1}} = 10\ cm}$$

conclusion and advice should be stated as follows;

The value of focal length, f of the lens is 10cm which lies in the range of

8cm to 15cm hence the hypothesis is tested positive. Therefore; the lens can be used to repair the lens camera of the camera man.

SUMMARY OF A PHYSICS SCIENTIFIC INVESTIGATION REPORT

- Aim of the investigation
- Variables
- Hypothesis
- List of apparatus
- Experimental set up (diagram)
- Procedures or steps
- Sources of errors and precautions
- Data presentation (recording of single measurements and table of results)
- Data analysis (plotting of a graph and calculation of the slope)
- Relate your slope, trend of your graph or value obtained by substituting the slope in suitable formula to your aim
- Conclusion and advice

WRITING UNITS AND THEIR SYMBOLS

When writing symbols of measured quantities, the following points should be noted

i. All units of measured quantities should be the same as those of their respective instruments unless told to write the values in other units. For example, when the length of a wire is measured using a metre rule, the value should be written in centimetres (cm) e.g., 5.0cm
when the diameter of a wire is

For example, $l = 5.0cm$

$$= 0.050m$$

ii. All units of derived quantities are derived units and should be written in index form (where applicable). Forward slash (/) should be avoided when writing such units e.g., density $\boldsymbol{\rho = 1000kgm^{-3}}$ but not $\boldsymbol{\rho = 1000kg/m^{3}}$

iii. Units named after persons to be written in full words using small letters or using their known symbols. If a single letter (normally the first letter of the full name of the unit) represents the symbol of such unit, it should be a capital letter e.g., force $F = 0.25N$ or $F = 0.25\, newtons$ but not $F = 0.25Newtons$

However, if first two letters of the word are to be used, the first letter should be the capital letter while the second letter should be small letter e.g., pressure

$P = 1500Pa$ or $P = 1500\, pascals$

Examples of units named after persons include force in newtons (N), temperature in kelvin(K), voltage (V), amperes (A), pascals (Pa), tesla (T) etc.

iv. Units which are not named after persons should be written in small letters whether in full or using their symbols e.g., centimetres (cm), kilometres (km), grams (g), kilograms(kg).

v. Units of quantities outside the table of results should not be in brackets for example length *l=5.0cm but not l=5.0(cm). You are advised not to put a full stop after a value or its unit e.g., 5.0. is not correct.*

vi. In the table of results, symbol of a quantity and its unit within brackets () is written once at the top of the column.

LEAST COUNT OF A MEASURING INSTRUMENT

ACCURACY (LEAST COUNT) OF DIFFERENT MEASUREMENT INSTRUMENT

Instrument	Quantity it measures	Units	Symbol of unit	Degree of Accuracy or least count (Number of decimal points dp)
Metre rule	Length *l* ($l \geq 10$cm)	centimetres	cm	0.1cm (1dp)
vernier caliper	Length, *l* (1cm $\leq l \leq$ 10cm) e.g., breadth of a metre rule, internal and external diameter of a test tube etc.)	centimetres	cm	0.01cm (2dp)
micrometer screw gauge	length *l* *($l \leq 1cm$)*	millimetres	mm	0.01mm (2dp)
Stop clock	Time	seconds	s	0dp, or 1dp. For one dp, the last figure is a 0 or 5 **Note.** 0dp or 1dp depends on the scale that your stop clock has
Stop watch	time	seconds	s	2dp
Voltmeter	Voltage	volts	V	1dp or 2p depending on the scale you are using

Ammeter	Current	amperes	A	1dp or 2dp depending on the scale you are using
Thermometers	Temperature	degrees celsius or centigrade	^0C	0dp or 1dp where last digit is 0 or 5
Measuring cylinder, pipette, beaker and flasks	Volume	cubic centimetres	cm^3 Note; $1cm^3 = 1ml$ Hence $250cm^3 = 250ml$	0dp
Protractor	Angles	degrees	^{0}	0dp
Beam balance	Mass	grams	g	1dp
Graph paper	Length	centimetres	cm	1dp (since 5small squares represents 1cm, $1sq = \frac{1}{5} = 0.2cm\ (1dp)$

DECIMAL PLACES AND SIGNIFICANT FIGURES

DECIMAL PLACES (dp)

A decimal place is a specific position of a digit in the fractional part of a decimal number.

A decimal point is a dot that separates whole and fractional parts of a given number.

Number of decimal places (dp) are counted from decimal point to the right for example the number 23.567 has three decimal places. 0.0456 has 4 decimal places.

PROCESS OF ROUNDING OFF

A figure can be rounded off to a given number of decimal places. This is done through the following steps

i. Note the number of decimal places to round off to
ii. Identify a digit that is in position of required number of decimal places.
iii. Leave this digit unchanged if the digit next to it is less than five
iv. Add one to this digit if the digit next to it, is equal to or greater than five

Example

Round off the following to the required number of dp as indicated in brackets

a) $23.44676\ (0,1,2dp)$

i. $23.44676\ =\ 23\ (0dp)$
ii. $23.44676\ =\ 23.4(1dp)$
iii. $23.44676\ =\ 23.45(2dp)$

b) $56.46997\ (1, 2,3,4dp)$

i. $56.46997\ =\ 56.5\ (1dp)$
ii. $56.46997\ =\ 56.47(2dp)$
iii. $56.46997\ =\ 56.470(3dp)$
iv. $56.46997\ =\ 56.4700(4dp)$

Exercise.

1. Round off the following as instructed in brackets

a) $0.0067459897(0,1,2,3,4,5dp)$.

2. Rund off the following as instructed in brackets

b) $2457.4567(1,2,3,4,5,7,9dp)$

SIGNIFICANT FIGURES (sf)

Significant figure represents the precision (consistency or reproducibility) of a measurement or a calculation.

IDENTIFYING THE SIGNIFICANT FIGURES.

a) All non-zero digits are significant figures. These digits are 1,2,3,4,5,6,7,8,9

b) Zeros may or may not be significant as explained below

i. **Leading zeros**. These are zeros just before first non-zero digit. These zeros are ***not counted*** as significant figures $e.g.,0.00456$ has 3sf (The first three zeros are leading zeros, that is they are before the first non-zero digit 4), 0056 has only 2sf

ii. **Trapped zeros.** These are zeros between non zero digits. They ***are counted*** as significant figures
$e.g.,405\ has\ 3sf, 0.00405\ has\ 3sf\ and\ 0.1010101\ has\ 7sf$

iii. **Trailing zeros.** These are zeros at the end of a number. If these zeros are from rounding off, they are ***not counted*** as significant figures.

However, if trailing zeros are not as a result of rounding off, they simply indicate the level of accuracy and precision of a measured value or calculated value. Hence, they ***are counted*** as significant figures.

Take a look at the following examples

- A number 249897 can be rounded off to 2sf so that it becomes 250000. The last four zeros are not counted as sf since they result from approximation (rounding off)
- All digits including trailing zeros in a measured value or varying values are significant.

If mass of an object is $500g$ as measured by a beam balance, then $500g\ has\ 3sf$.

In the same way, if the length of an object as measured by a metre rule is 5.0cm, the zero at the end is counted as a significant figure.

For that matter, it is correct to take all trailing zeros in varying or measured value as significant figures.

ROUNDING OFF TO THE GIVEN NUMBER OF SIGNIFICANT FIGURES

Steps

i. Identify the digit in the position of the required number of sf.
ii. Leave this digit unchanged if the digit next to it is less than 4.

iii. Add one to this digit if the digit next to it is equal to or greater than five

Note: When counting the number of significant figures, we start from the first significant number irrespective of the position of decimal point.

