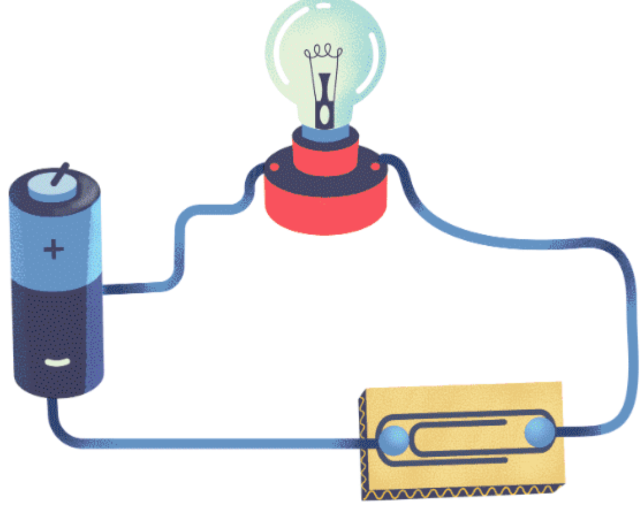
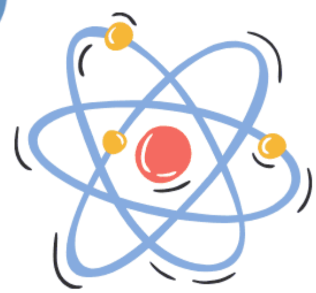
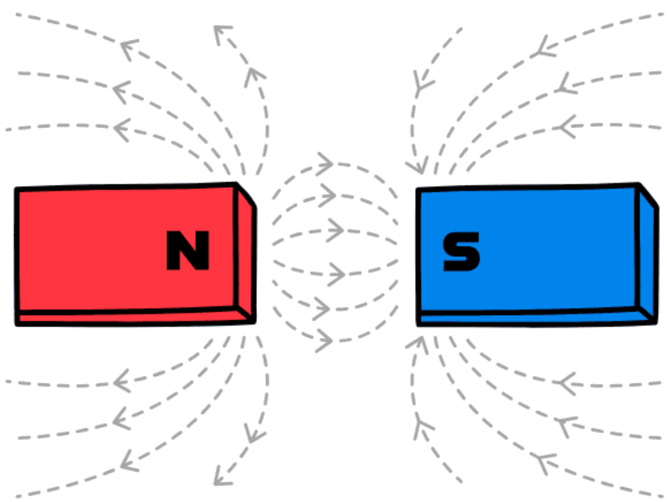


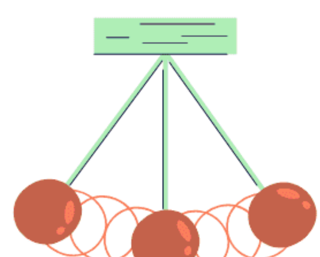


PRACTICAL PHYSICS

WORKBOOK WITH REAL LIFE PROBLEM SOLVING QUESTIONS



BYAKATONDA DENIS



Practical Physics

A competence based approach

This book is dedicated to all physics students, may your imaginations and experiments lead to revelations that will inspire the future

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Table of Contents

1.0 INTRODUCTION

Embracing a Competence-Based Curriculum

The landscape of education is constantly evolving, and one of the most significant shifts in recent years has been towards a competence-based curriculum. This approach emphasizes not just the acquisition of knowledge, but the development of skills and competencies that students can apply in real-world situations. The new lower secondary curriculum for physics reflects this shift, moving away from rote learning and towards a more hands-on, inquiry-based approach to understanding the physical world.

The New Approach to Practical Physics

Traditionally, practical physics assessments involved following a set of predefined instructions to achieve a particular result. While this method ensured that students could carry out experiments, it often lacked engagement with the underlying principles and theories. Students might complete an experiment successfully without truly understanding why they were performing each step or how the results related to the theoretical concepts they had learned in class.

In this new approach, practical physics is assessed differently. Students are no longer passive recipients of instructions; instead, they are active participants in the learning process. They are required to write extensive practical reports that demonstrate their understanding of the theory behind the experiments, their ability to apply this theory to solve real-world problems, and their proficiency in using scientific methods and techniques.

Writing Practical Reports

One of the key components of the new assessment strategy is the practical report. These reports are not merely records of what students did during an experiment; they are comprehensive documents that include:

- **Title**: A detailed title of the experiment, including its aim / objective and the scientific concepts being investigated.
- **Hypothesis**: A clear statement of the expected / guessed outcome based on theoretical understanding of the concepts.
- **Materials and Methods**: A detailed description of the apparatus used and the procedures followed, written in the student's own words; whenever

possible, a diagram should also be included to show how the apparatus were arranged.

- **Choosing variables:** The student has to choose their own dependent & independent variables basing on the theoretical knowledge they are applying and what variables they can control.
- **Data Collection:** Systematic recording of observations and measurements.
- **Analysis:** Interpretation of the data, including calculations, graphs, and discussion of errors and uncertainties.
- **Conclusion:** A summary of the findings, how they relate to the hypothesis, and their implications for the scientific theory.
- **Reflection:** A critical evaluation of the experiment, discussing what was learned, what could be improved, and how the experience connects to real-world applications.

Real-World Problem Solving

The heart of this new approach is problem-solving. Instead of conducting experiments in isolation, students are presented with real-world problems that require them to use their knowledge and skills to find solutions. This method encourages critical thinking, creativity, and practical application of theoretical concepts. For example, rather than simply measuring the resistance of a wire, students might be asked to investigate the design & properties of a heating element for a specific application, taking into account factors such as efficiency, safety, and cost.

