ABOUT THE AUTHOR

Mr. Ocaka Godfrey is a dedicated and passionate educator with a Bachelor's degree in science education (physical) from Gulu University. With a wealth of teaching experience in various schools across the country, he has honed his expertise in physics and mathematics. Currently, he teaches at St. Andrew's College, Moyo, where he continues to inspire and nurture young minds.

His passion for physics and desire to share his knowledge with others, drove him to write this book. He aims to make physics accessible and enjoyable for all, believing that every student can develop a deep understanding and appreciation of the subject.

About the Book

"First-Step Competence-Based Physics Practical Guide and Workbook" is a comprehensive resource designed to support students and teachers in the pursuit of experimental physics. This book is a testament to the author's love and desire for the subject, aiming to make physics accessible and engaging for all.

This practical guide and workbook is tailored to meet the needs of students and teachers seeking a competence-based approach to physics education. The book covers a range of topics, providing clear explanations, practical exercises, and activities to reinforce understanding. With a focus on hands-on learning, the book enables students to develop essential skills and competencies in physics.

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1st Step books
Step into Knowledge

FIRST-STEP COMPETENCE BASED PHYSICS PRACTICAL WORKBOOK

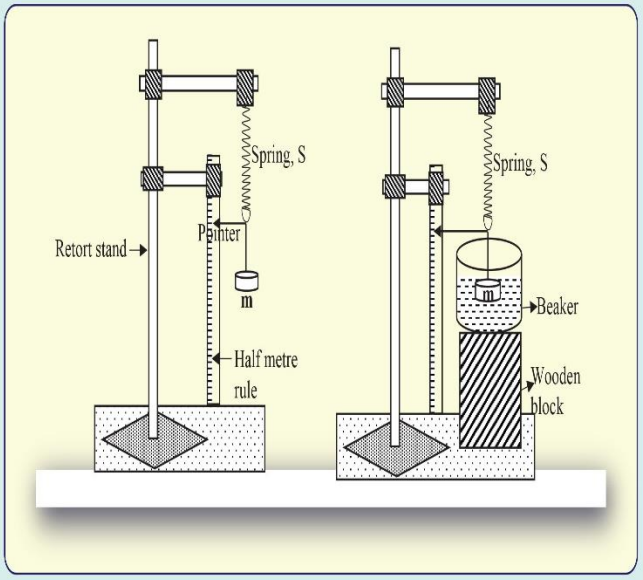
Ocaka Godfrey

FIRST-STEP COMPETENCE BASED

New Lower Secondary Curriculum

PHYSICS

PRACTICAL BOOK



(Guide & Workbook)

Ocaka Godfrey

FIRST-STEP COMPETENCE BASED

New Lower Secondary Curriculum

PHYSICS

PRACTICAL BOOK

(Guide & Workbook)

EDITION 2024

This book entails;

- ✓ Approach to experimental set items
- ✓ Making a good physics experimental report.
- ✓ Data presentation and analysis
- ✓ Sample questions with worked solutions
- ✓ Varieties of questions with workspace for learners.
- ✓ Evaluation score guide for teachers

By

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CONTENT

PREFACE

With the growing societal problems that require scientific approach in solving, there is need of educating learners who have ideas of using scientific knowledge and understanding to solve it. This has been deemed to by setting experimental science in order to apply the conceptual knowledge and understanding of leaners to solve the problems. Therefore, learners are to be assessed whether they can apply the knowledge and understandings they learnt in theory in a practical manna. This book has been designed to prepare learners and teachers on proper ways of handling competence based scientific investigation to solve the rising societal need.

One of the standout features of this book is its comprehensive guidance on conducting physics practical experiments and composing detailed reports in line with new lower secondary curriculum and UNEB. By demystifying the intricacies of experimental procedures and report writing, it empowers learners to navigate the practical aspects of physics with ease and precision. Through hands-on exploration and meticulous documentation, learners are equipped to deepen their understanding of scientific inquiry.

The book contains well developed, researched and formulated competence-based experiments which is very simple for learners to understand. The scenarios are developed from real life problems/challenges we face, which make this book not just a tool for preparation of end of cycle assessment, but a tool for developing learners who can apply science in practical environment.

