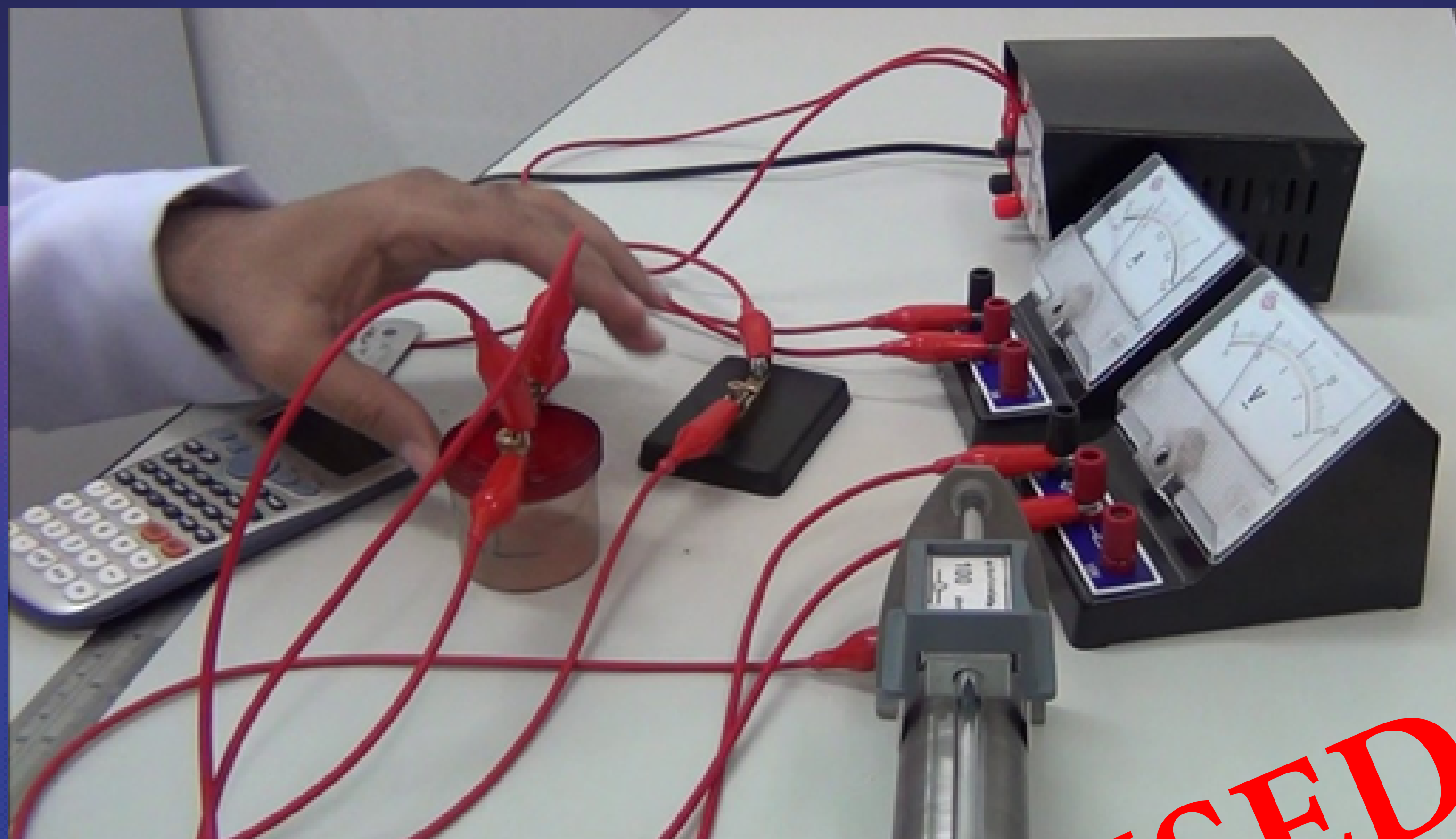

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UCLSE NEW CURRICULUM PHYSICS PRACTICAL WORK BOOK

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New Curriculum

Physics

Practical Workbook

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New Curriculum

Physics

Practical Workbook

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Introduction to New Curriculum Physics Practical

Practical skills form the backbone of any physics course. It is hoped that by using this book, you will gain confidence in this exciting and essential area of study. This book has been written to prepare Uganda Certificate of Lower Secondary Education (UCLSE) physics students for the practical paper.

For this practical paper, you need to be able to demonstrate a wide range of practical skills. Through the various investigations and accompanying questions you can build and refine your abilities so that you gain enthusiasm in tackling laboratory work. Aside from the necessary exam preparation, these interesting and enjoyable investigations are intended to kindle a passion for practical physics.

Great care has been taken to ensure that this book contains work that is safe and accessible for you to complete. Before attempting any of these activities, though make sure that you have read the safety section and are following the safety regulations of the place where you study.

Skills

Assessment Objective 3 (AO3) 'Experimental and Investigative skills' of the UCLSE is about your ability to work as a scientist. Each aspect of the AO3 has been broken and listed for you below.

- Demonstrate knowledge of how to safely use techniques.
- Demonstrate knowledge of how to use apparatus and materials.
- Demonstrate knowledge of how to follow a sequence of instructions where appropriate.
- Plan experiments and investigations.
- Make and record estimates.
- Interpret experimental observations and data.
- Evaluate methods.
- Suggest possible improvements to methods.
- Constructing own table.
- Drawing / analysing a graph.
- Planning safety of an investigation.
- Mathematical calculations.