Encouraging Innovation and Creativity

By allowing students to use their own techniques and methods, the competence based approach fosters innovation and creativity. Students are not limited to a single way of conducting an experiment; they are encouraged to think outside the box, try different approaches, and learn from their successes and failures. This freedom helps students develop a deeper understanding of scientific principles and how they can be applied in various contexts.

Preparing for the Future

The skills and competencies developed through this new approach to practical physics are essential for students' future success, both in their academic pursuits and in their careers. Whether they go on to become scientists, engineers, doctors, or professionals in any field, the ability to think critically, solve problems, and apply knowledge practically will serve them well.

Finally, this practical book aims to guide students through this exciting and challenging new approach to learning physics. It provides a comprehensive framework for conducting experiments, writing reports, and solving real-world problems, all while developing the skills and competencies that are essential for success in the 21st century. Let us embark on this journey of discovery and innovation together, as we explore the fascinating world of physics through a hands-on, inquiry-based approach.

Byakatonda Denis,

June 2024.

2.0 WHY PRACTICAL PHYSICS?

Physics practicals are a vital part of learning physics. They offer you a chance to do hands-on activities that help you understand the concepts you learn in class. By actually doing experiments, you can see how the principles of physics work in real life, making the subject more interesting and easier to grasp.

Exploring Scientific Questions

Physics practicals help you explore scientific questions through experiments. Instead of just reading about theories, you get to test them out. For example, you might conduct an experiment to see how a spring stretches when you add weights to it, which helps you understand Hooke's Law. This way, you see the relationship between force and extension firsthand. Doing these investigations helps you learn how to ask questions, design experiments, collect data, and make sense of your results.

Solving Real-World Problems

Physics practicals often involve solving real-world problems. You use your knowledge to tackle challenges you might encounter in everyday life. For example, you might figure out which material is best for insulating a house by measuring how well different materials keep heat in. These activities encourage you to think critically and creatively, applying what you know to solve practical problems.

Demonstrating and Verifying Physics Laws

Through practical experiments, you get to prove and understand fundamental laws of physics. For instance, you might measure the current and voltage in a circuit to verify Ohm's Law or use light experiments to see how reflection and refraction work. These experiments help you see that the laws you learn about in textbooks really do apply in the real world.

Precision in Measurement and Data Collection

Practical physics teaches you how to measure accurately and collect data. You'll use tools like meter rules, stopwatches, voltmeters, and ammeters to gather precise information. Learning to measure correctly and record your observations carefully is crucial. For example, timing how long it takes for an object to fall

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helps you understand gravity. These skills are important for doing science accurately and understanding the results of your experiments.

Developing Experimental Design Skills

Physics practicals help you learn how to design your own experiments. You'll figure out what variables to control, how to set up your experiment, and how to ensure your results are reliable. This process teaches you the scientific method and helps you become a better problem-solver. For example, designing an experiment to see how different angles affect a projectile's motion requires careful planning and thinking.

Understanding Complex Systems through Simulations

Sometimes, it's not practical or safe experiment on certain concepts in the lab. That's where simulations come in. Using computer models or laboratory models, you can study things that are too complex or dangerous to experiment with directly. For example, you can use a simulation to see how particles behave in different states of matter. Simulations help you visualize and understand difficult concepts in a safe and cost-effective way.

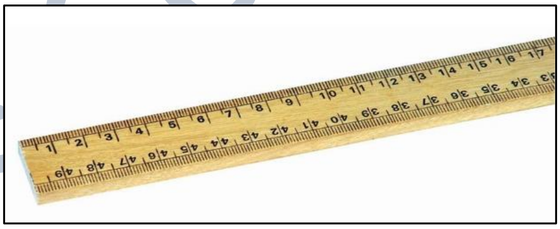
3.0 LABORATORY MEASUREMENTS

At the heart of every physics practical investigation, there are measurements to be taken in order to determine the relationship between certain variables. Accurate measurements are thus essential for obtaining reliable and reproducible results.

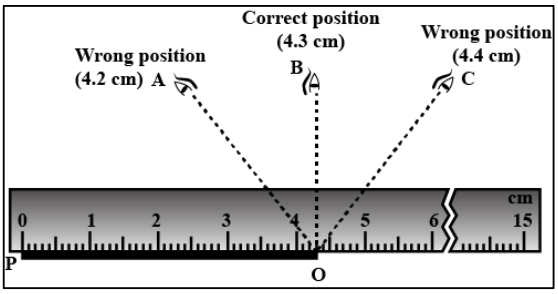
Different instruments are used to measure various quantities, each with its own specific method of reading, accuracy, and units. This section covers the common laboratory instruments used in lower secondary physics practicals, detailing how they are read, their accuracy.

3.1 Measurement of length

Meter Rules



A meter rule is a straightedge measuring tool, typically 1 meter in length, used to measure distances or lengths. Length is commonly measured in meters (m), centimeters (cm), or millimeters (mm).

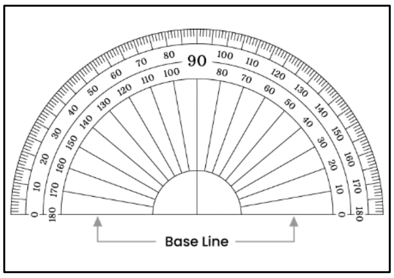


To read a meter rule, align the zero mark with the start of the object being measured, and read the scale at the endpoint. Ensure your eye is directly above the point being read to avoid parallax error.

The least count of a meter rule is the smallest division it can measure, typically 1 mm (0.1 cm). Hence measurements on a meter rule are typically read to one decimal places when using centimeters (e.g., 12.3 cm).

