NEW ORDINARY LEVEL PHYSICS PRACTICAL WORK BOOK

(HANDS-ON)

SENIOR ONE TO SENIOR FOUR

**** TEACHER'S GUIDE ****

"USING LOCALLY AVAILABLE MATERIALS"

BASED ON THE NEW LOWER SECONDARY CURRICULUM

By

lwangawilliam11@gmail.com
+256750549201 / +256771803014

LWANGA BOOKS LTD

" By God's Grace, We Serve"

**** Project Work Books (Simplified), Research Books (detailed new curriculum notes) and Practical Work Books ****

Kawempe - Tula Road, Kampala

Near Kakungulu Police

Tel: +256771803014 (WHATSAPP) / +256750549201

E-mail: lwangawilliam11@gmail.com

You can also locate " Lwanga Books Ltd" easily using the " Google search" or " Google maps".

Table of contents

Preface……………………………….……..…I

Background………………………………II

Acknowledgement……………….……….III

Chapter 1: Laboratory Equipment……….1

Voltmeters and Ammeters/Galvanometer..….3

Voltmeters . . . . …3

Ammeters . . . ………….. 3

Chapter 2: Physics Experiments Part I…..4

Measurement 4

Construction of a Metre Rule 4

Construction of a Measuring Cylinder 4

Construction of Beam Balance 5

Measurement Errors 6

Density and Relative Density 8

Relative Density of a Liquid 8

Construction and Use of a Hydrometer . . …. 9

Applications of Material Densities 11

Archimedes' Principle 12

Construction of Eureka Can 12

Flotation 13

Conditions of Flotation 13

Properties of Matter . . . . …. 14

Surface Tension in Bubbles . . . . …. 14

Changing Surface Tension . . . . …... ... 15

Cohesion in a Moving Liquid . . . . …. . . . 17

Elasticity . . . . ….…18

Determining Adhesion and Cohesion 19

Capillarity . . . . …. 20

Conservation of Energy 22

Potential Energy of a Spring 22

Forces . . . . …. 23

Presence of Gravity . . . . …. 23

Making a Spring and a Spring Balance..….. 24

Pressure . . . . …. . . 26

Automatic Flushing Tank 26

Cartesian Diver 27

A Siphon 28

Liquid Pressure and Depth 29

Making a Magdeburg Hemisphere 31

Air Pressure 32

The Effect of Surface Area on Pressure . . . 33

Light 34

Light in a Straight Line 34

Pin Hole Camera 35

Laws of Reflection 36

Chapter 3: Physics Experiments Part II..37

Static Electricity 37

Concept of Static Electricity 37

Construction of an Electroscope 38

Detection of Charges 40

Current Electricity .41

Conductors and Insulators 41

Finding Electric Circuit Components 42

Measuring Emf of a Cell 43

Magnetism 44

Magnetic and Non-magnetic Materials 44

Magnetic Fields . . . . …. 45

Earth's Magnetic Field 46

Creating a Simple Compass 46

Magnetic Dip Gauge 47

Newton's Laws and Forces 49

Inertia and Newton's First Law of Motion.....49

Conservation of Linear Momentum 50

Bottle Rocket 52

Match stick Rocket 53

Verify Newton's First Law of Motion..……..55

Rotation and Equilibrium 56

Centre of Gravity 56

Verify the Principle of Moments 57

Simple Machines 58

Pulley 58

Chapter 4: Physics Experiments Part III..61

Friction 61

Concept of Friction 61

Limiting Friction and the Coefficient of Static Friction . ……………………………….. . . 62

Reflection of light 64

Total Internal Reflection in Water 64

Refraction and Colour 65

Dispersion of White Light: Part 1 65

Newton Colour Wheel 66

Measuring Refractive Index of Glass 67

Refraction of Light in Glass 71

Heat Transfer 72

Designing a Calorimeter 72

Heat Conduction 73

Convection 75

Radiation 77

Thermal Expansion 79

Bimetallic Strip 79

Thermal Expansion of Gases 80

Thermal Expansion of Solids……………..81

Thermal Expansion of Liquids 83

Thermal Switch 84

Change of State 86

Boiling at Room Temperature 86

Heat Capacity and Latent Heat 88

Latent Heat of Fusion . . . .…88

Vapour 89

Measuring Humidity with a Hygrometer…..89

Gas Laws 91

Boyle's Law . . . . ….91

Charles's Law . . . . …91

Chapter 5: Physics Experiments Part IV..94

Electricity 94

Creating a Leclanche Cell. . . . . …94

Construction of a Metre bridge and Potentiometer . . . . ……..………………..95

Creating a Light Bulb . . …... 98

Fuse 99

Making an Electric Heater 101

Inverter: Converting DC to AC 102

Waves 106

Construction and Use of Slinky Spring….106

Construction of a Ripple Tank 107

Behaviour of Waves 109

Sound 110

Use of a Simple Sonometer………………110

Wave Propagation in Solids 112

Sound Amplifier 113

Determination of Resonance Frequency…...114

Speed of Sound in Air 116

