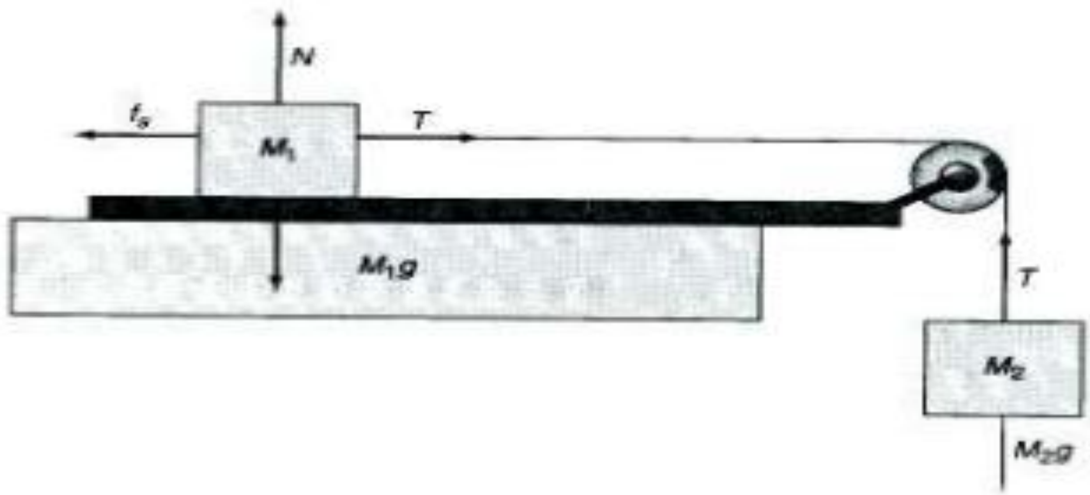
KAPASA MAKASA UNIVERSITY

SCHOOL OF AGRICULTURAL AND AQUATIC SCIENCES

PHYSICS DEPARTMENT



PH110 LABORATORY MANUAL 2024

Physics Lab Report Format

An excellent lab report shows the writer's understanding of the ideas behind the data in addition to just presenting the data. This booklet contains 15 experiments that you will carry out in groups but you will write reports individually. The cover of your reports should contain the following;

- Experiment Title and Number
- Your name
- Your Group details (in font 18)
- Your Id #
- Lab partners or group members

❑ TITLE

- The **title** should be brief and describe the main point of the experiment.
- Even better if you can come up with a catchy one — scientists love a good pun!
- If your instructor asks for a **title page**, this is usually a cover page that states: the title of your report, your name/lab partners, instructor's name, class section, and date.

ABSTRACT

- The **abstract** should be a brief (one-paragraph) overview of what is in the report.
- It should summarize the purpose of the experiment, your hypothesis, methods, key findings, significance, and conclusions.
- The goal is to get your reader interested in the work enough to keep reading!

This section can be challenging to write and is best saved for last.

❑ INTRODUCTION

The **introduction** should state:

- The purpose of the experiment,
- relevant background/previous research on the subject
- the hypothesis
- the reasons you believe the hypothesis is feasible.

Include in-text citations as appropriate.

Note that:

- Details about the experiment should be written in past tense, since it has already been finished.
- Theory, however, should be written in present tense. Always write this part in your own words, rather than quoting or paraphrasing references.

This section should set the scene for what's to follow

❑ MATERIALS & METHODS

In the **materials and methods**:

- you want to describe the procedures used to test your hypothesis in detail.

- Describe what you did, in the order you did it.
- Never use bullet points or numbered steps!
- Remember that you're describing what already happened, so you should again write in the past tense.

This section is merely detailing how you tested your hypothesis.

- ❑ **RESULTS**

- The **results** section is where you present the data you collected in the experiment and describe trends you observed.
- Data should be organized into tables, figures, and diagrams.
- Tables should be labelled as Table 1, Table 2, etc. and have the title **above** the table.
- Figures (graphs, diagrams, etc.) should be labelled as Figure 1, Figure 2, etc. and have their title **below** the figure.
- Remember to keep it professional — never use images you found on the web or have taken with your cell phone unless you've been asked to do so by your instructor.

This section should include all of your tables/figures and explicitly state all significant results in verbal form.

- ❑ **DISCUSSION/CONCLUSION**

- The discussion section is where you explain, analyse, and interpret your findings *in detail*.

This section focuses on the significance of your results, weaknesses in the experiment, and what you have learned.

EXPERIMENT 1: INTRODUCTION TO GRAPHICAL AND ERROR ANALYSIS

Objectives

1. Demonstrate the specific knowledge gained by repeated measurements of the length and width of a notebook.
2. Apply the statistical concepts of mean, standard deviation from the mean, and standard error to these measurements.
3. Demonstrate propagation of errors by determining the uncertainty in the area calculated from the measured length and width.