3.2 Measurement of angles

Protractors



A protractor is a semicircular or circular tool used for measuring angles in degrees (°).

To use it, place the midpoint of the protractor at the vertex of the angle, align one side of the angle with the zero line of the protractor, and read the scale where the other side of the angle intersects the protractor.

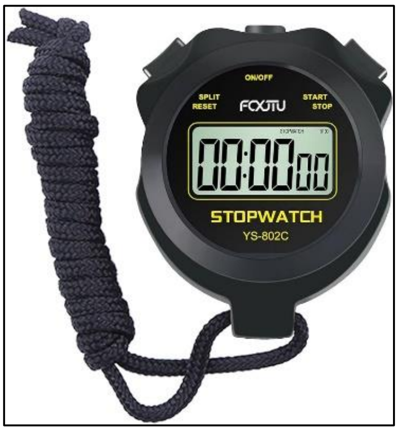
The least count of a standard protractor is 1 degree. Some protractors have finer graduations with a least count of 0.5 degrees. The accuracy is usually ±0.5 degrees.

Angles are mostly read to the nearest whole number (e.g., 45^0) or to one decimal place (e.g., 45.0°) depending on the type of protractor and it's least count.

3.3 Measurement of time

Stop Clocks and Stop Watches

A stop clock / watch is a device used to measure time intervals or the time elapsed from a particular time when it is activated to when the piece is deactivated. They are often equipped with buttons to start, stop, and reset the timer.



These devices can be analog or digital. The time is read directly from the digital display or analog dials. For accuracy, ensure to start and stop the clock precisely at the beginning and end of the event being measured.

The least count of a stop clock can be as small as 0.01 seconds for digital models hence these are read to two decimal places for digital models (e.g., 0 mins, 12 seconds & 34 microseconds, $00{:}12{:}34 \Rightarrow 12.34\ s$), on the other hand, most analog stopwatches have a least count of 0.5 seconds or 0.1 seconds, which means their values are read to 1 decimal place, e.g., 12.5s, 30.0s, 46.5s.

4.0 DATA COLLECTION AND ANALYSIS

In physics practicals, handling and manipulating data accurately is important. Understanding the rules for working with significant figures and decimal places ensures that your calculations are precise and reliable. This section will cover how to manage data through various mathematical operations, focusing on significant figures, decimal places, and the handling of constant values like π (pi) and float values.

4.1 Significant Figures and Decimal Places

Significant Figures are the digits in a number that contribute to its accuracy. This includes all non-zero digits, any zeros between significant digits, and trailing zeros in a decimal number. **Decimal Places** refer to the number of digits to the right of the decimal point. Significant figures & decimal concepts help maintain precision in your calculations.

Counting Significant Figures

- **Non-Zero Digits:** All non-zero digits (1-9) are always significant, e.g.,123 has 3 significant figures, 56.789 has 5 significant figures.
- **Trapped (or Captive) Zeros:** These are zeros located between non-zero digits, they are counted as significant; e.g., 1002 has 4 significant figures, 3.0701 has 5 significant figures.
- **Leading Zeros**: Leading zeros (zeros before the first non-zero digit) are not significant. e.g., 0.0056 has 2 significant figures, 0.000789 has 3 significant figures.
- **Trailing (or terminal) Zeros:** Trailing zeros (zeros at the end of a number) are significant only if they represent the accuracy or precision of an instrument, e.g.; if 23.0 cm is read from a meter rule, it has 3 significant figures, 30^0 from a protractor has 2 significant figures.
- **Scientific Notation:** Scientific notation is often used to clearly indicate the number of significant figures. In scientific notation, all digits in the coefficient are significant, e.g., in 4.00×10^3, the coefficient (4.00) has 3 significant figures, in 1.230×10^{-4}: The coefficient (1.230) has 4 significant figures.
- **Exact Numbers:** If a number was obtained by counting, e.g., 20 oscillations, 10 apples, 2 beakers, then the number is considered to be

exact. Exact numbers have an infinite number of significant figures. If a number is part of a definition, then the number is also exact. For example, 1 cm is defined as exactly 100 m. Therefore, in the statement 1 m = 100 cm, both the 1 & 100 have an infinite number of significant figures.

4.2 Addition and Subtraction

When adding or subtracting numbers, the result should be rounded to the same number of decimal places as the measurement with the fewest decimal places. For example;

- 12.345 (3 decimal places) + 7.1 (1 decimal place) = 19.445, which is rounded to 19.4 (1 decimal place).
- 25.678 (3 decimal places) - 3.12 (2 decimal places) = 22.558, which is rounded to 22.56 (2 decimal places).
- 100.01 (2 decimal places) + 2.1 (1 decimal place) = 102.11, which is rounded to 102.1 (1 decimal place).

4.3 Multiplication and Division

For multiplication and division, the result should have the same number of significant figures as the measurement with the fewest significant figures.

- 4.56 (3 significant figures) × 1.4 (2 significant figures) = 6.384, which is rounded to 6.4 (2 significant figures).
- 3.123 (4 significant figures) ÷ 2.1 (2 significant figures) = 1.487142857, which is rounded to 1.5 (2 significant figures).
- 5.678 (4 significant figures) × 2.0 (2 significant figures) = 11.356, which is rounded to 11 (2 significant figures).

Note: Much as reciprocals got by dividing 1 by a given number, they follow quite a different rule; since 1 is a counting number, it is considered to have an infinite number of significant figures (see *float* values), therefore, we consider the significant figures of the denominator, e.g., $\frac{1}{2.6} = 0.38$ since the denominator has 2 S.F. .