Example

Round off the following to the required number of sf as indicated in brackets

a) 10.1469879 (3,5,6 ,2,1)

i. $10.1469879 = 10.1\ (3sf)$

ii. $10.1469879 = 10.147(5sf)$

iii. $10.1469879 = 10.1470(6sf)$

iv. $10.1469879 = 10\ (2sf)$

v. $10.1469879 = 10\ (1sf)$

b) 45873 (1,2,3,6 sf)

i. $45873 = 50000(1sf)$

ii. $45873 = 46000(2sf)$

iii. $45873 = 45900(3sf)$

iv. $45873 = 45873.0\ (6sf)$

c) 0.01048976 (1,2,4sf)

i. $0.01048976 = 0.01\ (1sf)$

ii. $0.01048976 = 0.010(2sf)$

iii. $0.01048976 = 0.01049\ (4sf)$

Exercise

Round off the following as instructed in brackets

a) 1.09957 (1,2,3,7dp)

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b) 148976 (1,3,5sf)

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c) $0.0450675\ (1,2,4sf)$

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d) $0.75\ (1,2,3,4\ sf)$

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e) $4.09863 \times 10^{-6}\ (1,2,3,4,5sf)$

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MANIPULATION OF EXPERIMENTAL VALUES

RULES OF DATA MANIPULATION

(TREATMENT OF EXPERIMENTAL VALUES)

Addition and subtraction

Examples

a) $4.508\ (3dp)\ +\ 0.2(1dp)\ =\ 4.7\ (1dp)$
b) $0.2345\ (4dp)\ -\ 0.12\ (2dp)\ =\ 0.11\ (2dp)$
c) $If\ x\ =\ 0.075\ and\ y\ =\ 0.00483, then$
   i. $x + y\ =\ 0.075 + 0.00483\ =\ 0.080\ (3dp)$
   ii. $x - y\ =\ 0.075\ -\ 0.00483\ =\ 0.070\ (3dp)$

Multiplication and division

Examples

a)

Exercise

$If\ x\ =\ 0.075\ , y\ =\ 0.00483\ and\ \ z\ =\ 1.23,$ find;

i. $\frac{(x+y)}{xz}$

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ii. $\frac{(xy-z^2)}{xyz}$

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iii. $\frac{y}{xz} - xz$

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iv. $xyz - xy - z$

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Note:

i. The logarithm of a measured value, the roots (square root, cube root etc.) of a non-measured whole number or a float (to be discussed later), the trigonometric ratios of measured angles (sin, cos and tan) are all recorded to three decimal places $e.g., sin\, 38^0 = 0.616,\ \sqrt[3]{45} = 3.557,\ log2 = 0.301,\ In2 = 0.693\ etc.$

ii. For the root of non-float (e.g., a decimal number or measured value), maintain the significant figures of that number.

$For\ example\ \sqrt[3]{1.9320} = 1.2455$

THE FLOAT

A float is a non-measured whole number or constants like $1,2,\pi,e,etc.$

They are considered to have infinite number of significant figures e.g., 20 can be written as 20.00000 ... hence having infinite number of sf.

When multiplying or dividing a measured value with a float, maintain the number of sf of the measured value.

NOTE

Whole number

Example

If $t = 19.5$ seconds is time for 20 oscillations, then

period T$= \frac{t}{20\ (float)}$

$= \frac{19.5(3sf)}{20(float)}$

$= 0.975\ seconds$

Exercise

Given that $x = 23.5, T = 1.925,$

Compute

i. $\frac{1}{x}$

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ii. $\frac{10}{x^2}$

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iii. obtain t if T= $\frac{t}{20}$

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MANIPULATION OF EXPERIMENTAL RESULTS IN MAIN TABLE OF RESULTS

Single (non - repeated values) or non - varying values.

$G = 48.9cm$

If a letter or symbol is to be used to represent a physical quantity, it must clearly be defined e.g., let V represent the volume of liquid x.

i. Some constant values like breadth or width of a metre rule, thickness of a wire, diameter of a test tube etc. can be measured at least three times along different points and average value obtained. This increases the accuracy of your results

For example, a simple table is designed as below

Let the diameter of the wire be d

d_1 (cm)	d_2 (cm)	d_3 (cm)
………………….	………………….	………………….

$$d = \frac{(d_1+d_2+d_3)}{3}$$

NOTE

The average value obtained should be recorded to the same number of dp as that of the least count of the instrument used. That is, maintain the degree of accuracy (dp) of the instrument being used.

***In the main table of results, only varying values are tabulated* as follows**

i. Related values should be in columns that are next to each other. The table should be as detailed as possible e.g., if a column of $\frac{1}{sin^2\theta}$ is required in the table of results, expected columns in the table of results are those that contain values of $\theta, sin\theta, sin^2\theta \text{ and then } \frac{1}{sin^2\theta}$

ii. The table should be in column form and it should be continuous. It should be fully closed.

iii. Symbols used in the table of results should be clearly defined just before the main table of results unless they have been already defined in the procedures.

RULES OF DATA MANIPULATION IN THE MAIN TABLE OF RESULTS

The following rules should guide you when manipulating data in the main table of results.

ADDITION AND SUBTRACTION

or subtracted.

Example

Copy the table below and include values of uv and $u + v$

$u(cm)$	$v(cm)$
2.5	99.5
5.0	93.5
7.5	88.5
10.0	76.0
12.5	67.0
15.0	46.5

Solution

$$2.5(1dp) + 99.5(1dp) = 102.0(1dp)$$

u(cm)	v(cm)	(u + v)(cm)	(u − v)(cm)
2.5	99.5	102.0	97.0
5.0	93.5	98.5	88.5
7.5	88.5	96.0	81.0
10.0	76.0	86.0	66.0
12.5	67.0	79.5	54.5
15.0	46.5	61.5	31.5

DEALING WITH VALUES FROM A SINGLE COLUMN

Example.

Copy the table below and include the values of $y(m), \frac{1}{x}\ (m^{-1}), y^2\ (m^2)\ , \frac{y}{20}(cm)$

$x(m)$	$y(cm)$
0.05	26.1
0.10	31.0
0.15	38.0

0.20	45.0
0.25	53.2
0.30	62.0

Solution

x(m)	y(cm)	y(m)	$\frac{1}{x}(m^{-1})$	$y^2(m^2)$	$\frac{y}{20}\ (cm)$
0.05	26.1	0.261	20.0	0.068	1.31
0.10	31.0	0.310	10.0	0.096	1.55
0.15	38.0	0.380	6.7	0.144	1.90
0.20	45.0	0.450	5.0	0.203	2.55
0.25	53.2	0.532	4.0	0.283	2.66
0.30	62.0	0.620	3.3	0.384	3.10

62.0 is largest in this column with 3sf. Hence $\frac{62.0\,(3sf)}{100(float)} = 0.620(3sf, 3dp)$

In x, 0.30 is largest with 2sf. Hence $\frac{1(float)}{0.30(2sf)} = 3.3(2sf, 1dp)$

In column of y, 0.620 *is largest with 3sf*

Hence $0.620^2 = 0.384, (3sf, 3dp)$

in column of y (cm), 62.0 is highest with 3sf. Hence $\frac{62.0(3sf)}{20(float)} = 3.10(3sf, 2dp$

MULTIPLICATION AND DIVISION OF VALUES FROM TWO DIFFERENT COLUMNS

Example 1

Copy the table below and include the values of $xy\ and\ \frac{x}{y}$

$x(cm)$	$y(cm)$
0.05	0.261
0.10	0.310
0.15	0.380
0.20	0.450
0.25	0.532
0.30	0.620

solution

Note

i. For logarithm of a number, roots of floats (e.g., whole number and constants), trigonometric ratios like $sin\theta, cos\theta, tan\theta$, write your answer to 3dp.

ii. logarithm of a number, trigonometric ratios ($sin\theta, cos\theta, tan\theta$) and other ratios of quantities with similar units like refractive index, relative density etc. have no units

iii. In case you get constant (same) values in the column, do the following
   - ❖ For repeated measured values, try to carefully repeat the procedures that gave constant values so that you get different values
   - ❖ For calculated values in a column, increase the number of decimal points by one.