Electromagnetism 118

Force on a Current-Carrying Wire in a Magnetic Field……………………………………..118

Water Energy 120

Astronomy 122

Solar System Mobile 122

Star Gazing………………………………124

lwangawilliam11@gmail.com
+256750549201 / +256771803014

Preface

As the era of Alternative to Practical comes to an end, it is our hope that science teachers nationally embrace the new paradigm, that science lessons should be student-centred, competence-based, activity-oriented, and connect with student's life experience. Every learner in Uganda should perform practical exercises, not just the few that will be tested on national exams, but the wider range of hands-on activities teachers should employ to build a deep understanding in their students. Educational research has identified two obstacles to the universal implementation of hands-on science education. First, many teachers themselves learned in Alternative to Practical schools and therefore, lack essential experience with hands-on science. The remaining challenge is a fallacy rooted in ignorance and complacency: the idea that the materials required for hands-on science teaching are unavailable to most schools. We reject the notion that science education requires expensive, imported materials. Everything required to teach modern science is already available in our villages and towns. The challenge is simply to begin. Science belongs to Uganda as much as any country in the world. The law of gravity respects no national boundaries; we all feel its effect and can measure its strength. Those who decry the use of locally available materials as "stone age science" misunderstand the meaning of Science- that it applies universally, in any situation, with any material. Dependence on expensive imported materials teaches students that Science is a foreign concept, to be memorized rather than understood, and that Science lacks application to daily life. Science is the birthright of humanity, as much as Language or Mathematics or Music, and the time has come to embrace what we already own.

This learner's practical workbook has been written in line with the revised physics syllabus for the new lower secondary curriculum. It will equip teachers with the knowledge and skills to deliver hands-on science lessons in any school. We hope that this work book will also inspire school inspectors, examiners, curriculum developers and college tutors to increase their emphasis on the importance of hands-on education, and to reject material deficiencies as an excuse for any absence of practical work. In the same spirit, this work book seeks to expand the range of approaches to learning Physics and it is our hope that the many stakeholders in science education will embrace alternative methods that enable quality delivery of science education for every learner.

This learner's workbook is one of the materials which are to be used to support the teaching and learning process of the new lower secondary curriculum.

We feel confident that this Book will be of immense value to both the learners and the teachers. Any suggestions for improvement of this book are most welcomed, thanks.

Background

Motivation for Writing this practical work book

We came up with this write-up basing on the abridged report on **" Evaluation of teaching-learning and Assessment of practical skills in the Physical Sciences at Uganda Certificate of Education"** by Uganda National Examinations Board Research and Innovations Department issued out by June 2023. The study covered all the 16 zones of Uganda, including Kampala city.

Quality science education requires students to perform experiments with their own hands. Unfortunately, research on the situation of secondary science education shows that many students do not perform such experiments. This is due to several factors, all of which can be addressed.

Specifically, this book demonstrates that many quality hands-on science experiments are possible with very basic materials. The experiments in these pages require materials available in villages or, at worst, in a regional capital. Standard laboratory materials certainly add value to science teaching; this book merely makes it clear that they are not required as a condition for provision of quality education.