4.4 Trigonometric Functions

Trigonometric functions can be very sensitive to the precision used; when using trigonometric functions like sine, cosine, and tangent, the result should be written to three decimal places.

4.5 Square Roots

For square roots, the number of significant figures in the result should be the same as the number of significant figures in the original number.

- $\sqrt{4.00}$ (3 significant figures) = 2.00 (3 significant figures).
- $\sqrt{16.56}$ (4 significant figures) = 4.069 (4 significant figures).
- $\sqrt{9.7}$ (2 significant figures) = 3.1 (2 significant figures).

4.6 Float & Constant Values

Constants such as π (pi) & acceleration due to gravity, g are used frequently in physics calculations, some of these constants have a defined number of decimal places & significant figures while others have an infinite number of decimal places & significant figures, these are known as *float* values. When dealing with float values & constants, the rules of arithmetic operations are the same as those already described.

E.g., 2.4 π = 7.5 (2 significant figures), since π has an infinite number of significant figures and 2.4 has 2 S.F, we consider the one with the least significant figures for the final result.

4.7 Recording values in the table of results

It is important to maintain a consistent amount of decimal places in a given column in the table, this creates uniformity and ensures that all values have been recorded to the same level of accuracy.

Having a uniform number of decimal places in a column of directly measured values from an instrument is often obvious since each instrument gives readings already fixed to a certain number of decimal places. The problem arises when dealing with 'calculated columns'.

For 'calculated columns' of addition & subtraction, we simply add the values and record the answer with the least decimal places involved in the calculation. e.g., if a table has a column of x and y, and we need a column of $x + y$,

5.0 WRITING A PRACTICAL REPORT

Writing a practical report is an essential skill in practical physics. It helps you to document your experiment and key findings.

A practical report typically consists of, title, Hypothesis, Apparatus and Materials, Setup diagram, Procedures, Data Collection, Data Analysis & Conclusion.

1. Title or Aim

The title should be concise yet descriptive, indicating the main focus of the experiment. A good title gives the reader a clear idea of what to expect from the report and why the practical investigation was done.

2. Choosing Variables

Variables are quantities or characteristics that can be measured in some way within the experiment; we always need to state our variables especially if the experiment involves *comparing two quantities* and how they relate with one another. Variables are also necessary if graphs are to be used during your data analysis.

Identifying and choosing the correct variables is crucial for a successful experiment. There are three main types of variables:

- **Independent Variable:** This is the variable that you change or manipulate in the experiment. It is the cause that affects the outcome.
- **Dependent Variable:** This is the variable that you measure. It is the effect or outcome that happens as a result of changing the independent variable.
- **Control Variables:** These are the variables that you keep constant to ensure that the test results are due to the independent variable alone.

To choose the right variables, focus on what you are trying to achieve with the experiment and the theory behind the experiment you are doing (if it is known) – for this physics formulas are a good place to get your variables from.

If say you're doing an experiment to determine resistance of a given material, the related theoretical concepts here include Ohm's law; which is summarized mathematically as $V = IR$, from the formula, we can see that to find resistance, we shall need the potential difference, V and current, **I**; these become our variables. We then determine which one can easily be changed easily and make it the independent variable – for this case, we can easily change the current by using a rheostat in the circuit.

Note: If the experiment is going to be done in one trial, then there's no need to identify which variable is dependent or independent; using the above example, you can just take one measurement of V and one for I and then calculate resistance. However, you are advised not to rely on answers from single trials as they may yield results with a big error without any other value to be compared to. Only do single trials in cases where the variables can't be changed easily.

3. Hypothesis

The hypothesis is a statement predicting the outcome of the experiment based on prior knowledge or research. It should be clear and testable, providing a foundation for the experiment. However, not all experiments require a hypothesis , it is mostly useful for those whose outcome is predictable based on a certain set of outcomes; e.g., in an experiment involving a swinging pendulum, the hypothesis can be, "***the period of oscillation of a pendulum is not affected by the mass of the bob***" or "***the period of oscillation of a pendulum increases with increase in the mass of the bob***" or "***the period of oscillation of a pendulum decreases with increase in the mass of the bob***", the experiment can then be carried out to prove if the hypothesis is true or otherwise.

As you can see in the example above, such an experiment has a defined set of outcomes (which can be guessed). The experiment is then carried out to determine if the hypothesis is true or false.

4. Experimental Setup Diagram

The setup diagram is a visual representation of the experimental setup. It helps readers understand how the apparatus and materials are arranged and connected. A clear and accurate diagram can be helpful in replicating the experiment and understanding the procedure.

Remember, *"a good picture is worth a thousand words"*. Some best practices when drawing setup diagrams

- *Drawing the Diagram*: Use simple, labeled sketches to illustrate the arrangement of equipment. Ensure all components mentioned in the apparatus list are included in the diagram.

- *Labeling*: Clearly label all parts of the setup. Use arrows or lines to point to specific components. If your diagram uses internationally recognized symbols for the apparatus, then you do not need to label.
- *Neatness and Clarity*: Ensure the diagram is neat and easy to read. Avoid cluttering the diagram with too much information; focus on the essential components and their connections.
- *Consistency*: Ensure the diagram matches the written procedures and descriptions in the report. Any disagreements between the procedures and the diagram can lead to confusion or errors when trying to replicate the experiment.

5. Apparatus and Materials

In this section, you list all the laboratory equipment (apparatus) and any other objects (materials) needed for the experiment. Providing a detailed list ensures that anyone replicating the experiment knows exactly what is required.

You may be provided with a list of some of the basic apparatus at times to begin with, but in the event that you need extra tools to help you carry out the experiment, they should be provided as long as they are common laboratory tools. When you're given a predefined set of apparatus, it could also be an indicator that you should try to use theoretical knowledge that supports the use of such apparatus to carry out the experiment.