It also helps learners in interpretation of scenarios and formulation of good physics practical report. This equip learners with skills of handling physics apparatus, presentation of data, manipulation of data and analysis.

ACKNOWLEDGEMENT

I would like to express my deepest gratitude to the Almighty God for granting me the strength and guidance throughout the journey of creating this "Physics Practical guide and workbook." Your divine blessings have been instrumental in every step of this endeavour.

I extend my heartfelt appreciation to Mr. Mawa Patrick, the Principal of St. Andrew's College – Moyo for the unwavering support and encouragement provided during the development of this book. Your leadership and vision have been a constant source of inspiration.

I am thankful to Mr. Buga Biajo, a senior physics teacher and facilitator in Physics Paper 2 & 3, for his meticulous review and approval of the book.

A special thank you to Mr Ochela Simon Peter, the Head of Physics and Science Department St. Andrew's College-Moyo, for your invaluable insights, feedback, and guidance that have enhanced the quality of this workbook. Your expertise and mentorship have been truly invaluable.

I am grateful to my dedicated colleagues in the Physics Department, Mr. Viga Rolex and Mr. Ocan George for their collaboration, support, and camaraderie. Your contributions have enriched this work and made it a success.

I would like to acknowledge the entire staff of St. Andrew's College - Moyo for creating a conducive environment that nurtures learning and growth. Your dedication to education is truly commendable.

To my beloved wife, thank you for your unwavering love, understanding, and patience throughout this journey. Your support has been my rock, and I am deeply grateful for everything.

A heartfelt thank you goes out to my parents for instilling in me a love for learning and the pursuit of knowledge. Your encouragement and belief in me have been the driving force behind this accomplishment.

I am grateful to all my friends for their constant support, encouragement, and belief in my abilities. Your friendship has been a source of strength and inspiration.

Lastly, to everyone who has played a part, big or small, in the creation of this book, I offer my sincere appreciation. Your contributions have not gone unnoticed, and I am truly grateful for your support.

Thank you all for being a part of this journey and for making this book a reality.

With heartfelt thanks.

1.0 INTRODUCTION

Physics practical is designed to assess on the learners' knowledge and understanding of the theoretical concepts. The lower competence-based curriculum assesses whether learners can analyse, explain and apply the knowledge in practical manner. Scientific investigation is therefore used to assess the learners on their understanding of the theoretical concepts.

In this book we shall look at how learners can connect what they learned in theory to answer societal problems. The societal problems are designed in scenario based to allow learners to think and generate their own procedures, present data, carry out data analysis and conclusion on a given set item.

The book also gives pre-requisite overview of the common apparatus used in carrying out scientific investigations. Sample questions and their solutions are also presented in this book to help learners in guiding them on how to deal with scenario-based experiments. This also will help teachers in facilitating the practical sessions to achieve the desired outcome.

The scenarios are well presented, simple and easy for learners to understand that learners can easily generate their own ideas on how to answer the items.

2.0 PHYSICS SCENARIO BASED EXPERIMENTS

According to Lower Secondary Competence Based Curriculum, physics paper two is designed with set items in scenario based. The experimental questions give room to learners to think, analyse and carryout scientific investigation using their own procedures to arrive at the solution.

The scenario based experimental questions comprise of the following attributes;

- ✓ The question is generated from real life problems/challenges that require solution.
- ✓ It consists of the set value to enable learner arrive to it. It can be quantitative or qualitative

3.0 SCIENTIFIC INVESTIGATION

A scientific investigation is a process of finding the answer to a question using various methods. An investigation usually begins with observation then development of an experiment to test hypothesis, collection and analysis of data.

There are various methods of carrying out scientific investigation, but here we shall only use experimental method which involves developing hypothesis to determine the relationship between independent and dependent variable.

While carrying out scientific investigation, a learner should take into consideration of the following;

- ✓ Observation; this helps a learner to understand the context of problem and think of what should be done to solve it.
- ✓ Ask question of what, how and why to narrow the focus of experiment.

- ✓ Create hypothesis to predict the end product of the experiment.
- ✓ Conduct experiment; involves collection and presentation of data.
- ✓ Analyse the results, a student can accept or deny the hypothesis in accordance to result.
- ✓ Conclusion can then be made.