Manipulation of data

This involves generating other table columns from columns of given and measured values.
It is done by addition, subtraction, multiplication and division of data.

Addition and subtraction rule

The rule states that, you maintain the number of decimal places.
However, if the number of decimal places are different in the two quantities, the smaller number is considered in the generated column.

Examples

$3.16(2dp) + 5.32(2dp) = 8.46(2dp)$
Similarly, $5.32(2dp) - 3.16(3dp) = 2.16(2dp)$

- ✓ But if the numbers of decimal places are different, the smaller number is considered in generated column

Example

$3.16(2dp) + 5.3267(4dp) = 8.48\underline{6}7 = 8.49(2dp)$
(See that **6** was rounded)

Multiplication and division rule

- ✓ The rule states that you maintain the number of significant figures for only the first entry value of the column and then maintain the number of decimal places down the column.
- ✓ If the number of significant figures are different in the two columns, the smaller number is considered in generating the first entry value of the product or quotient column
  Note: Significant figures are digits which are relevant in determining the accuracy of a number. It can be noted that:

- All non-zero digits are significant i.e. 1, 2, 3, 4, 5, 6, 7, 8 & 9 are all significant
- Zeros obtained from apparatus measurements are significant
  e.g. from metre rule $(2\underline{\mathbf{0.0}})(3sf)$, Voltmeter$(2.5\underline{\mathbf{0}})(3sf)$
- Zeros that come after a non-zero digit are significant
  e.g. 3.**<u>0</u>**2, 0.4**<u>00</u>**6.
- Zeros that come from rounding off are not significant
  $$(4578)(4sf) \approx 4600(2sf)$$
- A zero from a rounded nine (9) may or may not be significant according to the question
  e.g. 29.8 when rounded off to $1sf$ and $2sf$ it gives $30(1sf)$ and $3\underline{\mathbf{0}}(2sf)$ respectively
  Similarly when 3697 is rounded to $2sf$ and $3sf$, it gives $3700(2sf)$ and $3700(3sf) respectively$.The rounded zero is significant yet the other zeros are not.
- Zeros which come before non-zero digits are not significant
  e.g. $0.007(1sf)$, $0.03\underline{\mathbf{00}}9(4sf)$ only the underlined zeros are significant besides 3 and 9

Examples on Multiplication and division rule

- ✓ If you multiply $16.3(3sf) \times 22.2(3sf) = 361.\underline{8}6(5sf) \approx 362(3sf)$ (we round the 8).

  Or if $16.3(3sf) \div 22.2(3sf) = 0.734\underline{2}3423424(11sf) \approx 0.734(3sf)$(we round the 2).

  However if the number of significant figures are different, the smaller number is considered

  Consider multiplying $17.1(3sf) \times 8.2(2sf) = 140.22(5sf) \approx 140(2sf)$

  Similarly, dividing $17.1(3sf) \div 8.2(2sf) = 2.08536585365 \approx 2.1(2sf)$

Float

This is a whole number which is not obtained from the experiment but it is applied throughout the entire column. E.g. When getting periodic time, T from $t, T = \frac{t}{20}$. This means that 20 is a float.

- ✓ All experiments with $\frac{1}{f}, \frac{1}{V}, \frac{1}{d}, \frac{1}{I}$, 1(one) is considered to be a float.
- ✓ The rule governing a float states that the number of significant figures of a float are ignored during any computation. In the same sense, irrational numbers like π do not have a specified number of significant figures, therefore they are also treated like a float.
  - ✓ But if π is given say $\pi = 3.14$, then it ceases being irrational and it is 3 significant figures now

Manipulation of other main table of results

- ➢ If you are required to measure and record distance, x in metres but when a metre rule measures distance in centimetres, then x is recorded in two different columns

  i.e. One in centimetres and the other in metres.

  Example:

  If measured $x = 30.0cm$, then it is recorded as shown below in the table

$x(cm)$	$x(m)$
30.0 $\downarrow 1dp$	0.300 $\downarrow 3dp$

- ➢ Obtaining $\frac{1}{U}$ from U

  Since 1 is a float, the number of significant figures of U is maintained for the first entry value in the column of $\frac{1}{U}$ and decimal places are maintained down the column.

$U(cm)$	$\frac{1}{U}(cm^{-1})$
$20(2sf)$	$0.050(2sf)$ $\downarrow 3dp$

$U(cm)$	$\frac{1}{U}(cm^{-1})$
$20.0(3sf)$	$0.0500(3sf)$ ↓ $4dp$

$u(cm)$	$\frac{1}{u}(cm^{-1})$
$200(3sf)$	$0.00500(3sf)$ ↓ $5dp$

Manipulation of data in the table of results

(a) <u>Metre rule experiments format</u>

$m(g)$	$u(cm)$	$v(cm)$	$\frac{1}{m}(g^{-1})$	$\frac{1}{u}(cm^{-1})$	$mu(gcm)$	$uv(cm^2)$	$\frac{v}{u}$	$(u+v)(cm)$	$\frac{m}{v}(gcm^{-1})$
$100(3sf)$ *Given values* ↓	$14.2(3sf)$ *measured values* $\mathbf{1dp}$ ↓	$50.0(3sf)$ *measured values* ↓ $\mathbf{1dp}$	0.0100 $(3sf)$ $\mathbf{4dp}$ ↓	0.0704 $(3sf)$ $\mathbf{4dp}$ ↓	1420 $(3sf)$ $\mathbf{0dp}$ ↓	$710(3sf)$ $\mathbf{0dp}$ ↓	3.52 $(3sf)$ $\mathbf{2dp}$ ↓	$64.2(1dp)$ $\mathbf{1dp}$ ↓	$2.00(3sf)$ $\mathbf{2dp}$ ↓