6. Procedures

The procedures describe the steps taken to perform the experiment. These should be readable and easy to follow, preferably in bulleted or numbered steps. Procedures should be written in a passive voice and avoid commanding speech (e.g., "The circuit was set up" instead of "Set up the circuit").

7. Data Collection

In any experiment, there is always data to be collected, it is from such data that conclusions are made. The data to be collected is mainly determined by the dependent & independent variables selected while planning the experiment. The data should be presented in a clear and organized manner, often using tables; the tables should be clear, concise and with all the quantities and their units indicated.

Furthermore, the data should be recorded with the right precision (decimal places & significant figures) and with the right units, e.g., $l = 12.8\ cm$

8. Data Analysis

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Practical Report: An Example

Problem: A newly launched company in your area wants to start manufacturing submersible water heaters. To accomplish this, they need to use a high resistance conducting material. A senior engineer has advised them that to make better heaters, that efficiently convert electric to heat energy, the material's resistance should be higher than 3 Ω.

Task: As a student of physics, you are provided with a sample X of the material that they want to use for the heater. Carryout an investigation to determine if the material is suitable for use.

Solution:

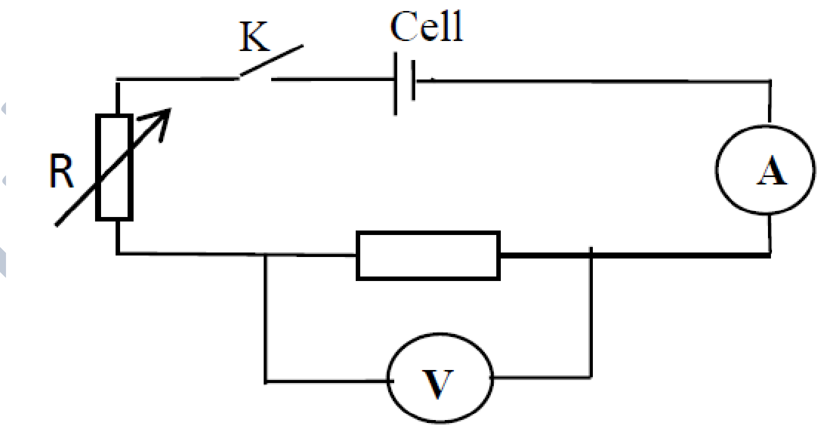
Title: An experiment to determine the Resistance of a Material to check if it is suitable for use in a Heater.

Hypothesis: The material has a high resistance (R > 3 Ω), and will be suitable for use in a heater as it will convert electrical energy into heat efficiently.

Apparatus and Materials:

Ammeter, Voltmeter, Power supply (Dry cells), Rheostat, Connecting wires, Material sample, Jockey, crocodile clips.

Experimental setup diagram:



Procedures:

a) The circuit was set up as shown in the diagram above, with the material sample connected in series with the ammeter and the dry cells.
b) The voltmeter was connected in parallel across the material sample.
c) The switch K was closed, and values of V and I recorded from the voltmeter and ammeter respectively.

d) The rheostat was then adjusted to vary the current I which also leads to a different potential difference, V.
e) Steps a) to d) were repeated for different values of current, I and potential difference, V.
f) The values were recorded in a table; including values of $R = \frac{V}{I}$ as shown below.
g) A graph of V against I was plotted to determine the relationship between V and I, the slope of the graph was calculated to determine the resistance.

Note: steps f) and g) both serve the same purpose of analysis, using one of them is still sufficient in this case.

Data Collection:

The following table summarizes all the data values of V and I collected, a column of R was added so that I can calculate resistance for each pair of values of I and V.

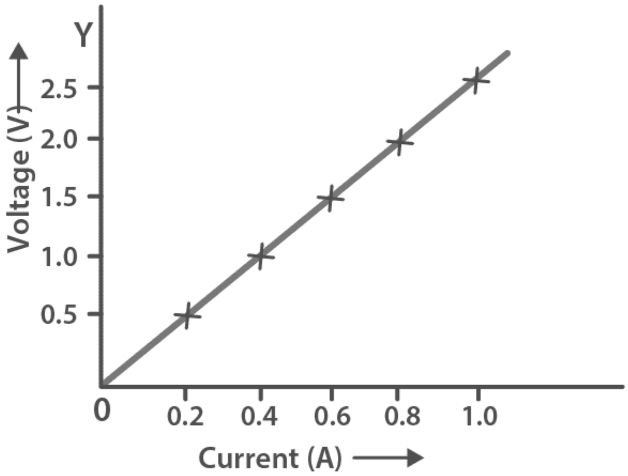
I (A)	**V (V)**	**R (Ω)**
0.20	0.5	2.5
0.40	1.0	2.5
0.60	1.5	2.5
0.80	2.0	2.5
1.00	2.5	2.5

Analysis (from the table):

From the R column in the table, the values of resistance have been calculated for each pair of values of V and I; if the values were slightly deviating, I would go on to calculate the mean or find the mode, but since they are the same, I will just make a conclusion that $R = 2.5\,\Omega$.

Graphical Analysis:

A graph of V against I



From the graph of V against I, a straight line passing through the origin is obtained which indicates that as potential difference increases, so does the current. The gradient or slope of the line $\left(\frac{Change\ in\ V}{Change\ in\ I}\right)$ is the resistance of the material;

$$Slope = \frac{Change\ in\ V}{Change\ in\ I} = \frac{2.5 - 0}{1.0 - 0} = 2.5\ \Omega$$

Conclusion: The experiment successfully determined the resistance of the material sample to be 2.5 Ω. This value is less than the recommended 3 Ω that was, therefore, the material is not suitable for use in designing the heater, as it cannot efficiently convert electrical energy into heat.