4.0 PRESENTATION OF SCIENTIFIC INVESTIGATION REPORT

After carrying out a scientific investigation, there is a need to present the report of what transpired from the word go to the conclusion of the experiments. Below are what to be considered in presentation of scientific investigation report;

(i) Aim
(ii) Hypothesis
(iii) Variables
- ✓ Independent
- ✓ Dependent
- ✓ Controlled

(iv) List of apparatus
(v) Experimental set up
(vi) Procedures
(vii) Presentation of data
(viii) Data analysis and interpretation
(ix) Possible sources of errors and precautionary measures
(x) Advice if any

4.1 Aim

The aim of the experiment is derived from the task in the scenario. It indicates the purpose with reason of carrying out the investigation. For example; to determine the mass of a uniform metre rule to be used in carrying out physics experiment.

4.2 Hypothesis

This is a possible answer to a question. It is based on observations, theories and information gathered from other sources. It is an educated guess as to what will happen during the experiment. For example, mass of a uniform metre rule is about 100g, density of pure water is about $0.998gcm^{-1}$ etc.

It should be stated with the reason of investigation. For example, the force constant of the spring provided is between 20-40Nm^{-1} to be used in replacing the damaged spring in spring balance.

9.0 DATA ANALYSIS AND INTERPRETATION

9.1 GRAPH WORK

There are very many ways we can present, analyse and interpret data when carrying out scientific investigations. But we shall use the one that has been widely used in the subject of physics. Therefore, we shall use line graph to present and analyse data.

The following will be highly considered when dealing with graph work and must be taken into account by whoever is using line graph in physics experiments.

9.1.1 Title

- The title of graph must be clearly written at the top of graph paper.
- It should be written in one line.
- It should contain the variables in vertical axis versus horizontal axis.

e.g. A graph of v against u, A graph of T^2 against l.

- No unit should included in the title

9.1.2 Axes

- The axes must be drawn perpendicular to each other.
- There should be arrows at the end of each axis.
- The axes must be well labelled with quantities and their units in a closed round brackets. E.g. $T^2(s^2)$, l(m)
- The quantities and units should be written in their symbols not their whole name. e.g. l(m) not length(metres).
- Each axis must be clearly marked at an interval of 2 cm from the origin.

9.1.3 Scales

The scales used must be taken from convenient scales. Convenient scales are, 1, 2,2.5 and 5 with all their multiples and sub-multiples.

Below are some of the convenient scales;

Sub-multiples ↑	0.001	0.002	0.0025	0.005
	0.01	0.02	0.025	0.05
	0.1	0.2	0.25	0.5
scales	**1**	**2**	**2.5**	**5.0**
multiples ↓	10	20	25	50
	100	200	250	500
	1000	2000	2500	5000

Determining a convenient scale

Scales can be determined by calculating the range, i.e. the larger value minus the smaller value and dividing it by the number of squares to be used.

$$\textbf{Vertical scale} = \frac{\text{larger value} - \text{smaller value}}{\text{number of 2cm sq used}} = \frac{\text{larger value} - \text{smaller value}}{10}$$

$$\textbf{Horizontal scale} = \frac{\text{larger value} - \text{smaller value}}{\text{number of 2cm sq used}} = \frac{\text{larger value} - \text{smaller value}}{8}$$

After calculating the scale, then it is compared to the convenient scales, or their multiples and sub-multiples.

Intercepts

When intercepts are required on both axes, the starting points on both axes **must** be zero (0). And the scale will be calculated as below.