Explanation

- ✓ 14.2cm and 50.0cm are recorded to $1dp$ since a metre rule measures to $1dp$
- ✓ For multiplication and division, significant figures are maintained for only the entry value and decimal places for the remaining values in the column
- ✓ For addition$(u + v)$, the number of decimal places $(1dp)$ was maintained
- ✓ The underlined zeros in 1**<u>00</u>**, 5**<u>0.0</u>**, 0.01**<u>00</u>**, 71**<u>0</u>** and 2.**<u>00</u>** are significant because they follow non zero digits. Besides, 100 is assumed to be measured before it is given

All zeros of measured values are significant

- ✓ The zero in 1420 is not significant **because** it comes from rounding off
- ✓ The underlined zeros in **<u>0.0</u>**100 and **<u>0.0</u>**704 are not significant **because** they come before non-zero digits

Exercise (Try me please)

Using the knowledge of data manipulation, complete the tables below

Table 1

$x(m)$	$t(s)$	$T(s)$	$T^2(s^2)$	$x^2(cm^2)$	$\frac{1}{T^2}(Hz^2)$
0.100	16.00				
0.090	15.71				
0.080	14.28				
0.070	13.00				
0.060	12.16				
0.050	11.60				

Table 2

$x(cm)$	$y(cm)$	$log_{10}x$	$log_{10}y$
90.0	4.5		
80.0	2.5		
70.0	1.5		
60.0	1.0		
50.0	0.5		
40.0	0.1		

Table 3

$i(^o)$	$x(cm)$	$y(cm)$	$\frac{x}{y}$	$sini$
10	1.0	6.6		
20	1.5	6.7		
30	2.4	7.0		
40	3.2	7.4		
50	3.8	7.6		
60	4.0	8.0		

forward approximation). We can now use $1cm$ to represent 0.05 units or 5 small squares to represent 0.05 units.

Now we can begin vertical axis from zero and in steps of 10 divisions (2cm) upwards (positive) And down wards (negative), increase / decrease respectively by 0.1 (i.e. 0.05×2)

Horizontal axis ($log_{10}d$)

Range = 1.95 − 0
= 1.95

(We have subtracted off zero because this axis **must** start from zero since intercept is required on the opposite perpendicular axis)

Scale: 1cm $= \frac{1.95}{20}$

1cm = 0.0975

But 0.0975 is not a convenient scale. The most convenient scale is 0.1.

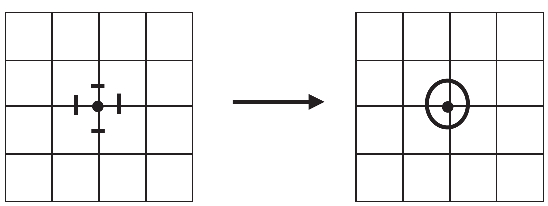
We can now use $1cm$ to represent 0.1 units or $2cm$(10 divisions) to represent 0.2

So we can begin horizontal axis from zero and in steps of 10 divisions (2cm), increase 0.2

Plotting

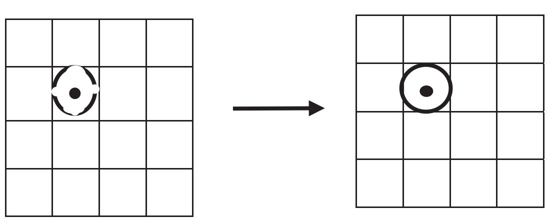
- ✓ Use the scales obtained to plot points accurately
- ✓ Use a dot with a small circle ⊙ to locate your points
- ✓ The circle must be of half a small square radius as illustrated below

Case 1



The point above is at the intersection of lines, so the circle must cut the mid points of the perpendiculars from it.

Case 2



The point above is midway of the square .The circle must stop at the boundary of the square.

Accuracy of the intercept

- ✓ This is the number of decimal places or significant figures to which the intercept is written
- ✓ It is given by the accuracy of the scale along the axis producing that intercept
- ✓ It is the number of decimal places of the value which 1 small square represents.

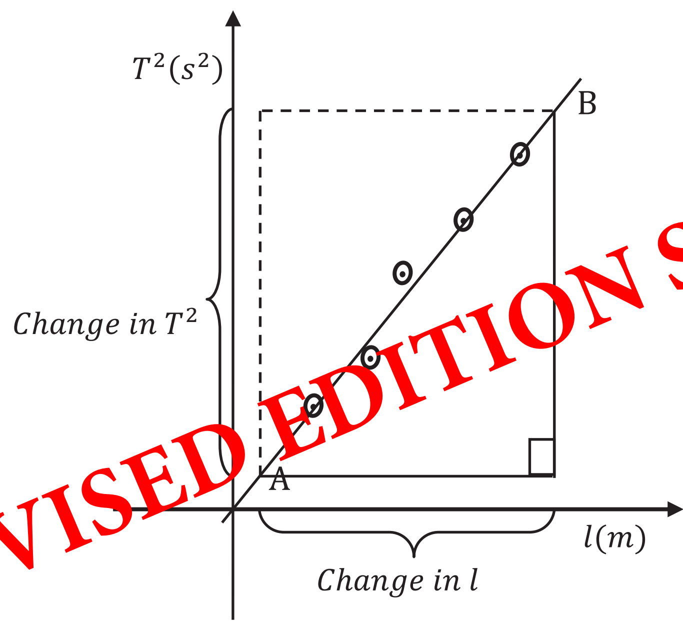
Slope/ Gradient

- ✓ The slope/ gradient of the graph is the change in the values on the vertical axis to the change in the values on the horizontal axis.
  Mathematically

$$Gradient = \frac{change\ on\ the\ vertical\ axis}{change\ on\ the\ horizontal\ axis}$$