Also a number of experiments are incorporated in this book to reinforce hands-on, many of them also include a "Notes" section to provide the teacher with additional information about the activity. This information may be practical or theoretical.

The vision as to why We have written this book is not for students to be spectators of science, but players themselves and also not for teachers to be passive implementors, but innovators themselves.

Any suggestions for improvement of this book are most welcomed, thanks.

Acknowledgement

Lwanga Books Limited is deeply indebted to all those who participated in the development of **Lwanga William S1-S4 New Ordinary Level Physics Practical Work Book.**

Special thanks go to **Mr. Lwanga William**, the CEO Lwanga Books Ltd for his valuable insights and advice on all publishing matters.

We would like to express our sincere appreciation to all those who worked tirelessly towards the production of this learner's practical work book.

First and foremost, we would like to thank our families and friends for supporting all our initiatives both financially and spiritually, Lwanga William's parents; **Mr. William Lwanga** and **Mrs. Harriet Lwanga,** his brother; Mr. Nsubuga Grace.

The initiative and guidance of the publishing partners, Ministry of Education and Sports (MoES) and National Curriculum Development Centre (NCDC) in development and implementation of the New Lower Secondary Curriculum are highly appreciated.

We thank God for the wisdom He has given us to produce this volume of work. May the Almighty God bless all the students that will use this book with knowledge to encounter all hands-on experiments.….**AMEN**.

We welcome any suggestions for improvement to continue making our service delivery better.

NB: "Search" { lwanga william} on youtube and subscribe (also tap on the notification bell) to that you-tube channel and watch the subject based project lessons that are on-going. " subscription is for free"

Chapter 1: Laboratory Equipment

Throughout this book you will see materials that have been marked with an asterisk (*). These are locally available materials which can be made or purchased for your laboratory. The guide for using and making these local materials are found in the following section.

Beakers

Use: To hold liquids

Materials: Water bottles, juice containers, lids for bottles or jars, and a knife

Procedure: Take empty plastic bottles of different sizes. Cut them in half. The base can be used as a beaker.

Delivery Tube

Use: For the movement and collection of gases, capillary tubes, hydraulic press

Materials: Straws, pen tubes, or pawpaw petioles.

Needles

Use: Compass needles, optical pins, making holes, flying wire

Materials: Office pins, sewing needles, needles from syringes

Droppers

Use: To add small amounts of liquid to something

Materials: 2 ml syringes

Procedure: Take a syringe. Remove the needle.

Funnel

Use: To guide liquid or powder into a small opening

Materials: Empty water bottles

Procedure: Take an empty water bottle and remove the cap. Cut them in half. The upper part of the bottle can be used as a funnel.

Heat Source

Use: Heating substances

Materials: Candles, kerosene stoves, charcoal burners or ethanol gel stoves

Procedure: Cut a metal can in half and add a small amount of ethanol gel

Stopper

Use: To cover the mouth of a bottle, hold a capillary tube

Materials: Rubber, cork, plastic water bottle cap.

Procedure: Cut a circular piece of rubber. If the stopper is being used to hold a capillary tube, a hole can be melted in a plastic cap or rubber stopper.

Water Bath

Use: To heat substances without using a direct flame

Materials: Heat source, water, and a cooking pot

Procedure: Bring water to a boil in a small aluminium pot, then place the test tubes in the water to heat the substance inside the test tube.

Circuit Components

Use: Building simple circuits, Ohm's Law, amplifier, wave rectifiers

Materials: Broken radio, computer, stereo, other electrical devices

Procedure: Remove resistors, capacitors, transistors, diodes, motors, wires, transformers, inductors, rheostats, pulleys, gears, battery holders, switches, speakers and other components from the devices.

Masses

Use: Calibrating and using beam balance and spring balance, Hooke's Law

Materials: Known masses, beam balance, sand, stones, plastic bags, thread, paper, tape, pen

Procedure: Use a beam balance and known masses to measure exact masses of sand or stones. Use a marker pen to mark the masses on the stones. If using sand, place a small piece of plastic bag on the scale pan and fill it with sand until you have the required mass. Tie the sand in the plastic bag with thread. Use paper and tape to make a label on the outside, marking the mass with pen. These masses can be used in your school. Water can also be as a known mass. The density of water is 1.0 g/ml, so you can use a known volume of water in a bottle to create a known mass. Be sure to also account for the mass of the bottle.