Vertical scale = $\frac{\text{larger value}-0}{\text{number of 2cm sq used}} = \frac{\text{larger value}-0}{10}$

Horizontal scale = $\frac{\text{larger value}-0}{\text{number of 2cm sq used}} = \frac{\text{larger value}-0}{8}$

However, when the intercept is required only on vertical axis, the starting point on horizontal axis **must** be zero and when the intercept is required only on horizontal axis, the starting point on vertical axis **must** be zero

Example

Find a convenient scale for a graph of $\mathbf{T^2}$ against $\boldsymbol{l}$ below

$\boldsymbol{l}$**(m)**	**t (s)**	**T(s)**	$\mathbf{T^2(s^2)}$
0.100	46.5	2.35	5.52
0.200	44.0	2.20	4.84
0.300	42.0	2.10	4.41
0.400	39.5	1.98	3.92
0.500	37.0	1.85	3.42
0.600	35.5	1.78	3.17
0.700	33.0	1.65	2.72

Vertical scale = $\frac{5.52-2.72}{10} = 0.28$

Since 0.28 lies between 0.25 and 0.50 convenient scales. We shall consider the greater value which is 0.50

our convenient scale in the vertical axis will be;

2 cm square represent $0.50s^2$

Horizontal scale = $\frac{0.700-0.100}{8} = 0.075$

0.075 lies between 0.05 and 0.10 convenient scales. We shall consider the greater value which is 0.1.

The convenient scale in the horizontal axis will be;

2 cm square represent 0.100 m

Choosing a starting value

If the intercept may not be required, the starting value may not be from zero. However, if the smallest value in the column is close to zero, starting point may be from zero.

If the smallest value is not close to zero, start from a convenient value which is smaller than and a distant from the smallest value from the required column. The starting point should be a multiple of the scale used in the respective axis.

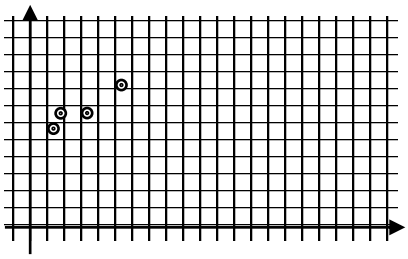
For instance, in the above example, in the horizontal axis, the starting value will be zero since 0.100 is close to 0 in relation to other continuing values in the column.

For vertical axis, we shall check for the multiples of our scale from 0 to the first smallest value in the column.

The multiples are 0.0, 0.50, 1.00, 1.50, 2.00, 2.50……., since 2.00 is below and a distance to 2.72 which is the smallest value in the column, therefore our starting point will be 2.00.

9.1.4 Plotting

- Points should be correctly plotted with a dot enclosed with a ring, ⊙**not** a cross × or ⊗
- When plotting, the circle should cut half of the 1 cm square all sides. Below are how



points are plotted at different positions.

How to find a plotting point

A simplest way of finding a plotting point is locating where it is found in the graph. It is located by calculating numbers of small squares from the starting point to where the point lies.

$$\text{Number of small squares} = \frac{\text{value to be plotted} - \text{starting value}}{\text{value of small squares}}$$

The number of small squares will be counted from the starting point to where it stops. This is a point where the value will be plotted.

Finding line of best fit

Line of best fit is a straight line that is drawn to pass through most of the lines in a graph. Its however drawn depending on one's judgement.

If the graph is a line graph, it should leave equal numbers of points on both sides.

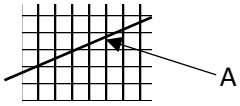
If the points are scattered, then the line is drawn to divide the points into two.