Example 2

Copy and complete the table below

$i(°)$	$r(°)$	$x\ (cm)$	$sini$	$cosr$	$xcosr$	$logx$
20	11	1.0	0.342	0.982		
30	16	1.2	0.500	0.961		
40	20	1.4	0.643	0.940		
50	25	1.8	0.766	0.906		
60	31	2.0	0.866	0.857		
70	38	2.8	0.940	0.788		

Exercise on data manipulation in the main table of results

1) Complete the following tables

a

2) Given the table below

$i(°)$	10	20	30	40	50	60
$r(°)$	5	13	21	27	29	34
$x(cm)$	1.0	1.5	2.4	3.2	3.8	4.6
$y(cm)$	6.6	6.7	7.0	7.4	7.6	8.0

Rearrange the table above in column form and include values of $xy, \frac{x}{y}, x^2, y^2, cosr, sinr, tani\ and\ \frac{x^2}{y^2}$. Use the space provided below.

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GRAPH WORK

A graph is preferred in a physics practical to make analysis of experimental results. This is because, it is considered most accurate method of data analysis.

When drawing a graph in physics practical, take note of the following key features of a good physics graph

Title (heading)

Write the title of your graph in the first square line of your graph paper. It should be well balanced in a middle of that line. Use small letters and do not underline your title. Do not put units in your title. An example of a title is

A graph of $sini$ against $sinr$

Drawing and labelling of axes

- The axes should be clearly drawn putting in consideration of the nature of data you are to plot. This helps you to plan for your graph paper properly. The axes must slightly cross and should be perpendicular to each other.
- Once the axes are drawn, they must be labelled basing on your title. For example, if your title is

  A graph of T^2 against l, Vertical axis is labelled $T^2(s^2)$ and horizontal axis is labelled l(m).

  Write a quantity with its unit in brackets in the same line when labelling axes. Do not label axes as y-axis and x -axis unless otherwise

- Each axis should be demarcated every after 2cm (2 big squares).
- You should make at least 10 demarcations on the vertical axis and at least 8 demarcations on the horizontal axis from the origin

Scales.

- We strictly use convenient scales which are; 1,2 and 5 including their multiples and sub multiples
- The scale to be used should be picked from the scale chart below that is based on special multiples and sub multiples of 1,2 and 5

1000	2000	5000
100	200	500
10	20	50
1	2	5
0.1	0.2	0.5
0.01	0.02	0.05
0.001	0.002	0.005

$\times$ **10**

$\div$ **10**

- ❖ A scale of 2.5 including its multiples and submultiples may be used though it's not most convenient.
- ❖ Once a scale is picked, its number of dp should be maintained when labelling axes with values
- ❖ The obtained scale is divided by 10 so that we get the value of each small division (least count of given axis) that is crucial in plotting, calculating slopes and intercepts.
- ❖ When a value is read from a given axis, ***it should be recorded to the same number of dp as that of each small division*** (least count) on that particular axis.

Calculation of scales

a) When no intercept is needed

b) When intercept(s) are needed

Intercept may be required on one of the axes or on both axes.

Cases where intercepts are required, the scales are obtained as follows

i. Vertical intercept

When ………………..

ii. **Horizontal intercept**

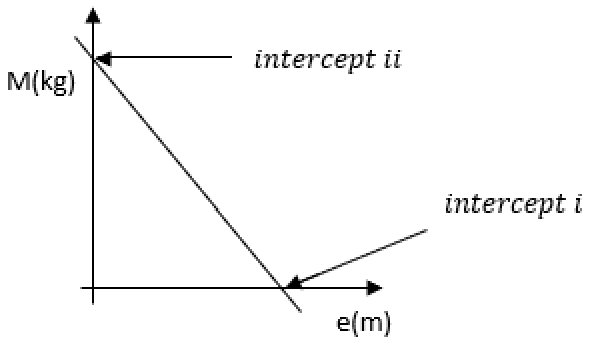
When an ………………………

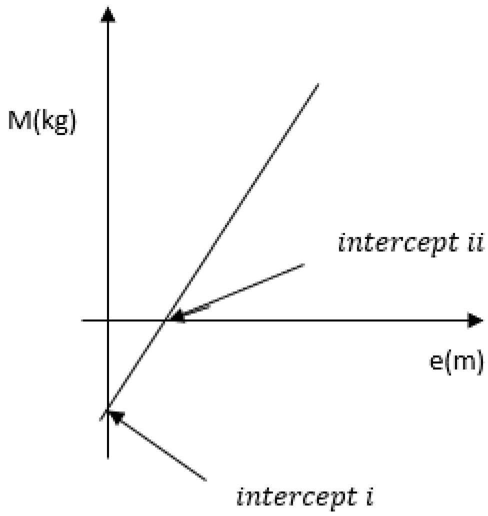
Intercepts on both axes

When the *intercept is required on both axes*, both axes must start from zero. Both scales are obtained as follows

- $Vertical\ scale = \frac{highest\ value - zero}{10}$,
- $Horizontal\ scale = \frac{highest\ value - zero}{8}$

When correctly plotted, and the line of the best fit produced so that it cuts both axes, the resulting graph may look as that shown below





Starting values.

- Each axis must be having its own starting value that is a multiple of the convenient scale to be used on that axis.
- The number of decimal places used on a given axis should be equal to the number of dp of your scale.
- At the end of each axis, put an arrow to show the direction of increasing or decreasing values.

How to obtain the starting value

Follow the following steps to get the starting value

NB. There are other ways of obtaining a suitable starting value.

Plotting

- The values should be accurately plotted.
- Note that you should not assume the position of the values to be plotted.
- You should also not round off the values in the table of results so that they become easy to plot.

  To locate position of a value to be plotted, use any of the following methods

Method 1

$$Position\ of\ value\ to\ be\ plotted = \frac{value\ to\ be\ plotted - starting\ value\ on\ that\ axis}{value\ of\ each\ small\ division\ on\ that\ axis}$$

This gives you the number of small divisions you are to count from starting point up to the position of the value to be plotted.

Method 2

Identify two labelled points on a given axis between which the value to be plotted lies.