- ✓ Gradient is obtained using a right angled triangle. The triangle should be big enough to cover all the plotted points, it should cover at least half of each of the axes and should not pass through any plotted points
- ✓ The correct right angled triangle that should be considered is shown below

A graph of T^2 against l



- ✓ The points A and B selected for calculating the slope must be on the intersection of squares which lie on the line of best fit

$$Gradient, S = \frac{Change\ in\ T^2}{Change\ in\ l}$$

OR $$Gradient, S = \frac{number\ of\ small\ squares\ along\ the\ vertical \times vertical\ scale}{number\ of\ small\ squares\ along\ the\ horizontal \times horizontal\ scale}$$

Units of slope above

$$Units\ of\ S = \frac{units\ of\ T^2}{units\ of\ l} = s^2/m \quad \text{or} \quad s^2m^{-1}(Square\ seconds\ per\ metre)$$

- ✓ The number of decimal places of the gradient is determined by the quotient(division) rule of data manipulation

Accuracy is a measure of how close the measured value is to the true value. The accuracy of any results depends on the measuring apparatus used and the skill of the person taking the measurements.
You can improve the accuracy of your results by:
• improving the design of an investigation to reduce errors
• using more precise apparatus
• repeating the measurement and calculating the mean.

Precision relates to how accurately you take your measurements. Precise results have very little deviance from the mean.
You can improve the precision of your investigation by:
• using apparatus that has smaller scale divisions.

Designing an investigation

When asked to design an investigation, you must think carefully about what level of detail to include. The following is an example of how to create a method. Follow these steps to be able to design reliable, accurate investigations.

- State the aim of the investigation.
- State the hypothesis for your investigation. In science, a hypothesis is an idea or explanation that you then test through study and experimentation. Outside science, a theory or guess can also be called a hypothesis. A hypothesis is something more than a wild guess but less than a well-established theory.
- List down apparatus or materials to be used in your investigation.
- Identify what your independent variable is and the range of values that you are planning to use for it.
- The dependent variable must also be identified along with how (using equipment and apparatus) you are going to measure it.
- Suggest how you will control other variables.
- Outline the method in a series of numbered steps that is detailed enough for someone else to follow.
- Remember to include repeat readings to help improve reliability.
- Check the validity of your investigation and results.
- You must also include any hazards and safety warnings, as well as safety equipment that should be used in the investigation.

Experiment 5

Imagine you are a student helping to design a new see-saw for the playground. To make sure it balances correctly when children of different weights use it, you need to understand how balancing works.

Task:
Use a metre rule and some weights to model this.

Hint:
✓

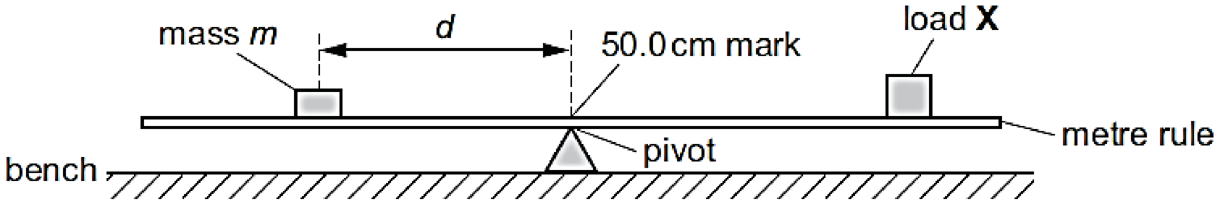


Fig. 5

✓ Other experimental set ups may be used.

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Experiment 6

Imagine you are a student in class, and your plastic bottle of water tips over. Instead of just cleaning up the mess, you decide to turn this into a physics experiment to understand why the bottle tips and how it moves.

Task:

Plan an experiment to investigate how the quantity of water in a plastic bottle affects its stability.

Hint:

- ✓ The plastic bottle holds up to 2000 cm^3 of water and has a height of 42 cm.

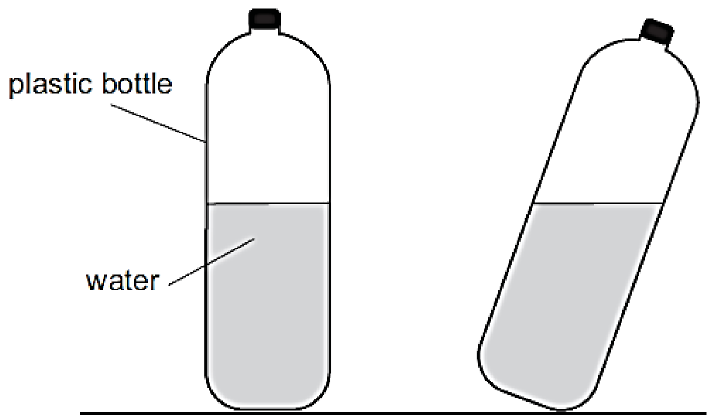

Fig. 6

- ✓ Other experimental set ups may be used.