The hypothesis that a material has a high resistance was not supported by the experimental data.

The possible sources of errors include poorly calibrated devices but I carefully checked them before starting the experiment, the connecting wires also have a resistance which affects the results.

Note: The values used in this experiment were not obtained from a practical experiment, in practice, the values obtained usually do not all lie along one straight line; in these cases, a line of best fit is drawn as an average line for all plotted points.

6.0 THEORY OF COMMON EXPERIMENTS

Understanding the underlying theory before carrying out an experiment is very important as it provides a foundational context for the procedures and outcomes. It allows you to grasp the principles and concepts that govern the experiment, ensuring you can easily understand what you are observing and why it occurs.

Applying theoretical knowledge to practical scenarios, encourages critical thinking and problem-solving. It also helps in predicting results, troubleshooting issues, and interpreting data accurately.

Without this theoretical understanding, experiments may become mere procedural tasks, losing the educational value and the opportunity to connect practical experiences with scientific principles.

6.1 Density of Liquids and Solids

Density (ρ) is defined as the mass per unit volume of a substance. It is expressed in units of grams per cubic centimeter (g/cm^3) or kilograms per cubic meter (kg/m^3).

$$1 g/cm^3 = 1000\ kg/m^3$$

Each substance has a unique value of density which is why we commonly use density to identify substances. and

Mathematically, density is the mass (m) of a substance divided by its volume (V).

$$\rho = \frac{m}{v}$$

Mass (m) is the amount of matter in an object, measured in grams (g) or kilograms (kg) while Volume (V) is the amount of space an object occupies, measured in cubic centimeters (cm^3) or cubic meters (m^3).

6.2 Measuring the Density of a Liquid

Apparatus: Measuring cylinder: to measure volume, beam balance: to measure the mass, liquid sample.

Procedure:

1. Measure the mass of the empty measuring cylinder using the balance, e.g., m_b.
2. Fill the measuring cylinder with a known volume of the liquid, V.
3. Measure the mass of the measuring cylinder with the liquid, m_{b+l}.
4. Subtract the mass of the empty cylinder from the total mass to find the mass of the liquid, $m_l = m_{b+l} - m_b$.
5. Calculate the density using $\rho = \frac{m_l}{V}$
6. For accuracy, you can take different measurements and calculate the density in each case, then take the average value.

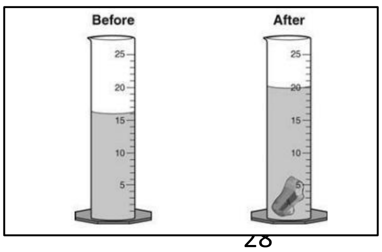
m_l (g)	V(cm^3)	ρ (g/cm^3)

Ask your teacher or laboratory technician to provide you with the materials & apparatus above and carry out this experiment, have your teacher check your work

6.3 Measuring the Density of a Solid:

Apparatus: Balance, measuring cylinder or water displacement method, solid sample.

Steps:



1. Measure the mass of the solid using the balance.
2. If the solid is regular, measure its dimensions and calculate its volume.

3. If the solid is irregular, use the displacement method to find its volume, i.e., fill a measuring cylinder with water and record the initial volume, V_1, Submerge the solid in the water and record the new volume, V_2.
4. Calculate the volume of the solid by subtracting the initial volume from the new volume, $V = V_2 - V_1$.
5. Calculate the density using $\rho = \frac{m}{v}$

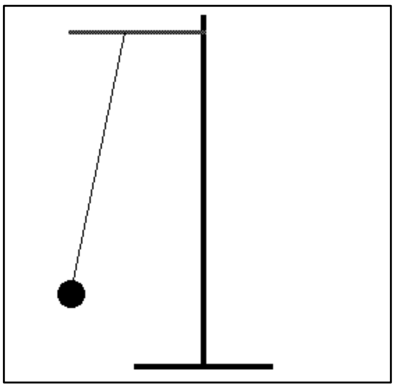
Applications of density :

- **Material Identification:** Density is used to identify substances and determine their purity.
- **Quality Control:** Ensures that materials used in manufacturing meet specific density criteria.
- **Buoyancy and Shipbuilding:** Understanding density helps in designing ships and submarines to ensure they float or submerge correctly.
- **Geology:** Helps in identifying minerals and understanding Earth's composition.

6.4 Oscillations and Acceleration Due to Gravity

An oscillation is the to and fro movement of an object. Oscillations occur in many aspects of the physical world, from the atomic scales to large scales; we use oscillations to describe movement of atoms, waves & signals, and a lot more!

The simple pendulum



One of the common oscillating systems we use in the physics laboratory is the simple pendulum; which is a setup involving a small mass attached at the end of a string tied to a fixed support.

When the small mass is pulled through a certain angle, it starts to oscillate. The period (T) is the time taken for the bob to make one complete oscillation, it is measured in seconds (s).

The relationship between the period of oscillation (T), length of the bob, L and acceleration due to gravity, g is;

We can design an experiment around this formula to determine some unknown mass, m or to determine the spring constant K.