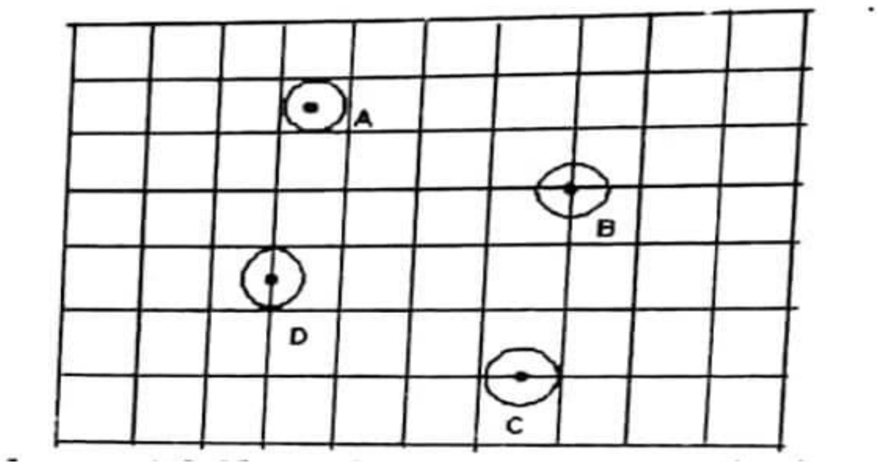
$$Position\ of\ value\ to\ be\ plotted = \frac{value\ to\ be\ plotted - value\ just\ below\ it\ on\ a\ given\ axis}{value\ of\ each\ small\ division\ on\ that\ axis}$$

This gives you the number of small divisions to count from the value just below the value to be plotted to the position of the value to be plotted

NOTE

i. The value of each $small\ division\ (least\ count)\ = \frac{scale\ on\ a\ given\ axis}{10}$.

ii. When plotting, use a dot with a small circle around it as illustrated in the square grid below.



The small circle around the dot should be drawn as guided below

- If the dot is at the point of intersection of lines of the squares e.g., dot B, the circle should be drawn such that it passes through the halves (centres) of small squares on either side of the dot
- If the dot is in the middle of the square e.g., dot A, the circle should not go beyond that square. It should be within the boundaries of the square
- If the dot lies on the vertical line e.g., dot D, the circle drawn should be within the boundaries of the upper and lower lines but it should not touch the neighboring vertical lines

- If the dot lies on the horizontal line e.g., dot C, the circle drawn should be within the boundaries of vertical lines but it should not touch the neighboring horizontal lines

The line of the best fit

- ❖ This should be drawn so that it follows the trend of the points plotted
- ❖ It may pass through all the points plotted, or passes through the most plotted points such that it averages the rest. That is, the number of points left on either side of the line should be equal or approximately equal
- ❖ Where possible, the line of the best fit should pass through or pass close to the first and last points plotted. This will help you to draw accurate triangle that will be used to calculate the slope.

Drawing slope triangle

- ❖ The triangle used in getting values to be used in calculation of slope should be drawn in a such way it is a **right-angled triangle** and it encloses all the points plotted. No plotted point should lie outside of this triangle.
- ❖ It must cross the line of the best fit at one of the points where small squares meet the line of the best fit.
- ❖ The triangle is drawn using a solid line (recommended) or dotted lines.

NOTE

Calculation of slope

- ❖ Values to be used in calculating the slope are directly read from your graph

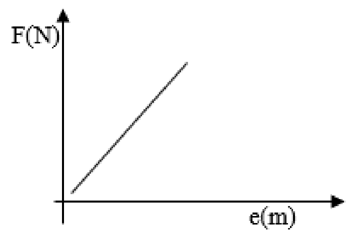
The slope is then obtained from

Slope = $\frac{change\ in\ values\ of\ vertical\ axis}{change\ in\ values\ of\ horizontal\ axis}$

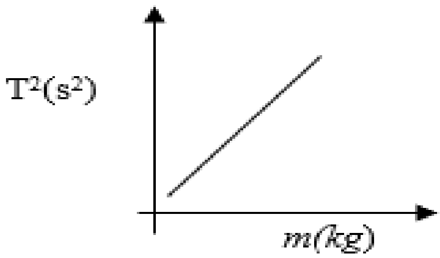
❖ The units of the slope should be derived from the graph. For example, if $T^2(s^2)$ was plotted against e(m), the units of slope would be s^2m^{-1}

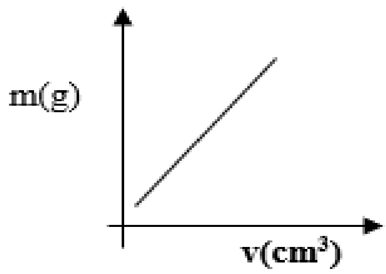
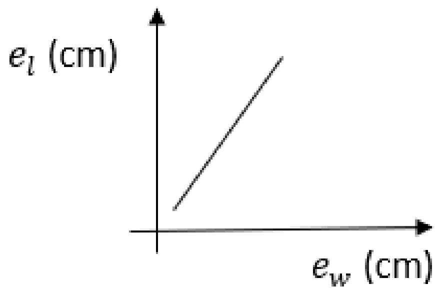
When the slope is obtained, it can be substituted in a suitable formula to draw conclusions

THEORY OF COMMON EXPERIMENTS IN PHYSICS

<table>
<tr><td rowspan="2">A scientific investigation to</td><td rowspan="2">Transformed equation in form $y = mx + c$.
For intercept $c = 0, then$
$y = mx$</td><td colspan="2">Variable on</td><td rowspan="2">Shape of expected graph and slope, s</td></tr>
<tr><td>vertical axis</td><td>horizontal axis</td></tr>
<tr><td>$(\boldsymbol{a})$
determine the spring's constant k of a spring
Theory. From hooks' law, extension of an elastic material is proportional to the applied force provided the elastic limit is not exceeded. Hence
$F \propto ke$; $F = ke$</td><td>$F = ke$
where F is wight or force in newtons (N) and e is extension in metres (m)</td><td>F</td><td>e</td><td>

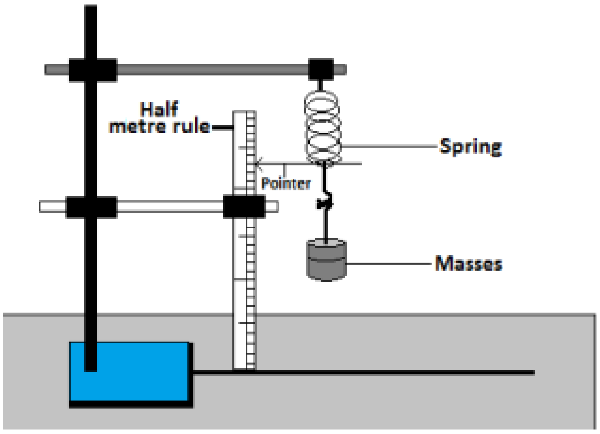
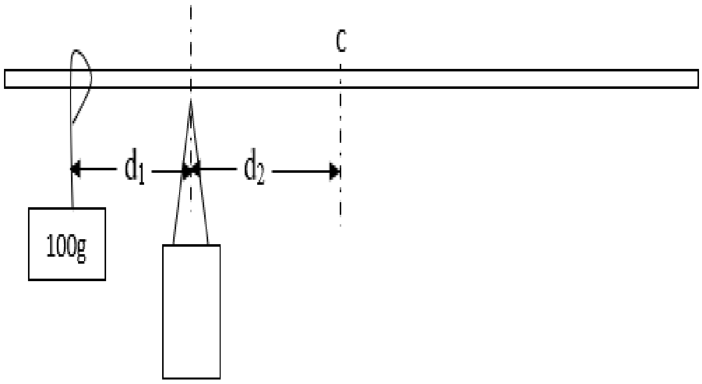
slope
$s = force\ constant\ k$
$s = k\ in\ Nm^{-1}$
Note that a graph of e against F can be plotted if your transformed equation
is $\mathbf{e} = \frac{1}{k}\boldsymbol{F}$
slope $S = \frac{1}{k}$ hence</td></tr>
</table>