Materials/Equipment

1. Notebook
2. 1-meter stick

Theory

In this laboratory, it is assumed that the uncertainty in the measurement of the length and width of the table is due to random errors. If this assumption is valid, then the mean of repeated measurements is the most probable value for the length or width.

Consider the general case in which n measurements of the length and width of the table are made. We will make five measurements, so n = 5 for this case, but we will develop equations for the case where n can be any chosen value. If L_i and W_i stand for the individual measurements of the length and width, and $\bar{L}$ and $\bar{W}$ Stand for the mean of those measurements; the equations relating them are:

$$\bar{L} = \left(\frac{1}{n}\right)\sum_{i}^{n} L_i \qquad \bar{W} = \left(\frac{1}{n}\right)\sum_{i}^{n} W_i \tag{1.1}$$

We get information about the precision of the measurement from the variations of the individual measurements using the statistical concept of the standard deviation. The values of the standard deviation from the mean for the length and width of a notebook σ_{n-1}^{L} and σ_{n-1}^{W} are given by the equations:

$$\sigma_{n-1}^{L} = \sqrt{\frac{1}{n-1}\sum_{1}^{n}(L_i - \overline{L})^2} \qquad \sigma_{n-1}^{W} = \sqrt{\frac{1}{n-1}\sum_{1}^{n}(W_i - \overline{W})^2}$$

(1.2)

If errors are only random, it should be true that approximately 68.3% of the measurements of length should fall in the range $\overline{L} \pm \sigma_{n-1}^{L}$ and that approximately 68.3% of the measurements of width should fall within the range $\overline{W} \pm \sigma_{n-1}^{W}$: Furthermore, 95.5% of the measurements of both length and width should fall within $2\sigma_{n-1}$ of the mean, and 99.73% should fall within $3\sigma_{n-1}$ of the mean. The precision of the mean for $\overline{L}$ and $\overline{W}$ is given by quantities called the standard error, α_L and α_W. These quantities are defined by the following equations:

$$\alpha_L = \frac{\sigma_{n-1}^{L}}{\sqrt{n}} \qquad \alpha_W = \frac{\sigma_{n-1}^{W}}{\sqrt{n}}$$

(1.3)

The meaning of α_L and α_W is that, if the errors are only random, there is a 68.3% chance that the true value of the length lies within the range $\overline{L} \pm \alpha_L$ and the true value of the width lies within the range $\overline{W} \pm \alpha_W$. An important problem in experimental physics is to determine the uncertainty in some quantity that is derived by calculations from other directly measured quantities. For this experiment, consider the area A of the notebook as calculated from the measured values of the length and width L and W by the following:

$$A = \overline{L} \times \overline{W}$$

(1.4)

For the case of an area that is the product of two measured quantities, the uncertainty in the area is related to the uncertainty of the length and width by:

$$\alpha_A = \sqrt{(\overline{L})^2(\alpha_W)^2 + (\overline{W})^2(\alpha_L)^2}$$

(1.5)

Experimental Procedure

1. Place the 1-meter stick along the length of the notebook near the middle of the width and parallel to one edge of the length. Do not attempt to line up either edge of the notebook with one end of the meter stick or with any certain mark on the meter stick.
2. Let X stand for the coordinate position in the length direction. Read the scale on the 1-meter stick that is aligned with one end of the notebook and record that measurement in Data and Calculations **Table 1.1** as X1. Read the scale that is aligned at the other end of the table and record that measurement in Data and Calculations Table 1 as X2. Note that the stick has 1 millimeter as the smallest marked scale division. Therefore, each coordinate should be estimated to the nearest 0.1 millimeter (nearest 0.0001 m).
3. Repeat Steps 1 and 2 four more times for a total of 5 measurements of the length of the notebook. For each measurement place the 1-meter stick on the table with no attempt to align either end of the stick or any mark on the stick with either end of the notebook. Make the measurements at 5 different places along the width of the notebook so that any variation in the length of the notebook is included in the measurements.
4. Perform Steps 1 through 3 for 5 measurements of the width of the notebook. Let the coordinate for the width be given by Y and record the 5 values of Y1 and Y2 in Data and Calculations **Table 1.2**. Again, place the stick along the different lines each time, but make no attempt to align any particular mark on the stick with either edge of the notebook.