Plane Mirror

Use: Laws of Reflection, periscope, water prism

Materials: piece of thin glass, oil lamp with a wick, Optional: small pieces of mirror glass are cheap or free at a glass cutter's shop

Procedure: Light the oil lamp so that it creates a lot of smoke. Pass one side of the glass repeatedly over the oil lamp until that side is totally black. The other side acts as a mirror.

Iron Filings

Use: To map magnetic fields

Materials: Steel wool / Iron wool used for cleaning pots

Procedure: Rub some steel wool between your thumb and fingers. The small pieces that fall are iron filings. Collect them in a matchbox or other container to use again.

Checking Voltmeters and Ammeters/Galvanometers

Needed: Meters to check, a couple of wires, some resistors and a fresh battery.

Important note: There is a wrong way to hook up the meter. The needle will try to detect down because negative and positive are swapped. If the reading is zero, make sure that you try the opposite connection to be sure.

Voltmeters

Hook up the voltmeter across the battery. The battery is probably 1.5 V, but do not worry if you see 1.1, 1.2, even if using a brand new battery. Try not to use a battery that reads much below 1 V on several different meters.

Unusable Voltmeters

- Totally dead, no detection of the needle
- Voltage reading jumps excessively. Ensure that the connections are solid and test again.
- Measured voltage is totally wrong, not close to 1.5 V

Usable Voltmeters

- Read a voltage close to 1.5
- If the voltage if not 1.5 exactly, the voltmeter is probably working and the battery is just old a bit.

Ammeters

Hook up the ammeter in series with a resistor. Because you do not necessarily know the condition of the ammeter before testing, be sure to have several different resistors on hand. An ammeter may appear not to work if resistance is too high or too low. Start testing different ammeters.

Unusable Ammeters

- Totally dead, no detection of the needle
- Current reading jumps excessively (but check connections)
- Totally wrong, reads much different from other ammeters

Usable Ammeters

Reads a current similar to other ammeters.

Hard to say exactly what current, but feel free to calculate based on your resistor using $V=IR$, although do not forget that there is some internal resistance "r" of battery, so $V = I(R + r)$.

The resistance of the resistor is usually coded on the resistor in a series in stripes - see the instructions under Resistors in the Sources of Equipment section.

Tip: You can hold the wires onto the battery with your fingers; the current is far too low to cause a shock.

Other: Now that you have tested to see if your voltmeters and ammeters work, you can feel free to check all of them for accuracy, by calculating expected values and comparing between meters. Most practicals will still work alright with somewhat accurate meters.

Chapter 2 : Physics Experiments Part I

Measurement

Expt 14: Elasticity

Learning Objectives

• To explain the concept of elasticity.

• To demonstrate elasticity.

• To deduce the relationship between the applied force (tension) and the increase in length (extension) from Hooke's law.

Background Information

The force applied to a spring is related to the extension of the spring as it stretches under the force. This is described by Hooke's Law. Provided that the elastic limit of the spring is not exceeded (meaning that the spring is not stretched too much), the extension of a spring or other material is directly proportional to the load or tension force. This is because of its elasticity.

Materials

Rubber band, spring balance*, and sling shot (catapult), metre rule, weights

Hazards and Safety

• When making the small extension of the rubber/spring balance, be careful not to use too much force to avoid breaking the material.

Experiment Procedure

1. Take the rubber band or spiral spring and measure its original length. Record this measurement.

2. Hold the rubber band/spring balance and fix one end while slightly pulling on the other end. Check the increase in length after stretching and record the new length.

Results and Conclusions

There is an increase in length when a force is applied to the rubber band/spring balance. The increase in length of the material when there is an applied tension, along with the return of the body to its original length when the tension is removed, is known as Elasticity. There is a relationship between the amount of force(tension) applied and increase in length(extension). This relationship is stated in Hooke's law.