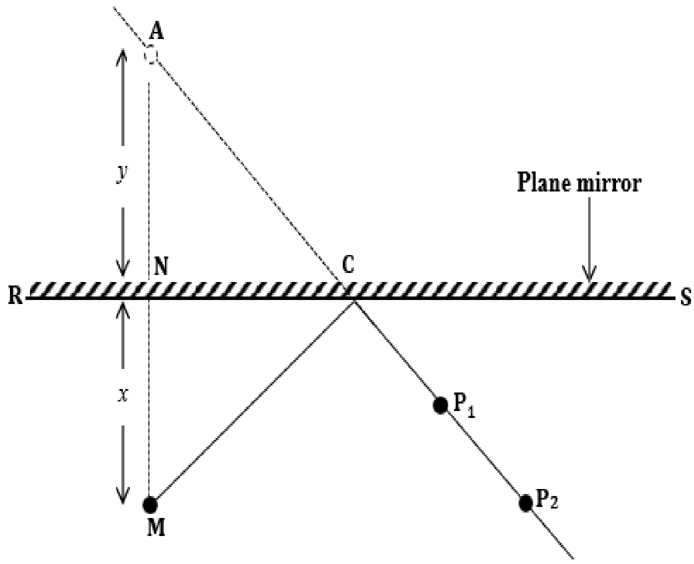
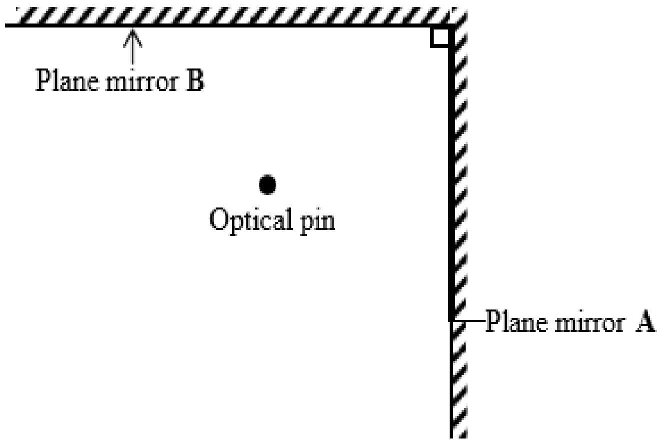
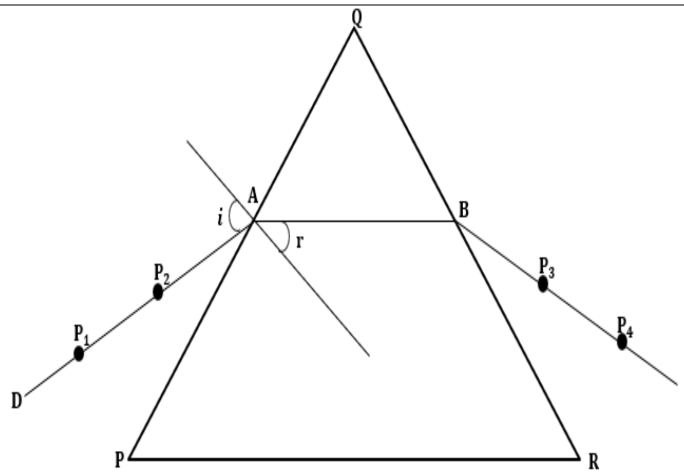
				$k = \frac{1}{s}$ A graph e against F is an inverse of a graph of F against e **Note**: mass in grams can be plotted with extension in centimeters. The slope of graph is $s = \frac{k}{g}$ $where\ g = 10ms^{-2}$
OR. You can use a loaded spring When a loaded spring is slightly pulled vertically downwards and then left oscillate, the period T of oscillation is related to mass m by the equation $T = 2\pi\sqrt{\left(\frac{m}{k}\right)}$ where k is springs constant. The masses should be converted into kg for easy manipulation	$T^2 = \left(\frac{4\pi^2}{k}\right)m$	T^2	m	 slope s $=\left(\frac{4\pi^2}{k}\right)$ hence $k = \left(\frac{4\pi^2}{s}\right)\ in\ kgs^{-2}$. Note that from definition of a newton, $1kgs^{-2} = 1Nm^{-1}$ Therefore, the value of k obtained is in Nm^{-1}

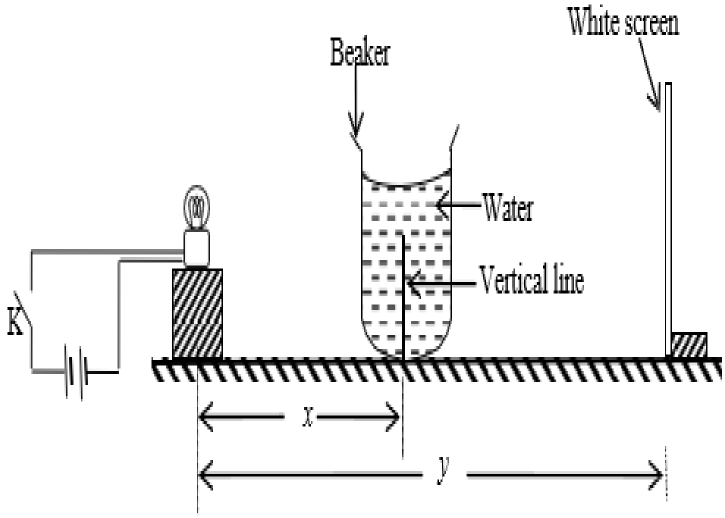
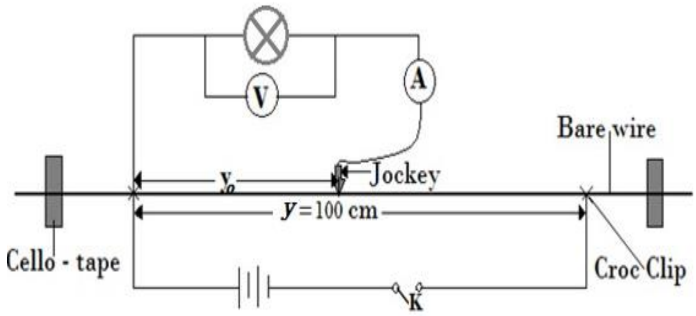
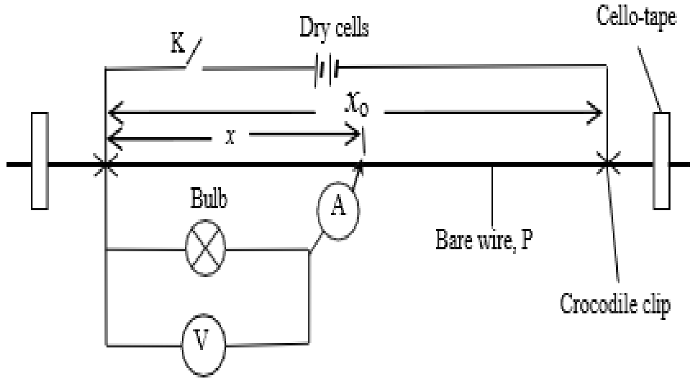
You need a stop clock or stop watch to measure time t of given number of oscillations which will help you to get period T and T^2				
$(\boldsymbol{b})\ (\boldsymbol{i})$ determine the density ρ of a liquid $\rho = \frac{m}{v}$	m= ρv	m	v	 slope $s = \ \rho\ in\ gcm^{-3}$ which can be converted to SI units, kgm^{-3}
$\boldsymbol{b(ii)}$ We can also obtain the relative density of the liquid and use it to obtain the its density using the equation $\boldsymbol{R.D} = \frac{\boldsymbol{density\ of\ the\ liquid}}{\boldsymbol{density\ of\ water}}$ To obtain R.D of the liquid, obtain extensions e_l of the spring caused by a	$R.D = \frac{e_l}{e_w}$ $e_l = (R.D)e_w$	e_l	e_w	 $slope$ $s = relative\ density, R.D$ of the liquid. The $density\ of\ the\ liquid\ =$ $R.D \times\ density\ of\ water$