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Experiment 7

Imagine you are a student helping to design a playground. You want to investigate how a playground swing moves, which is similar to a pendulum.

Task:

Design an experiment to help you understand the motion of the swing, how long it takes to go back and forth, and how the length of the swing affects its movement.

Hint:

✓

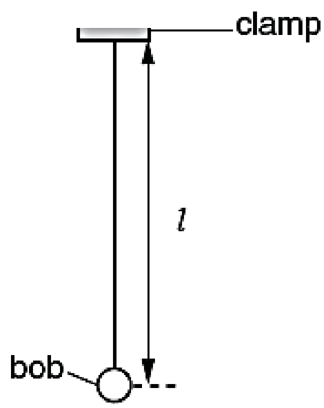

Fig. 7.1

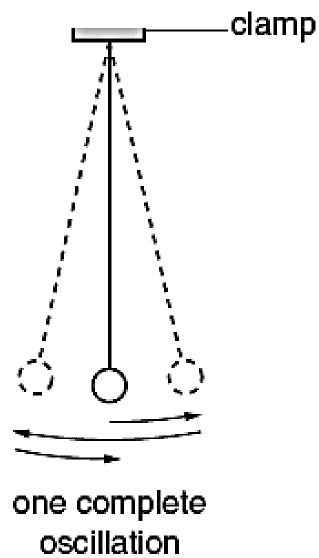

Fig. 7.2

✓ Other experimental set ups may be used.

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Experiment 24

Sophie's uncle is a jeweler who often uses different gemstones. He explains to Sophie that the way light bends through a gemstone can help identify it. Sophie decides to investigate how light refracts through a glass block to understand this concept better.

Task:

Design an experiment to measure the angles of incidence and refraction for light passing through the glass block. Use these measurements to calculate the refractive index of the glass, similar to how gemologists identify gemstones.

Hint:

✓

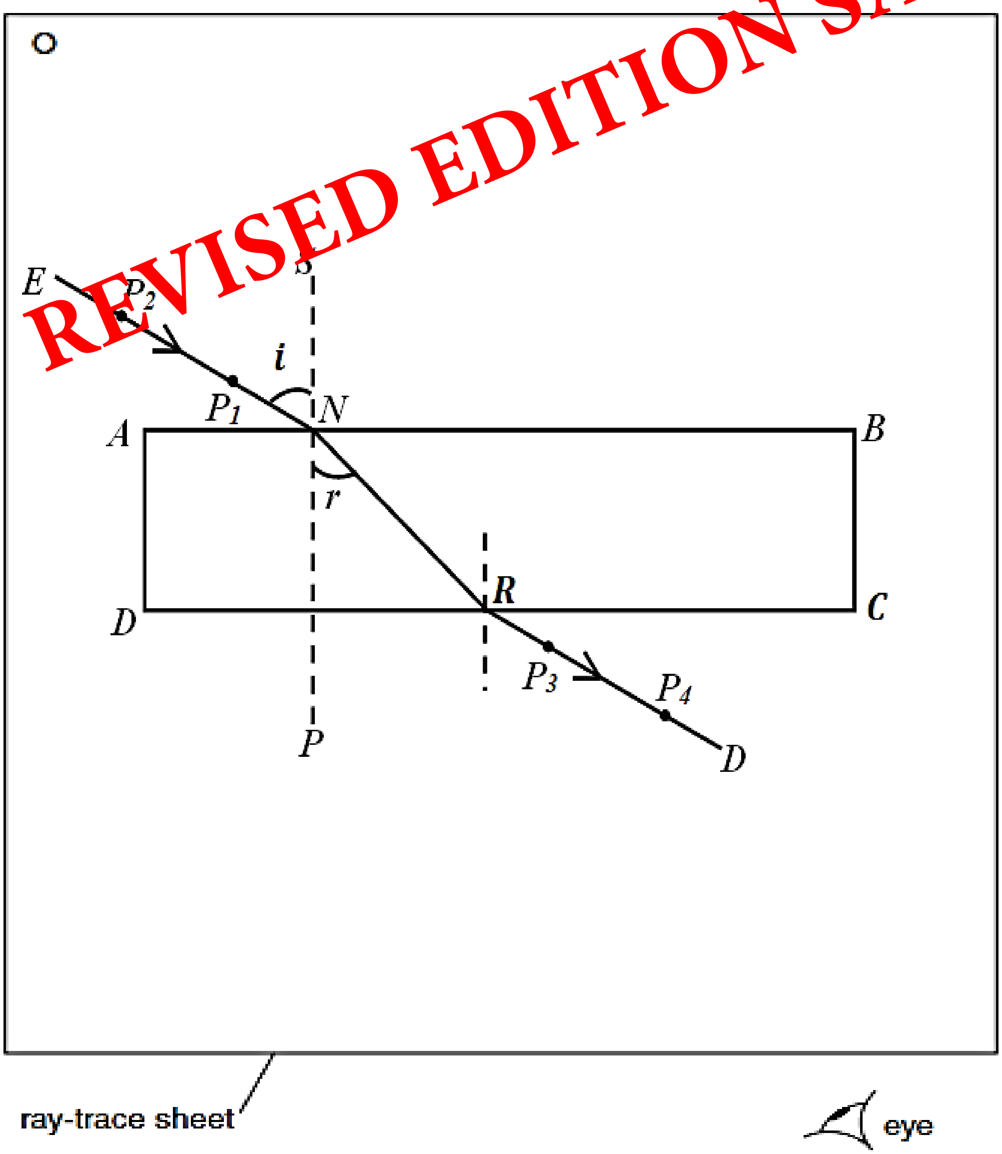

Fig. 24

✓ Other experimental set ups may be used.