Clean Up Procedure

After finishing the demonstration, untie the rubber band/spring balance and leave it in the normal state as it was in the beginning.

Discussion Question

Explain why the rope or spring breaks when very high tension (force) is used.

Notes

Everything has an elastic limit where it will break or cease to be elastic. Stretching a spring to far will cause it to exceed its elastic limit and stop working.

Forces

Expt 18: Presence of Gravity

Learning Objectives

• To identify the force of gravity as it acts on falling bodies

• To identify the effect of air resistance on falling bodies

Background Information

All objects on the earth experience a force of attraction exerted by the earth. This is a natural force called Gravity and it acts on all bodies at all times. The force of gravity varies from one point to another; some areas experience stronger gravity than others, but this effect is not noticeable. All objects are pulled by gravity with equal force, regardless of their weights or masses.

Materials

Various objects, a piece of paper, and a book (the book should be the same size or bigger than the paper)

Experiment Procedure

1. Hold the various objects at shoulder height.
2. Drop the objects to the ground one at a time. Repeat this step, but releasing the objects at the same time.
3. Observe if there is any difference in speed as the objects fall to the ground.
4. Hold a piece of paper at shoulder height and then release it.
5. Place a piece of paper on top of a book and hold the book flat at shoulder height.
6. Release the two items together and observe any differences between the motion of the paper by itself and of the paper and book together.

7. Bunch the paper into a tight ball and drop it again.

Results and Conclusions

It will be seen that all objects, with the exception of paper and other light, wide objects, fall at exactly the same rate. This is because the acceleration due to gravity for all objects on earth is the same. The paper, however, falls very slowly. This is not because gravity pulls less on paper; it is because the paper is more affected by air resistance. All objects are affected by air resistance, but it is most obvious with objects that have a small weight but a large surface area. The effects of air resistance can be greatly reduced by placing a book under the paper. The book moves easily through air and blocks all of the air which would normally push against the paper. This is why the paper and book fall at the same rate. When the paper is bunched into a ball, the mass stays the same but the air resistance is greatly reduced so it should fall at the same rate as the book.

Clean Up Procedure

Collect all materials and return them to their proper place.

Discussion Questions

1. Did the objects fall at the same rate or at different rates?
2. Why did the paper fall slowly the first time?
3. Why did the paper fall quickly when it was placed on top of the book?
4. Why did the paper fall quickly when it was bunched into a tight ball?
5. What force is pulling all objects down? Does this force ever change?

Notes

When performing this experiment, it is important to remember the effect of air resistance. Gravity pulls equally on all bodies, but air resistance opposes the motion of light-weight objects more effectively than heavy-weight objects.

Expt 25: Air Pressure

Learning Objectives

• To observe the effects of air pressure on a flexible material

Background Information

Air in a container pushes out with equal force on all sides of the container. If the pressure in the container is low, the force is small; if the pressure is high, the force is large. If the pressure is high, it is difficult to bend or crush the container as the air pressure inside resists being pushed. If the pressure is high enough, it can cause a flexible container to be rigid.

Materials

Plastic straw, potato

Experiment Procedure

1. Hold a straw and push it hard into the potato.
2. Observe what happens to the straw.
3. Place your thumb firmly over one end of a straw and push the other end into the potato.
4. Observe what happens to the straw and potato.

Cleanup Procedure

Dispose of the potato and return the straw to its proper place.

Discussion Questions

1. Why does the straw not pierce the potato when your thumb is not blocking the back of the straw?
2. Why does the straw pierce the potato when your thumb is blocking the potato?

Results and Conclusions

When the straw is pushed into the potato, it bends. The skin of the potato is strong enough that the straw cannot pass through it. However, when your thumb covers the back of the straw, the straw breaks the skin of the potato and passes through. This is because the air in the straw pushes out against the sides of the straw. Without your thumb, the air can simply escape out the back of the straw without applying a force. When your thumb covers the hole, the air cannot go anywhere so it applies a force outward. This causes the side of the straw to become rigid, allowing it to break the skin of the potato.