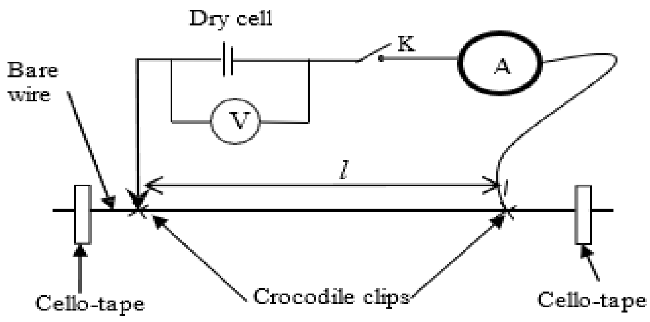
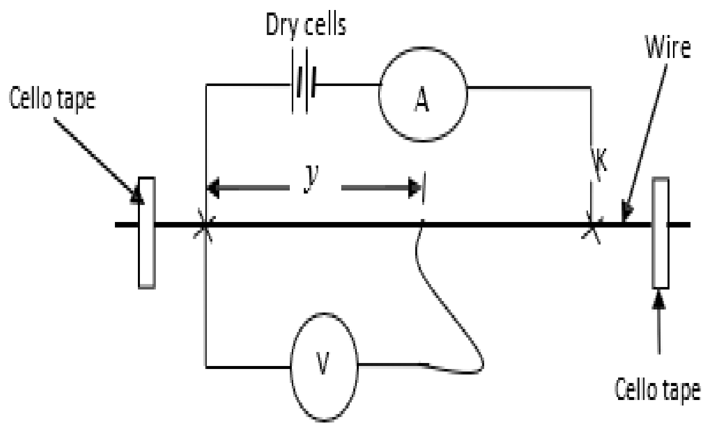
given volumes of the liquid. Repeat the procedure to obtain the extensions e_w of the same spring caused by equal volumes of water				

DIAGRAMS (SET UP) OF SOME COMMON EXPERIMENTS IN PHYSICS

Experiment	possible set up or diagram
To determine the force constant of a spring OR: To determine the acceleration due to gravity g using a loaded spring	
To determine the mass of a metre rule or uniform rod	 C is initial balancing point (position of centre of gravity)

To show that object distance is equal to image distance from the plane mirror **Note;** A graph of x against y is a straight line with a slope of one. This shows that x is always equal to y	
To investigate the relationship between the angle θ of inclination of two plane mirrors and number of images formed. **Note** $n = 360\left(\frac{1}{\theta}\right) - 1$ A graph of $n\ against\ \frac{1}{\theta}$ is a straight line. This shows that n is inversely proportional to θ	
To determine the refractive index of a glass prism	

To determine the focal length or power of a water lens **Note** y is object distance u while $(y - x)$ is image distance v when a graph of uv against $(u + v)$, its slope is focal length f. hence power $p = \frac{1}{f}$ The same applies to concave mirror and convex lens	
To determine the resistance of a conductor e.g., a resistor or filament bulb	 OR 

To determine the internal resistance or emf of a cell(s)	
To determine resistivity or cross section area or diameter d of a constantan wire	

Note

- You will not be given a hint in form of a diagram or an equation in the scenario-based. You are therefore required to think of suitable list of apparatus, experimental set up (diagram) and procedure or steps that can clearly bring out the aim of an investigation.

The **whole theory** of how to achieve the aim of the investigation should be at the back of your mind.

EXAMPLES ON DATA MANIPULATION, PLOTTING A GRAPH AND FINDING SLOPES

Example 1

In a scientific investigation to determine the refractive index of a glass block, the student obtained the following angles of refraction $r(°)$ for respective angles of incidence $i(°)$

$i(°)$	$r(°)$
10	5
20	15
30	20
40	24
50	31
60	37

Tasks

a) Copy the table above and include columns with values $sini, sinr, \frac{1}{sin^2 i}$ and $\frac{1}{sin^2 r}$.

b) Plot a graph of $sini$ against $sinr$

c) Obtain the slope of your graph.

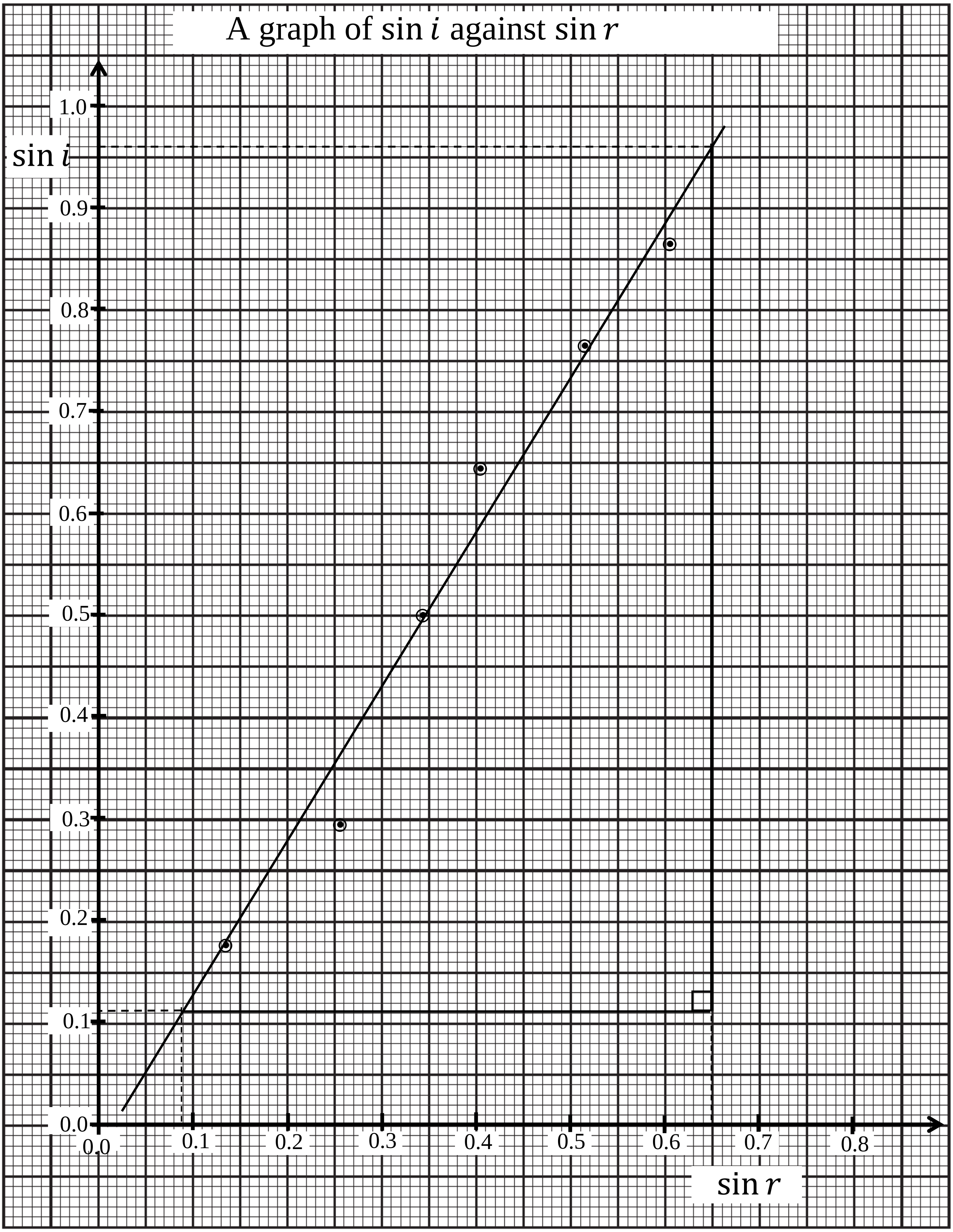
d) comment on the value of slope obtained