Examples

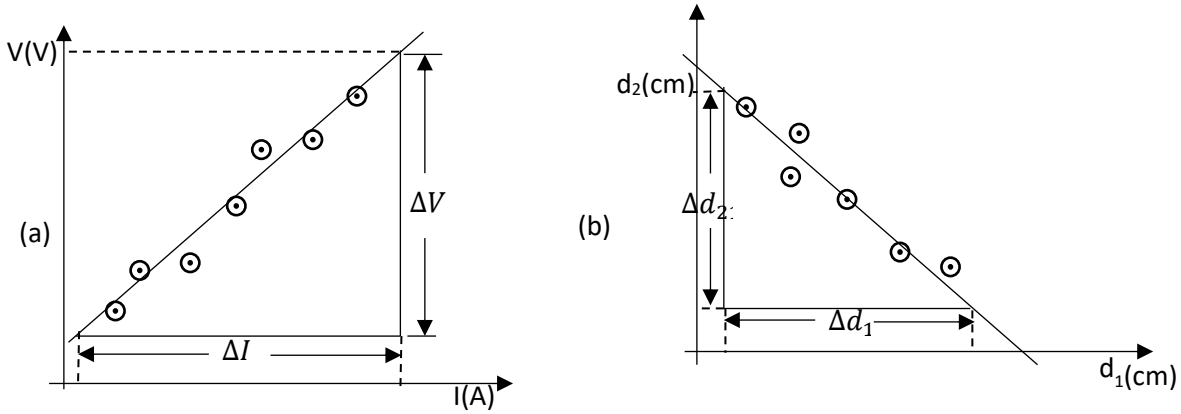
9.1.5 Slope of the graph/gradient

Slope is calculated by drawing a right-angled triangle enclosing all the points and determining two points with coordinates.
The right-angled triangle should be at least half of the graph paper.
Points touched by the right-angled triangle on line of best fit should be at the meeting point of the horizontal and vertical lines.

For example, point A



The right angled triangle should be drawn as below,



A graph (a) has a positive slope and graph (b) has a negative slope.
Slope of a graph is calculated from a formula below;

$$\text{Slope, S} = \frac{change\ in\ vertical\ axis}{change\ in\ horizontal\ axis}$$

For example for graph (a) above,

$$\text{Slope, S} = \frac{change\ in\ V}{change\ in\ I}$$

$$\text{S} = \frac{V_2 - V_1}{I_2 - I_1}$$

The unit of calculated slope is derived from the units of quantities on both axes. For graph (a) above, $S = \frac{(V_2 - V_1)(V)}{(I_2 - I_1)(A)}$, the unit will be VA^{-1} and for graph (b), $S = \frac{\Delta d_2(cm)}{\Delta d_1(cm)}$, the units will cancels out and the slope will be without unit.

SAMPLE QUESTIONS WITH SOLUTIONS

Item 1 (UNEB SAMPLE)

In a certain trading centre, empty mineral water bottles were littered everywhere causing blockage of trenches and other environmental hazards. A trader came to the trading centre with the intention of buying empty water bottles of mass 15 g each. A student had gathered a pile of 20000 empty identical mineral water bottles (500 ml each) but was not sure about the mass of each bottle. There was no instrument to determine the mass of the bottles and the student did not know the amount of money to be earned from the sale of the bottles.

Task:

As a student of physics, carry out a scientific investigation to help the student determine the mass of an identical empty bottle provided to you in order to ascertain how much the student will earn. The trader pays UGX.400 per kilogram of such bottles.

SOLUTION

Aim

To determine the mass of the empty bottle provided in order to ascertain how much the student will earn.

Hypothesis

The mass of the bottle provided is between (10 – 20) g in order to ascertain how much the student will earn.

Variables

Independent – Distance, $\mathbf{d_1}$ from the pivot to the 20g mass

Dependent – Distance, $\mathbf{d_2}$ from the pivot to the empty bottle

Controlled - Balanced position of the metre rule on the knife edge.

Possible sources of errors and precautionary measurers

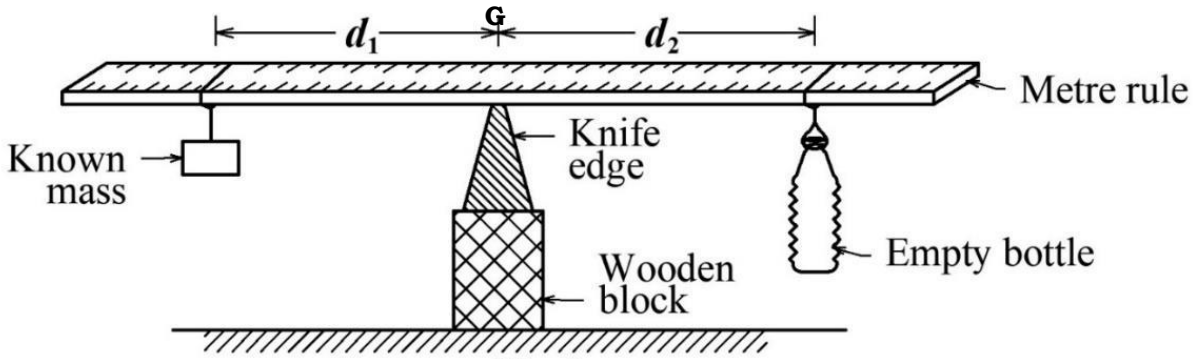
Parallax errors mitigated by taking reading at right angle from an instrument.