Insert your ray−trace sheet opposite this page.

Experiment 27

The Ministry of Science, Technology, and Innovation has procured a concave mirror for the construction of a reflecting telescope to observe the Pearl Africa Sat.1 satellite in its orbit. However, the mirror does not have any specifications regarding its radius of curvature.

Task.

As a student of physics, which investigations would you carry out to help the Ministry determine the radius of curvature of the concave mirror?

Hint:

✓

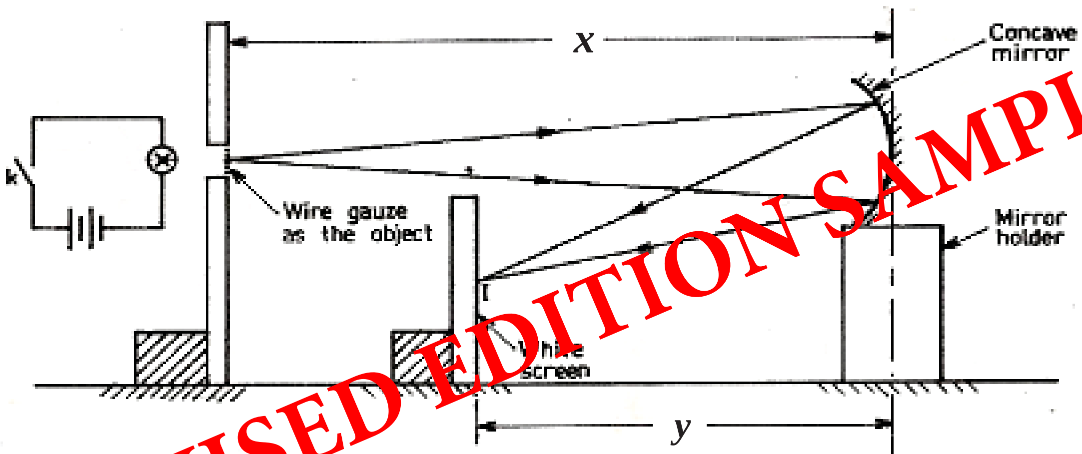

Fig. 27

✓ Other experimental set ups may be used.

Experiment 29

A leading manufacturer of magnifying glasses has received several customer complaints about the quality of their products. The head of quality assurance tasks the engineering team to investigate the issue. One of the senior engineers suggests checking the specifications of the magnifying glasses, as the lenses may have a different focal length than indicated.

Task:
As a student of physics, carry out a scientific investigation that can help the engineers verify the focal length of the magnifying glasses and determine if they meet the specified standards.

Hint
✓

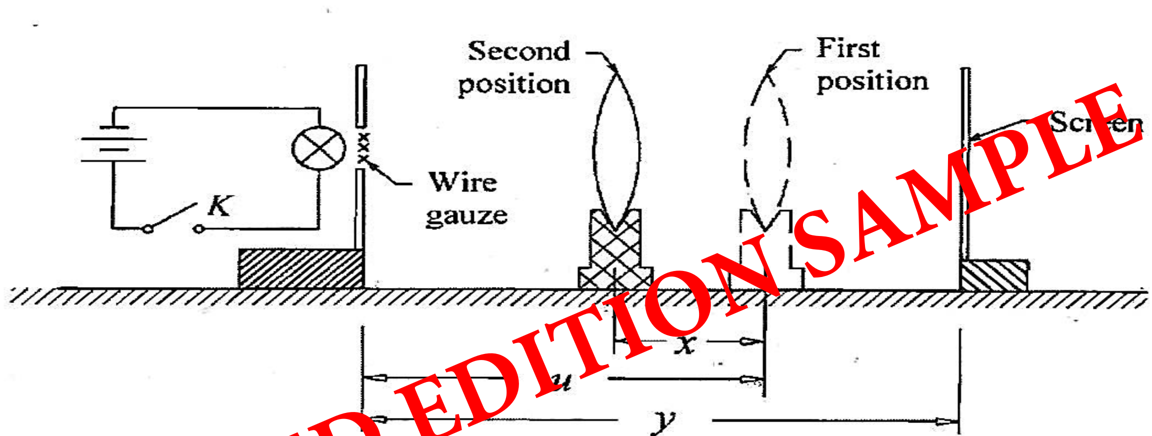

Fig. 29.1

Experiment 40

A company specializing in home lighting solutions has received feedback that their lamp filaments may not be providing consistent resistance. To ensure quality control, they task a new engineer, Alex, with investigating the resistance of the lamp filaments under different conditions.

Task:

As a student of physics, you are to help Alex carry out a scientific investigation to measure the resistance of the lamp filament under different conditions and determine if it meets the specified standards.