Notes

Be sure that, in the first step, you are not holding your thumb over the back of the straw. This should only be done later.

Newton's Laws and Forces

Expt 40: Inertia and Newton's First Law of Motion

Learning Objectives

• To understand the concept of inertia

• To demonstrate Newton's First Law (the Law of Inertia)

Background Information

Newton's first law, also called the Law of Inertia, states that "an object in motion will continue in that motion, and an object at rest will remain at rest unless acted upon by an external force". This simply means that an object will continue doing what it is doing and will resist any changes. The inside of a fresh egg is liquid while the inside of a boiled egg is solid. Therefore, if you change the motion of the shell of a fresh egg, the liquid inside will resist the change and continue with whatever motion it had. If you change the motion of a boiled egg shell, the inside of the egg will follow the same motion as the shell.

Materials

1 fresh egg and 1 boiled egg

Experiment Procedure

1. Place both eggs on the table and note that it is impossible to tell which egg is fresh and which egg is boiled.
2. Spin the first egg.
3. While the egg is spinning, stop it briefly with your hand and then release the egg. Record any observations.
4. Spin the second egg.
5. While the egg is spinning, stop it briefly with your hand and then release the egg. Record any observations.

Results and Conclusions

The fresh egg, which is liquid inside, will continue spinning even after its rotation is stopped briefly by your hand. The boiled egg, which is solid inside, will stop spinning after its rotation is stopped briefly by your hand. The fresh egg continues spinning because the liquid inside continues to spin and causes the shell to move with it. However, the boiled egg stops spinning because the solid inside has stopped moving and thus will remain stationary.

Discussion Questions

1. Which egg is fresh and which egg is boiled?

2. Why does the boiled egg stop completely when your hand releases it while the fresh egg continues spinning?
3. Explain the motion of the eggs in terms of inertia.

Expt 41: Conservation of Linear Momentum

Learning Objectives

• To demonstrate the principle of conservation of linear momentum

Background Information

Everything has momentum which depends on its mass and velocity.

$$\text{momentum} = \text{mass} \times \text{velocity}$$

The momentum of an individual body can change as its velocity or mass changes. However, if two objects collide, the total momentum of the objects is conserved. This means that the total momentum of the objects before the collision is equal to their total momentum after the collision.

Materials

Toy car with motor, plane surface or smooth table, metre rule or tape measure, beam balance*, different sized stones, and stop watch

Preparation Procedure

1. Measure the masses of different stones on the beam balance.
2. Measure the mass of the toy car.
3. Measure a distance of 2 m on the plane surface or table.
4. Make a mark at 0 m and place an obstacle at 2 m.

Experiment Procedure

1. Place the toy car at the 0 m mark on the table.
2. Release the car and start your stop watch.
3. Record the time it takes for the car to move from the 0 m mark to the obstacle at the 2 m mark.
4. Use this time and distance to calculate the average velocity of the car.
5. Place a stone on top of the toy car (use tape or string if necessary in order to secure it).
6. Measure the new mass of the car with the stone on top.
7. Start the car and release it on the table at the 0 m mark.
8. Again, measure the time it takes for the car to reach the obstacle at the 2 m mark.
9. Calculate the average velocity of the car and stone.

10. Repeat these steps for various stones, measuring the masses and average velocities for each case.
11. For each case, calculate the momentum of the car and stone.
12. Record your results in a table. Fill in values for mass, time, velocity and momentum.
13. Compare the values for momentum.

Results and Conclusions

The momentum for each experiment is almost the same. As the mass increases, the velocity decreases. However, the product of the two remains the same. However, the momentum decreases slightly more than expected with increased mass because friction on the axles of the car is also increased. When two bodies, one heavy and one light, are acted upon by the same force for the same amount of time, the lighter object's velocity increases more than that of the heavy object. However, the momentum that each gains is the same.

Clean Up Procedure

Return all materials to their proper places.

Discussion Questions

1. What factors affect the momentum of the car?
2. When the mass of the car is increased by adding stones, what happens to the average velocity?
3. What do you observe when comparing the values for momentum?