Responses

a)

$i(°)$	$r(°)$	$sini$	$sinr$	sin^2i	sin^2r	$\frac{1}{sin^2i}$	$\frac{1}{sin^2r}$
10	8	0.174	0.139	0.030	0.019	11.49	52.63
20	15	0.342	0.259	0.117	0.067	8.55	14.93
30	20	0.500	0.342	0.250	0.117	4.00	8.55
40	24	0.643	0.407	0.413	0.166	2.42	6.02
50	31	0.766	0.515	0.587	0.265	1.70	3.77
60	37	0.866	0.602	0.750	0.362	1.33	2.76

b) (On the graph paper)


A graph of sin i against sin r
sin i
sin r
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
0.8

c) From the graph

$$slope\ s = \frac{\Delta sini}{\Delta sinr}$$

$$s = \frac{0.96-0.11}{0.64-0.09}$$

$$s = \frac{0.85}{0.55} = 1.5$$

d) From Snell's law of refraction of light, $n = \frac{sini}{sinr}$ $hence\ sini = nsinr$ which is in the form $y = mx + c\ for\ c = 0$

Hence the slope s of graph of $sini$ against $sinr$ is equal to refractive index of a material (glass block)

Therefore, $n = 1.5$

Example 2

In an attempt to determine the value of the acceleration due

$h(m)$	$t(s)$
0.100	47.5
0.200	45.5
0.300	43.0
0.400	40.0
0.500	37.5
0.600	35.5

Tasks

Using experimental results above,

a) copy the table and include the values of T^2 where T is the period

b) Plot a graph of T^2 against h

c) Obtain the slope s of the graph

d) Use the slope s in (c) above to obtain the value of acceleration due to gravity g from $g = \frac{4\pi^2}{-s}$

Responses

Exercise

1 a) Copy the table below and include values of frequency f, f^2 and $\frac{1}{f^2}$ where t is time for 20 oscillations

$l(m)$	$t(s)$
0.300	22.0
0.400	25.5
0.500	28.0
0.600	31.0
0.700	33.5
0.800	36.0

b) Plot a graph of $\frac{1}{f^2}$ against *l* and obtain its slope s

c) Obtain the value of acceleration due to gravity from $g = \frac{4\pi^2}{s}$, use $\pi = 3.14$

2 a) Copy and complete the table below. Include the values of *l in metres,* $\frac{1}{\mathrm{v}}$ $,\frac{1}{\mathrm{I}}$ $,\frac{V}{\mathrm{I}}, IV,$

b) Plot a graph of $\frac{1}{\mathrm{I}}$ $against$ $\frac{1}{\mathrm{V}}$ and obtain its slope

PRECAUTIONS WHEN CARRYING OUT A PHYSICS SCIENTIFIC INVESTIGATION

Precautions are measures taken to prevent or minimize the risks of harm and also to improve on the accuracy of experimental results

Precautions in mechanics experiments

For experiments involving oscillations (e.g., oscillation of loaded spring or swinging The spring should not be stretched beyond elastic limit. After loading the spring with a mass, the mass should be removed to find out whether the spring returns to its original position before adding other loads/masses.

- ❖ The pointer should be horizontal so that its direction is perpendicular to scale of vertically clamped metre rule.

For experiments in light

- ❖ The surfaces of mirrors or lenses should be thoroughly clean.
- ❖ The mirror or lens should be vertically fixed firmly in their holders using small pieces of plasticine.

For experiments in electricity

- ❖ Avoid loose connections at the cell holder and on other external circuit components

Note

In all experiments that involve taking a reading from the scale of instrument, avoid parallax errors by making sure that the line of view is perpendicular to the point being read off from the scale.

WORKED EXAMPLES OF SCENARIO BASED ITEMS

Item 1

Scenario

A barber in your nearby trading center uses a manual hair clipper to trim the hair of his customers

Of recent, he realized that when the handles of the clipper are pressed, a sufficient force is no longer generated to trim the hair effectively. Worried, he took the clipper to a mechanic for repair. When the mechanic assessed the clipper, he concluded that the spring in the clipper had weakened and therefore needed to be replaced with another spring whose force constant is between $15Nm^{-1}$ and $40Nm^{-1}$

When the barber went to the nearby shop to buy the spring for replacement, he was given a spring with unknown spring constant. Therefore, there was a need to carry out an investigation to find out whether the spring bought was of the recommended force constant.

As the learner of physics, you are provided with the spring that was bought by the barber

Task.

Carry out a scientific investigation to determine whether or not the spring provided to you is appropriate to replace the one in the hair clipper of the barber

RESPONSE

Aim

A scientific investigation to determine the force constant of the spring provided and ascertain whether spring is appropriate to replace the one in the hair clipper of the barber

Variables

Independent variables;

- Known mass m

Dependent variables;

- New position of the pointer
- extension of the spring

Controlled variables

- Initial position of the pointer
- mass of the spring

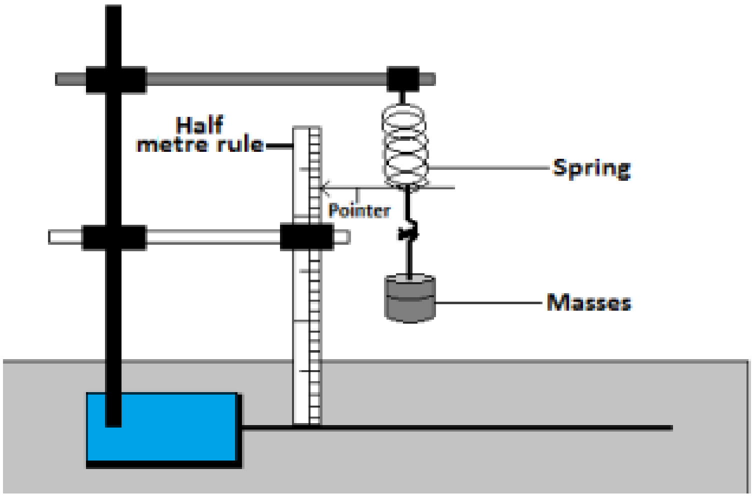
Hypothesis

The force constant of the spring provided is in the range $15Nm^{-1}$ to $40Nm^{-1}$ and it is appropriate to replace the one in the hair clipper of the barber

List of apparatus

- 1 Retort stand with a clamp,
- 1 helical spring,
- 2 small pieces of wood,
- 5 known masses each of 100g,
- 1metre rule
- 1pointer
- 1 string of length of about 50cm

Experimental set up



Procedures/steps

a) One end of the helical spring is suspended from a clamp using two pieces of wood as shown in the diagram above.

b) A pointer is attached to the lower end of the spring such that it points on to the vertical scale of a vertically clamped metre rule

c) The initial position, P_0 of the pointer is recorded from scale of a metre rule

d) A mass $m = 100g$ is suspended from the lowest end of the spring using a thread.

e) The new position of the pointer P is read and recorded from the metre rule

f) The extension, e of the spring is calculated from $e = P - P_o$ and recorded in metres

g) The procedures from (d) to (f) are repeated for values of $m = 200,$ $300, 400\ and\ 500g$

h) Results are tabulated in a suitable table including values of force F

i) A graph of F against e is plotted

j) The slope S of the graph is obtained

k) The force constant K, of the spring is obtained from $S = K$

Sources of errors

i.