6.5 Extension and Hooke's Law

Hooke's Law describes the behavior of springs and other elastic materials like rubber bands. It states that the extension of an elastic material is proportional the applied force provided the elastic limit is not exceeded; mathematically written as, $F = kx$, where, F is the applied force, x is the extension

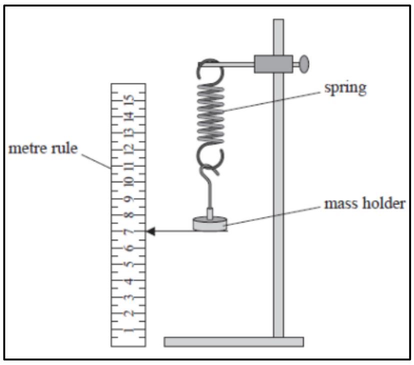
The Spring Constant (K) is a measure of the stiffness of the spring, if K is high, the spring is very stiff and if K is lower, the spring can easily be stretched or compressed. K is measured in Newton per meter (N/m).

The Elastic Limit is the maximum extent to which a material can be stretched without permanently deforming.

Investigating Hooke's Law:

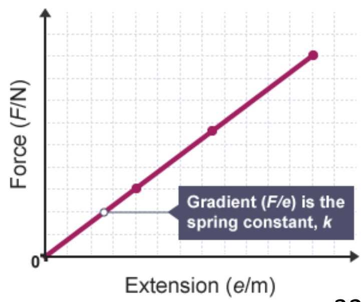
Apparatus**:** Spring, weights, ruler, stand, and clamp.

Steps:



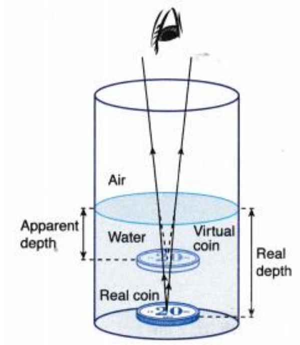
1. Attach the spring to a stand and measure its original length or position along a meter rule scale.
2. Add a known mass to the spring and measure the new length or the new position.
3. Calculate the extension x by subtracting the original length from the new length.
4. Repeat steps 2) to 3) with different masses and tabulate your results in a table.

M (kg)	F (N)	x(m)



5. A graph of the applied force, F is plotted against the extension; a straight line through the

Real and Apparent Depth:



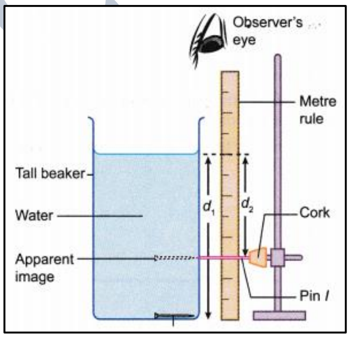
One of the most observable effects of refraction is the illusion of objects appearing shallower (nearer) than they actually are; this is seen in swimming pools filled with water and when a coin is placed in a glass of water.

This concept can also be used to determine refractive indices of objects in the laboratory using the expression;

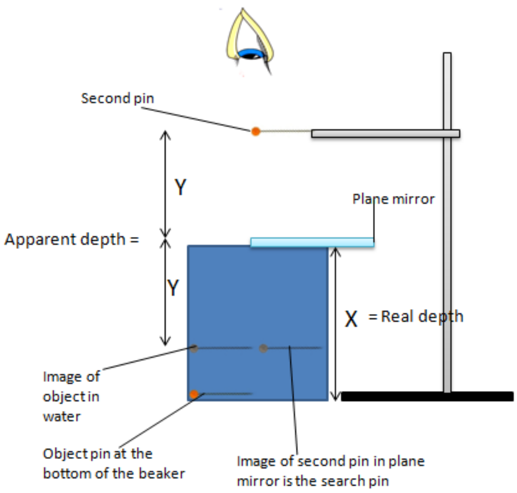
$$n = \frac{real\ depth}{apparent\ depth}$$

Apparatus: Transparent container, liquid (e.g., water), pin, ruler, and a thin object like an optical pin.

Steps:



1. Fill the transparent container with the liquid & measure the real depth d_1.
2. Place a pin at the bottom of the container.
3. View the pin from directly above the container and using a clamped search pin, note the apparent position of the pin and hence the apparent depth, d_2 by measuring with a ruler.
4. Finally, calculate the refractive index (n) using the formula, $n = \frac{d_1}{d_2}$



Another way is of locating the apparent position of the pin is by using a plane mirror. This works because plane mirrors form images whose image distance is equal to object distance. Here, the observer doesn't have to look from the edge, they just look through the mirror while moving the search pin up or down until its image coincides with that in seen in the water.

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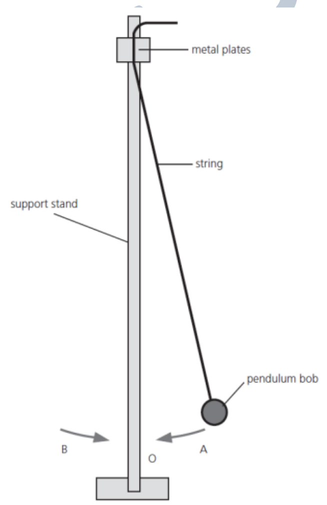
7.0 MECHANICS EXPERIMENTS

Problem / Scenario Based Item 1

Scenario: There has been an argument among physics students in the country that the acceleration due to gravity on earth is different for different places on earth depending on altitude. To stop the argument, different students will carry out experiments to determine the acceleration due to gravity in their areas and you are one of those selected to participate.

Apparatus: Meter rule, thread, retort stand, small mass (pendulum bob), stop clock.

Sample experimental setup:



NB: Other experimental setups may also be used

Task: Using the given set of apparatus, carry out an experiment to determine the value of acceleration due to gravity at your school.