Notes

Conservation of momentum is only true in a frictionless environment. However, the effects can be seen clearly even if friction is present. The toy car has friction between its wheels and axles, so adding mass to the car will increase the effect of friction. However, it will still be seen that the momentum is relatively equal for each mass.

Expt 53: Measuring Refractive Index of Glass

Learning Objectives

• To explain the refraction of a light ray from one medium to another

• To show the refraction of a ray of light at different angles

• To apply Snell's Law to find the refractive index of a medium by measuring incident and refracted angles

• To see the effect of refraction on an image

Background Information

Light bends as it moves from one medium to another. When moving from a medium of low density to one of high density, a ray of light will bend inward towards the normal;when Moving out again from the medium of high density to the medium of low density, the light ray will bend outward away from the normal.

Refracted light obeys Snell's Law, which states that $n_1 \times \sin i = n_2 \times \sin r$ where n_1 is the refractive index of the first medium, i is the incident angle of the light, n_2 is the refractive index of the second medium and r is the refracted angle of the light in the second medium. Because we know the refractive index of air, and we can measure the angles of incidence and refraction with a protractor, we can calculate the refractive index of any material.

Materials

Protractor from a mathematical set, pen, 30 cm square piece of thick cardboard from a box, piece of white paper, four-figure or calculator, tape or glue, 4 pins or syringe needles, rectangular glass block at least 6 mm thick from a glass shop (the glass block does not need to be large: 8 cm × 10 cm is easily enough). Often the glass block can be found for free, just make sure that the edges are even and that you can see through the block by looking through the edges.

Hazards and Safety

• Be careful when using the glass. If you are using a local glass block from a glass cutter, the edges may be sharp enough to cut skin.

• If using syringe needles, use pliers or a hammer to bend the end of the needles so that they may not be used for any other purpose.

Preparation Procedure

1. Collect all of the materials on a table.
2. Tape or glue the white paper to the cardboard and cut the paper so that it is the same size as the cardboard.

Experiment Procedure

1. Place the cardboard flat on the table with the paper-side up.
2. Place the glass block in the center of the paper and trace it with a pen.
3. Remove the block from the paper; you should see its outline clearly from the pen.
4. Use a protractor to draw a line perpendicular (90°) near the center of one of the long sides of the glass block outline.
5. Extend this line through both sides of the glass block so that on the paper you should have a picture of a rectangle with a line through its center.
6. Where the line intersects one of the long sides of the rectangle, make a mark and label it *O*.
7. From the point *O*, draw a line outward at an angle of 10 degrees to the normal. Use a protractor to do this.
8. Repeat this step to draw lines at angles of 20° , 30° , 40° and 50° to the normal, all converging on the point *O*.
9. Replace the glass block in its outline on the paper.
10. Place two pins or needles on the line for the incident light at 10°. Place one of the pins close to the glass block and the other as far away as possible on the 10 degree line. The pins should stick upright easily in the cardboard
11. From the opposite side of the glass block, look through the block so that you can see the two pins on the other side through the block (do not look over the block).
12. Close one eye and move left or right until the two pins you see through the block are perfectly aligned so that they look like one pin.
13. On this side of the glass block, place another pin close to the block so that all three pins are aligned.
14. Repeat this step with a fourth pin closer to your eye.
15. Make sure that, as you look through the glass block, all four pins are aligned perfectly.
16. Remove the pins on this side of the block and mark their positions (the holes in the paper) with a pen.
17. Use the straight edge of the protractor to trace a line through the two points to the edge of the glass block.
18. Mark this line as 10 degrees.
19. Repeat steps 10 through 18 for the incident rays of 20, 30, 40 and 50 degrees. At the end you should have five lines coming from your side of the glass block at different points,