Air resistance / wind mitigated by shielding the experiment from wind.

List of Apparatus

Wooden block, Knife Edge, Metre rule, 2 pieces of thread, Empty bottle and 20g mass

Experimental set up



Procedures

a) The metre rule is balanced on a knife edge and the point of balance noted and recorded, G.
b) A known mass, m is suspended from one end of the metre rule at a known distance $d_1 = 5.0$ cm from the G.
c) The bottle whose mass is required is suspended from the other end of the metre rule and its position from G is adjusted until the metre rule balances again.
d) The distance d_2 of the bottle from G is recorded.
e) The procedure (b) to (d) is repeated for values of $d_1 = 10.0, 15.0, 20.0, 25.0$ and 30.0 cm.
f) The results are tabulated in a suitable table.
g) A graph of d_2 against d_1 is plotted and the slope, S of the graph determined.
h) The mass, M_b of the empty bottle is then determined from $M_b = M \times S$.

Presentation of data

The balanced point of the metre rule, $G = 50.1$ cm

Table of results

d_1(cm)	d_2(cm)
5.0	6.6
10.0	13.7
15.0	20.6
20.0	25.8
25.0	33.7
30.0	41.0

Data analysis

From the graph;

Slope, S = $\frac{\Delta d_2(cm)}{\Delta d_1(cm)} = \frac{(31.0-4.0)}{(42.0-5.5)} = 0.74$