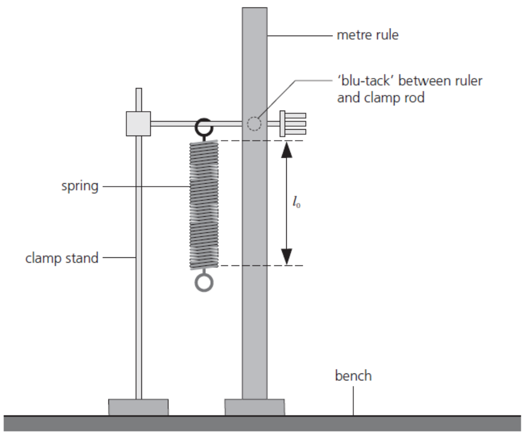
Problem / Scenario Based Item 3

Scenario:

'Quantum Electronics' is a new company that plans to start manufacturing torches in your area. They intend to use springs to hold dry cells within their torches. Their chief engineer has advised that for the torches to be long lasting, the springs to be used should obey Hooke's law. The company has therefore decided to send a sample of the spring they plan to use to your school for lab investigation.

Apparatus: Helical spring, laboratory masses, retort stand, meter rule.

Sample experimental setup:



Task: As a student of physics, you have been provided with a sample spring that the company intends to use, carry out an investigation on it and make a recommendation.

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Name: ....

Date: ...... /....... /........ Experiment No.......

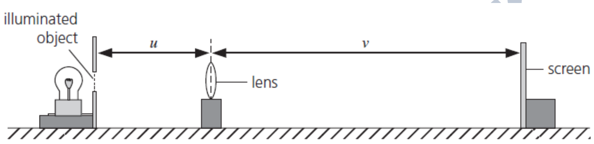
Problem / Scenario Based Item 2

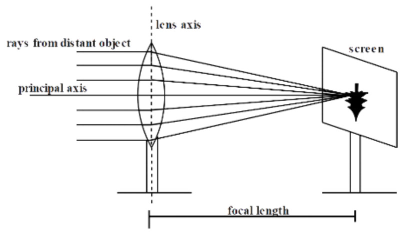
Scenario:

The lens in your school projector is spoilt and needs a replacement, according to the projector's user manual, the lens should have a focal length of 10cm. The school technician went and bought a lens from a dealer but on inserting it into the projector, only blurry images are seen on the screen. There's a suspicion that the lens that was bought is not of the right focal length.

Apparatus: Convex lens, meter rule, lens holder, screen, wire gauze, bulb, cell holder with 2 dry cells, connecting wires.

Sample experimental setups:





NB: Other experimental setups may also be used.

Task: You are provided with a lens that the technician bought. As a student of physics, carry out two experiments, a rough experiment to approximate the range in which the focal length of the lens falls & a more accurate one in order to determine the actual focal length and thereafter, write a detailed report to the school technician about your findings.

LAB REPORT

Name: ....

Date: ...... /....... /........ Experiment No.......

Problem / Scenario Based Item 8

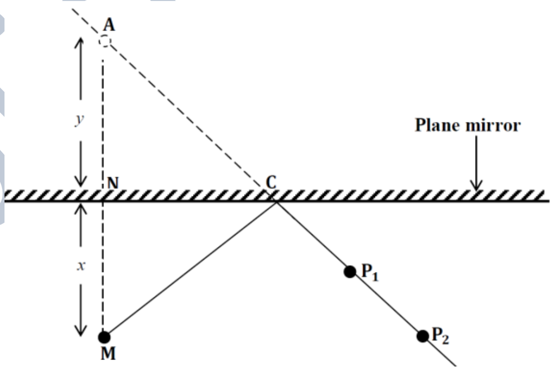
Scenario:

A businessman plans to open a five-star saloon for celebrities and the rich class within Kampala. One of the crucial components he will need in his saloon are plane mirrors. He needs accurate mirrors such that the images seen in the mirrors are the same distance as the objects are from the mirror. A dealer from within Kampala has approached him saying he sells quality plane mirrors; the businessman however doesn't trust vendors from Kampala and wants to first confirm if these mirrors will accomplish what he wants.

Task:

You have been given a small piece of mirror cut from the sample that the dealer is selling; help the businessman verify if it will meet his specifications.

Sample setup diagram



NB: Other experimental setups may be used

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Problem / Scenario Based Item 2

Scenario: Resistance is the measure of how difficult it is for electric current to pass through a conductor. During transmission of electricity, it is preferred to use wires with less resistance as they save electricity and can last longer since they do not easily heat up when electricity flows through them.

Imagine your family has just built a new home and they are about to install electric wires in it; there are two options of wires available, the wires are of the same material but have different cross-sectional areas.

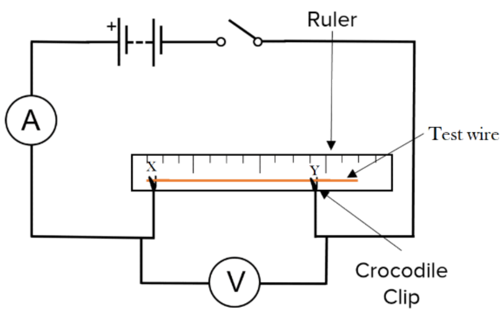
Apparatus: Voltmeter, Ammeter, 2 dry cells, wires X & Y of different cross sectional area but same length & material, e.g. (Constantan wire, X of SWG 28 & Y of SWG 30).

Task:

a) You are provided with the two wire samples X & Y of different cross-sectional areas but same length & material. Carry out an experiment and provide a detailed report on which wires to use in the house installation in order to save electricity bills.

b) What can you say about the resistance of a wires versus it's cross-sectional area?

Sample setup diagram:



NB: Other setups may be used

LAB REPORT

Name: ....

Date: ...... /....... /........ Experiment No.......