Precautions

SCENARIO ITEMS FROM MECHANICS

Item 1

Scenario

The supplier of physics laboratory apprāratus of your school has supplied a set of metre rules. However, the mass of each metre rule is not specified. The laboratory technician normally uses digital beam balance to determine the mass of each metre rule. The expected mass of each metre rule is always in the range 80g to 120g. However, the beam balance is now faulty hence it can not be used to accurately determine the mass of each metre rule. The laboratory technician is confused whether or not he should pay for them.

Your physics teacher has chosen you to go in the laboratory and help the laboratory technician in determining the mass of a metre rule. You have been given a metre rule which is a sample of metre rules supplied.

Task

As a physics learner, carry out a scientific investigation to ascertain whether or not the mass of each of the metre rules supplied lies within expected range and advise the laboratory technician accordingly

Item 6

Scenario

A certain mock examination body has sent to your school laboratory technician, the list of apparatus that will be used by each candidate in upcoming physics practical exam. Among the list of apparatus each candidate will use; there is a rubber bung of mass not less than 80g and not more than 110g.

In the laboratory, there are some rubber bungs of unknown mass that were previously bought by the school laboratory technician. In the school laboratory, there is no weighing scale that can be used to measure and ascertain their correct range of mass. The technician is a bit challenged whether or not the available rubber bungs are suitable to be used by students in upcoming physics practical exam.

The laboratory technician has chosen you to assist him. He gives you one piece of rubber bung which is sample of available rubber bungs that were previously bought.

Task

Carry out a scientific investigation to determine the mass of rubber bung provided and advise the laboratory technician accordingly.

SCENARIO ITEMS FROM LIGHT

Item 11

Scenario

A man was driving his car through a heavy jam on Kampala Road. Accidentally motor cyclist knocked his car head lamp and broke it. The mirror inside the head lamp was damaged as well hence it needed replacement. The concave mirror used in the car head lamp has focal length of $15 \pm 1cm$ according to car's log book. The man has decided to take his car to nearby garage for repair.

At the garage, the mechanic has a concave mirror of unknown focal length and therefore he is not sure whether or not it is suitable to be used in repairing man's car head lamps. The mechanic approaches you to help him identify the exact focal length of his mirror.

You are provided with a concave mirror, the mechanic had at the garage

Task

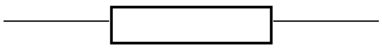
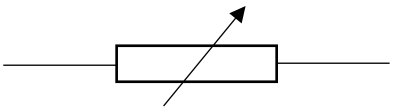
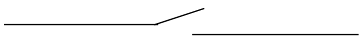
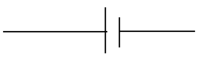
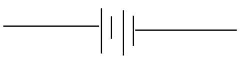
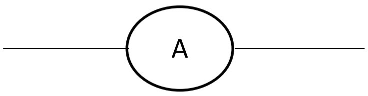
As a physics learner, determine the focal length of the concave mirror provided and advise the mechanic whether or not it is suitable to be used in repairing the man's car head lamp

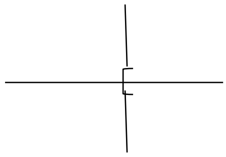
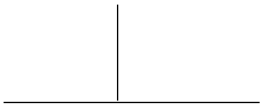
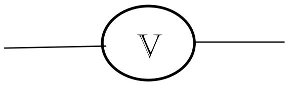
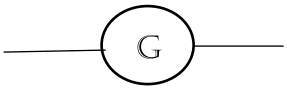
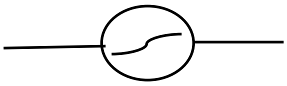
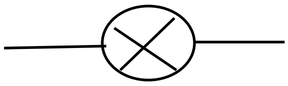
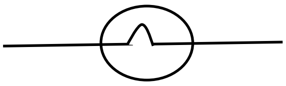
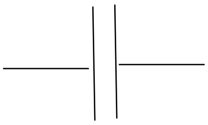
CURRENT ELECTRICITY

Electric current is the rate of flow of charges through the conductor. Current flows in a closed electric circuit that is made up of different electrical components such as resistors, dry cells, wires, ammeters, voltmeters etc. Therefore, a candidate is supposed to arrange and connect appropriate electrical components so as to come up with a closed-circuit diagram that allows current to flow.

In a circuit diagram, electrical components are represented by their standard symbols as given in the table below

ELECTRICAL SYMBOLS OF COMPONENTS USED IN ELECTRIC CIRCUITS

Electrical symbol	**Name**
	standard resistor
	Variable resistor /rheostat
	Switch
	cell
	battery (combination of cells)
	Ammeter

	crossing wires
	connected wires
	voltmeter
	Galvanometer
	alternating current supply
 	bulbs/lamp
	capacitor

Note

- ❖ In all circuit diagrams, an ammeter should be connected in series with the component so as it reads the current through that component
- ❖ The voltmeter should be connected across (in parallel with) the component so that it reads the potential difference (voltage) across that component

SCENARIO ITEMS FROM ELECTRICITY

Item 12

Scenario

The physics laboratory technician is preparing a simple practical exam for senior four class. She has been presented with a confidential having an instruction that each candidate should be given one fresh dry cell of internal resistance not exceeding 1.5Ω. She faces a challenge of how to determine the internal resistance of available fresh dry cell in the box. She approaches you for assistance. She gives you one dry cell which is a sample of available fresh dry cells in the box

Task

As a physics learner, advise the laboratory technician whether she should or should not give the available dry cells to the students.

MISCELLANEOUS TRIAL QUESTIONS

Item 18

Scenario

A senior 3 student had a project of making a prism periscope. In his research from the libraries about the project, he noted that the prism to be used in making the project should be of refractive index 1.5 ± 1

The student picks one prism of unknown refractive index from the physics laboratory. The student does not know how to determine the refractive index of the prism. When he went to the teacher for help, the teacher had no enough time to help him. The teacher directed the student to come to you for help.

The senior 3 student gives you the prism he intends to use in his project of making a prism periscope

Task

As a physics learner, carry out a scientific investigation on the prism and advise the boy accordingly

Item 21

Scenario

You have been shortlisted for a job oral interview to work as a store keeper of a company that deals with selling of plane mirrors

In the interview room, the interviewer has requested you to stand upright in front of two plane mirrors that are inclined to each other at right angle.

You are requested to note the number of your images formed.

The interviewer repeats the procedure by adjusting the angle between the plane mirrors. Each time the angle is adjusted, different number of images is obtained.

This amazed the interviewer and therefore wanted to know from you how the angle of inclination between two plane mirrors is related to the number of images formed.

Task

Carry out a scientific investigation to determine relationship between the angle of inclination between two plane mirrors and the number of images formed.

SUMMARY OF MARKING GUIDE AS OF 2024 UNEB PHYSICS PRACTICAL PAPERS

Basis	Code	Maximum weights
Aim and purpose	A	6
variables	VAR	5
hypothesis	H	6
procedures (list of apparatus, diagram, procedures/steps)	P	3
sources of errors and mitigations/precautions	EP	3
presentation of data	PD	2
recording of data with accuracy	RDA	3
data analysis and interpretation (graph work)	DAI	4
conclusion and advice	CAD	6
Total weights	T/W	38