If known mass, M = 20g,

Mass of the bottle, M_b is calculated from,

$M_b = M \times S$

$M_b = 20 \times 0.74 = 14.8$g

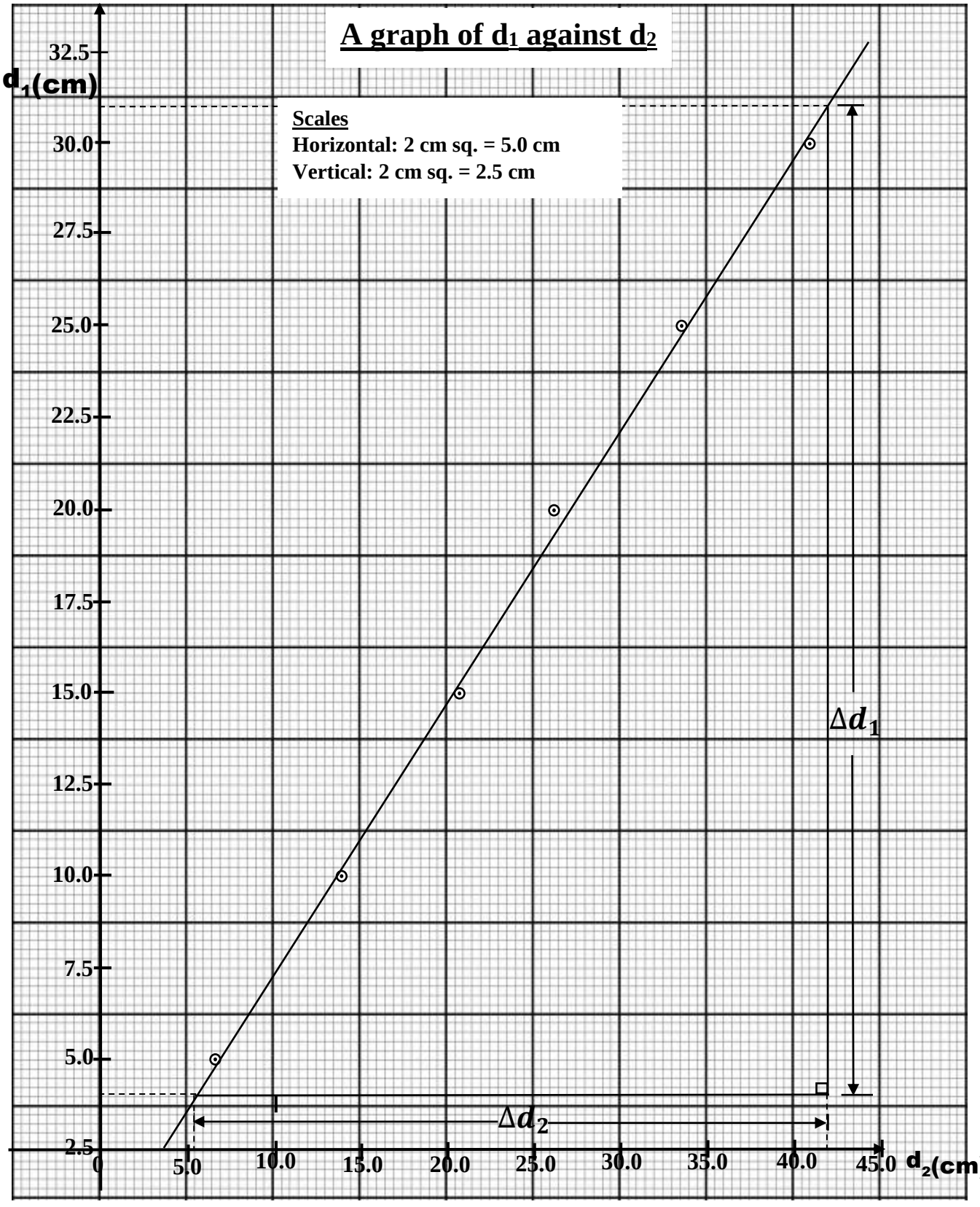
Conclusion with Advice

The experimental result lies between the predicted value, therefore, mass, M_b of a 500ml bottle is 14.8g

Since the student collected 20000 empty bottles of identical sizes, therefore, total mass can be got from, $20000 \times M_b = 20000 \times 14.8\text{g} = 296000\text{g} = 296\text{kg}$

If the trader will pay UGX. 400 per kilogram,

Then the amount earn by the student is got from, 296×400 = UGX. 118,200



OTHER SAMPLE QUESTIONS IN THE FULL BOOK

BASES OF ASSESSMENT FOR TEACHERS

CONSTRUCT: Appreciates physics in everyday life

Element of construct: Conducts scientific investigation in physics

FULL BASES OF ASSESSMENT FOR TEACHERS IN FULL BOOK

PART I

MECHANICS SCENARIO BASED EXPERIMENTS

ITEM 14:

A trader who trade in produce in a village uses a spring balance whose force constant ranges from $1200Nm^{-1}$ to $1300Nm^{-1}$ for determining weight of items bought from farmers. However, one day a farmer overloaded the spring balance and the spring got damaged. Unfortunately, he was unable to find the new spring with such a specification.

Task

As a learner of physics, advise the trader whether he can use the available springs in the laboratory to replace the damaged spring in the spring balance.

PART II

LIGHT SCENARIO BASED EXPERIMENTS

ITEM 20:

Dembe construction company is looking for a supplier of glasses to be used in windows of a building. They want a supplier who can supply a quality glasses of refractive indices ranging between 1.4 to 1.6. Kipara and Sons company is a new company who wants to be contracted to supply the glasses. Unfortunately, they lack the knowledge of determining a quality glass as indicated by Dembe construction company.

Task

Being a learner of physics, how best can you help Kipara and Sons company wins the contract of suppling glasses to Dembe construction company.

PART III

ELECTRICITY SCENARIO BASED EXPERIMENTS

ITEM 37:

A box of dry cells rated (1.5V,1.0Ω) each which was stored in the laboratory went missing at the beginning of third term. The laboratory assistant claimed that students of certain class might have stolen it. But in preparation of end of year examinations, he noticed that the box of dry cells was hidden under other apparatus. He then contacted head of physics department to inquire whether the dry cells can be used for physics practical in the end of year's examinations. The head of department said that dry cells lose their e.m.f whenever they are not stored well due to rise in their internal resistances. Therefore, there is need to check on their rating before using these dry cells for physics practical. He then selected a group of learners from certain class to verify whether the dry cells are still within their ratings.

Task

Being among the learners selected, carryout scientific investigation to ascertain the ratings of these dry cells.

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