each labeled with a different angle. These lines should be diverging from one another.
20. Remove the glass block from the paper.
21. Using the straight edge of the protractor, trace a line from *O* to the point on the edge where the ray labeled “10 degrees” emerges.
22. Repeat this step for each line so that you have five lines inside the glass block outline, each connecting point *O* with one of the lines emerging from the block. These lines inside the block are the refracted rays corresponding to each of the incident rays (10, 20, 30, 40 and 50 degrees).
23. Use the protractor to measure the angle between the normal inside the block and the first refracted ray.
24. On a separate piece of paper, record the incident angle (10°) and the corresponding refracted angle (which should be around 7° , though this will change depending on the material you are using).
25. Repeat these steps for the incident angles of 20, 30, 40 and 50 degrees and their respective refracted angles.
26. Record these results in a table showing each incident angle and its respective refracted angle.
27. Use a four-figure or calculator to find the Sine of each of these angles and record these in your table as well.
28. Use a ruler to make a graph of sin *r* against sin *i*. The x-axis (horizontal axis) should contain the values for the Sine of the incident angles, and the y-axis (vertical axis) should contain the values for the Sine of the refracted angles.
29. Mark each of the five data points on the graph using your table of values for sin *i* and sin *r*.
30. Use a ruler or other straight edge to draw a straight line through the five points. Extend this line back through the y-axis (the axis containing values of sin *r*).
31. Calculate the slope of this line by using:

$$\text{slope} = \frac{\text{change in y}}{\text{change in x}}$$

32. Calculate the refractive index of glass by using:

$$\text{refractive index} = \frac{1}{\text{slope}}$$

Results and Conclusions

It will be observed that the angle of a ray of light changes when moving from one medium to another. An object seen through two or more media appears to be in a different place than where it actually is. We can measure the angles of incidence and refraction, then use Snell's Law to find refractive index.

Clean Up Procedure

Return all supplies to their proper places making sure that the glass block is in a safe place where it will not break.

Discussion Questions

1. Why does light bend when moving from one medium to another?
2. In what direction does light bend when moving from a low-density medium to a high-density medium?
3. In what direction does light bend when moving from a high-density medium to a low-density medium?
4. What other materials could you use to measure refractive index instead of the glass block?
5. Why is it better to repeat the experiment for many angles of incidence instead of just one angle?
6. On the graph, what is the y-intercept? Why?

Notes

This activity is very simple to perform but requires some practice, especially when trying to align all of the pins. Make sure that you can do the entire activity easily before you do it with students. Any material may be used; the glass block is only one option. Stained glass, water and plastic also work well. This activity appears often as a practical on the exams, so you can repeat it many times with students so that they know it very well.

Contact Lwanga Books Ltd on +256750549201 or +256771803014 to get a complete copy for your self. You can also email on lwangawilliam11gmail.com

OR : You can also visit Lwanga Books Ltd for more business, thank you.

NB: The complete copy consists of *eighty six* hands-on physics experiments in which a learner has to workout using locally available materials. This new ordinary level physics practical work book was written in line with the physics special book for new ordinary level curriculum(learner's Research Book) by the same company.

- **Excel In Ordinary Level Mathematics(S.4 2023)**
- **S.1-S.2 Physics Project Work Book**
- **S.1-S.4 Physics Project Work Book**
- **S.1-S.4 Mathematics Project Work Book**
- **S.1-S.4 Chemistry Project Work Book**
- **S.1-S.4 Biology Project Work Book**
- **S.1-S.4 Geography Project Work Book**
- **S.1-S.4 ICT Project Work Book**
- **S1-S4 History Project Work Book**
- **S.1-S.4 Agriculture Project Work Book**
- **S.1-S.4 C.R.E Project Work Book**
- **S.1-S.4 Entrepreneurship Project Work Book**
- **S.1-S.4 New Ordinary Level Physics Practical Work Book**
- **S.1-S.4 Physics Learner's Research Book(Detailed)**
- **S.1-S.4 Biology Learner's Research Book(Detailed)**
- **S.1-S.4 Mathematics Learner's Research Book(Detailed)**
- **S.1-S.4 Chemistry Learner's Research Book(Detailed)**

Books by the same company

❖ **All New Ordinary Level Practical Work Books are available that is; Physics, Biology and Chemistry.**

NB: "Search" {lwanga william} on youtube and subscribe (also tap on the notification bell) to that you-tube channel and watch the subject based project lessons that are on-going. " subscription is for free"

END