Hint:

✓

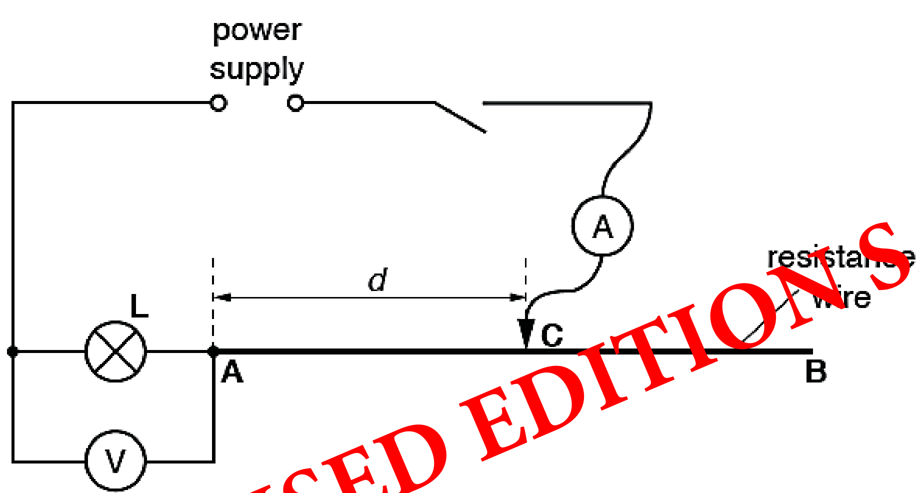

Fig. 41

✓ Other experimental set ups may be used.

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Experiment Requirements(Practical Instructions)

In addition to the apparatus ordinarily contained in Physics laboratory, each candidate will require:

EXPERIMENT 1

No apparatus is required for this question

EXPERIMENT 2

No apparatus is required for this question

EXPERIMENT 3

(i) Steel spring (see note 1).
(ii) Two clamps, two bosses and two stands.
(iii) Metre rule (see note 2).
(iv) Masses of 100 g, 200 g, 300 g, 400 g and 500 g, labelled 1 N, 2 N, 3 N, 4 N and 5 N (see note 4).

Notes

1. An expendable steel spring is suitable, for example a 55 mm long spring with diameter 15 mm. The spring must be able to take a load of at least 5 N without overstretching.

2. The metre rule is to be held vertically, using one of the clamps, with the zero end in contact with the bench.

3. The apparatus is to be set up for the candidates as shown in Fig. 3. The spring is to be sufficiently high above the laboratory bench that when the 5 N load is hung on the spring, the bottom of the load is about 10 cm above the surface of the bench.

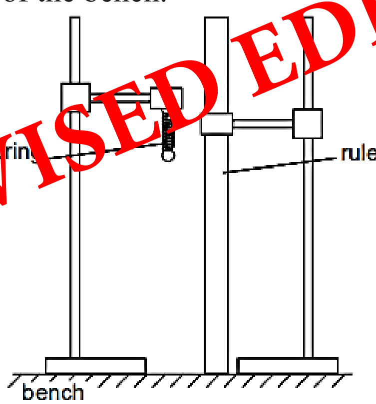

Fig. 3

4. A 100 g mass hanger with four 100 g slotted masses, each labelled 1 N, is ideal. If these are not available a suitable light hook must be provided so that the masses can be hung from the spring.

EXPERIMENT 4

(i) Expendable spring, approximately 20 mm coiled length × 15 mm diameter, capable of supporting at least 500 g without overstretching (e.g. Philip Harris expendable steel spring, B8G87194). See note **1**.
(ii) Metre rule.
(iii) A 300 g mass and a 500 g mass. See note **2**.
(iv) 2 clamps, 2 bosses and a stand. See notes **3** and **4**.
(v) A pin mounted in a cork. See note **3**.

(vi) Stopwatch.

Notes

1. The spring must be capable of executing at least 10 complete oscillations (down, up and back down) when one of the masses is suspended from the spring and given a small vertical displacement.
2. Four 100 g slotted masses and a 100 g mass holder would be suitable. Alternatively, a suitable light hook must be provided so that each mass can be hung from the spring.
3. Set up the apparatus as shown in Fig. **4**, with no mass attached to the spring. The pin should be positioned so that when a mass is attached to the spring, the pin is close to the mass.
4. The height of the top clamp must be such that when the 500 g mass is suspended from the spring it is well clear of the bench.

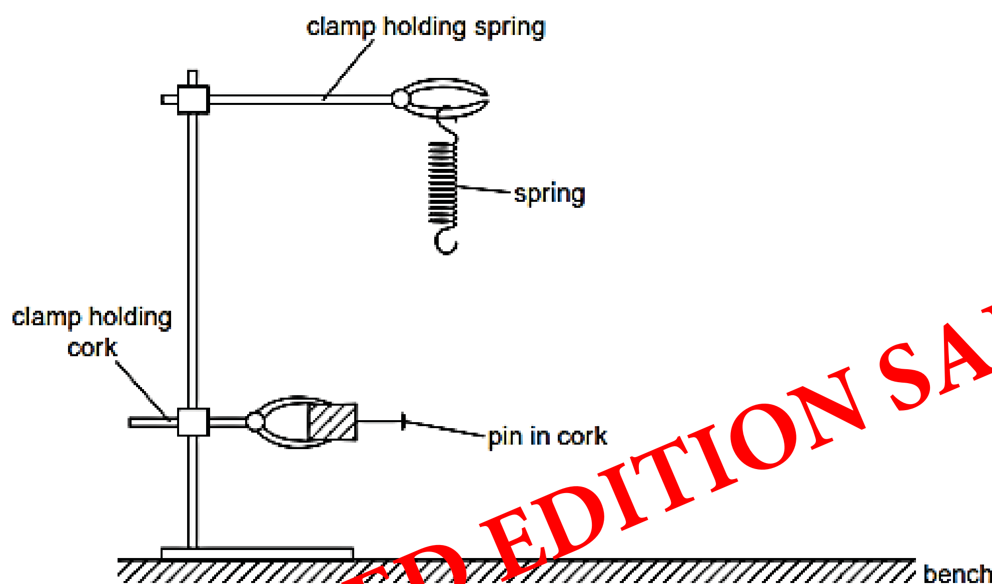

Fig. 4

EXPERIMENT 5

(i) Metre rule (see note 1 below).

(ii) Triangular block to act as a pivot for the metre rule. This block is to stand on the bench.

(iii) 30g mass (see note 2 below).

(iv) A selection of masses so that candidates can use masses of 40g, 50g, 60g, 70g and 80g (eight 10g slotted masses would be suitable).

Notes

1. The metre rule should balance on the pivot when the 50cm mark is approximately over the pivot.
2. The 30g mass is to be taped to the metre rule so that its centre is at the 90.0cm mark. The value of the mass is not to be given or to be visible to the candidates. Label this mass X.

EXPERIMENT 6

A plastic bottle filled with water
A ruler or measuring tape
A stopwatch

3. These will be used to construct the circuit shown in Fig. **41**. One crocodile clip must be attached to the end of a flying wire to act as a jockey as shown in Fig. **41**.

4. If a digital meter is used it must be set to a suitable range e.g. 0–20V. The voltmeter must be connected to the circuit so that there is a positive reading when the jockey (crocodile clip) is clipped to the resistance wire around the 50cm mark.

EXPERIMENT 42

(i) A resistance wire approximately 1 m in length, labelled resistance wire. 32 swg (0.274 mm diameter) constantan (Eureka) or any other wire with a resistance of approximately 8 Ω / m is suitable. See note 1.
(ii) Metre rule, graduated in mm. See note 1.
(iii) Crocodile clip.
(iv) Power supply of approximately 2 V to 3 V. See note 3. Where candidates are provided with a variable power supply, the voltage should be set by the supervisor and fixed, e.g. taped.
(v) Switch. The switch may be a part of the power supply.
(vi) Sufficient connecting leads to set up the circuit shown in Fig. **42**.
(vii) Ammeter capable of measuring currents up to 2.00 A with a minimum resolution of 0.05 A. See note 4.
(viii) Voltmeter capable of measuring up to 3.0 V with a minimum resolution of 0.1 V. See note 4.
(ix) Spare leads and crocodile clips.

Notes

1. The wire is to be fixed to the metre rule in such a way as to allow candidates to connect a crocodile clip to points between the 35 cm and 95 cm marks. Alternatively, a potentiometer fitted with an appropriate wire is suitable. Transparent tape must be used to tape over the wire between the 0.0 cm and 35.0 cm marks and between the 95.0 cm and 100.0 cm marks to prevent connection to these two sections.

2. The circuit is to be set up for candidates as shown in Fig. **42**, with the crocodile clip not connected to the wire.

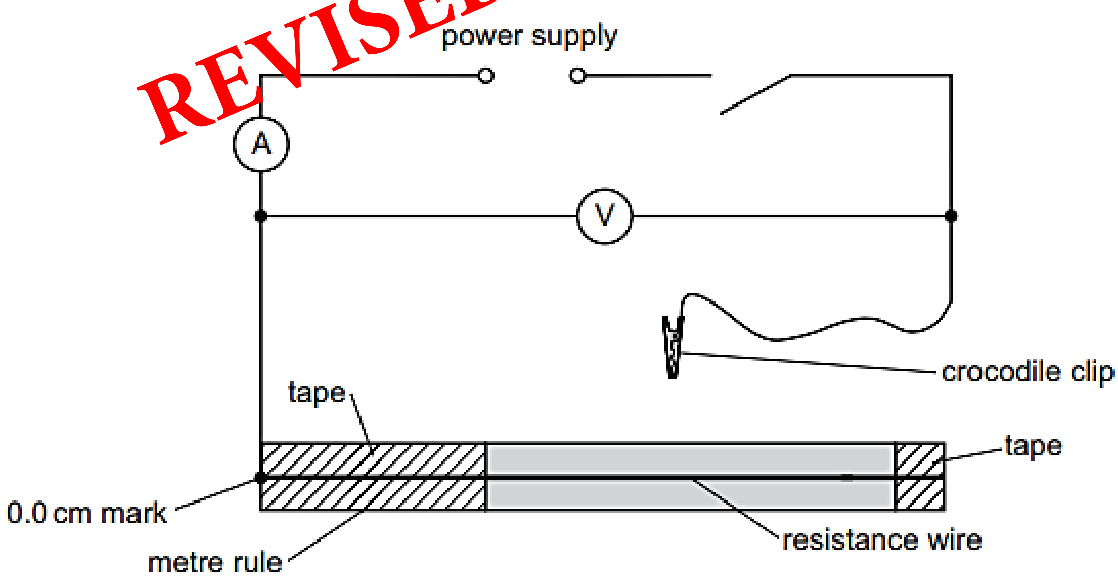

Fig. 42