Calculations

1. After all measurements are completed, perform the subtractions of the coordinate positions to determine the 5 values of the length L_i, and the 5 values of width W_i. Record the 5 values of L_i and W_i in the appropriate table.
2. Use Equation 1 to calculate the mean length L and the mean width W and record their values in the appropriate table. Keep five decimal places in these results.
3. For each measurement of length and width, calculate the values of $L_i - \bar{L}$ and $W_i - \bar{W}$ and record them in the appropriate table. Then for each value of the length and width, calculate and record the values of $(L_i - \bar{L})^2$ and $(W_i - \bar{W})^2$ in the appropriate table.
4. Perform the summations of the values of $(L_i - \bar{L})^2$ and the summations of the values of $(Wi - W)^2$ and record them in the appropriate box in the tables.
5. Use the values of the summations of $(L_i - \bar{L})^2$ and of $(W_i - \bar{W})^2$ in Equations 1.2 to calculate the values of σ_{n-1}^{L} and σ_{n-1}^{W} and record them in the appropriate table.
6. Calculate $\bar{L}$ - σ_{n-1}^{L}, L + σ_{n-1}^{L}, $\bar{W}$ - σ_{n-1}^{W} *and* $\bar{W}$ + σ_{n-1}^{W} and record the values in the appropriate table.
7. Use the values of σ_{n-1}^{L} and σ_{n-1}^{W} in Equation 3 to calculate the values of $\propto_L$ and $\propto_W$ and record them in the appropriate table.
8. Use the values of $\bar{L}$ and $\bar{W}$ in Equation 4 to calculate the value of A, the area of the notebook, and record it in the appropriate table. Use Equation 5 to calculate the value of $\propto_A$ and record it in the appropriate table.

Results

Table 1 Data and Calculations for Length

Trial	X_1	X_2	$L_i = X_2 - X_1$	$L_i - \bar{L}$	$(L_i - \bar{L})^2$
1					
2					
3					
4					
5					
				$\sum_{1}^{n}(L_I - \bar{L})^2$	

$\bar{L}$ = …………σ_{n-1}^{L} = ………….. $\bar{L} - \sigma_{n-1}^{L}$ = ………….. $\bar{L} + \sigma_{n-1}^{L}$ = ……………. α_L = …………

Table 2 Data and Calculations for Width

Trial	Y_1	Y_2	$W_i = Y_2 - Y_1$	$Wi - \bar{W}$	$(W_i - \bar{W})^2$
1					
2					
3					
4					
5					
				$\sum_{1}^{n}(W_I - \bar{W})^2$	

W = ………… σ_{n-1}^{W} = ………….. $\bar{W} - \sigma_{n-1}^{W}$ = ………….. $\bar{W} + \sigma_{n-1}^{W}$ = ……………. α_w = ………..

A = $\bar{L}$ x $\bar{W}$ = …………………………. α_A = ………………….

Additional Questions

According to statistical theory, 68% of your measurements of the length of the table should fall in the range from $\bar{L} - \sigma_{n-1}^{L}$ to $\bar{L} + \sigma_{n-1}^{L}$. What is the range of these values for your data? From __________m to __________m. How many of your 5 measurements of the length of the table fall in this range? __________? [2]

According to statistical theory, 68% of your measurements of the length of the table should fall in the range from $\bar{W} - \sigma_{n-1}^{W}$ to $\bar{W} + \sigma_{n-1}^{W}$. What is the range of these values for your data? From __________m to __________m. How many of your 5 measurements of the length of the table fall in this range? __________? [2]

If possible, state the accuracy of your measurements of the length and width and give your reasoning. If this cannot be done, state why it is not possible. If possible, state the precision of your measurement of the length and width and give your reasoning. If this cannot be done, state why it is not possible.

[2]

EXPERIMENT 2: MEASUREMENT OF LENGTH, MASS AND TIME

2.1 OBJECTIVES

The objectives of this experiment are to:

(i) Study the physical construction of length-measurement instruments and determine their accuracy.

(ii) To measure the length and diameter of various objects and

(iii) To calculate the volume and density of the objects given with associated experimental error.

2.2 APPARATUS

Flat plate, metal block, Sphere / or Cylindrical pipe, meter rule, Vernier caliper, Micrometer screw gauge and electronic balance.

2.3 THEORY

Read on Vernier calliper, Micrometer screw gauge and how to calculate their Least Count (LC).

Serway (9^{th} Ed). Refer to Sections Q and C.3 proved to you.

PROCEDURE

PART 1: Physical Construction and Accuracy of Meter Rule, Vernier Caliper, and Micrometer screw gauge.

A) The Meter Rule

Examine the metre rule and record the information in the table below

Length of each division	
Experimental error for the meter rule, ΔX_{MR}	

B) The Vernier Caliper

Examine the Vernier Caliper and record the information in the table below

Number of main scale divisions	
Number of Vernier scale divisions	
Length of each division of the Vernier scale	
Least Count	
Zero reading	
Zero correction	

Question: Compare the accuracy of the two length measurement instruments investigated. Which instrument is the most accurate? Explain.

<u>PART 2</u>: Determination of measurements using a Meter rule, Vernier caliper and Micrometer Screw Gauge.

A) METRE RULE READINGS

Using the metre rule measure the length *L*, Width *W* of the and thickness of the metal block given.

Parameter measured	Reading				Experiment reading
Length *L (cm)*	1st Trial	2nd Trial	3rd Trial	Average	
Width *W(cm)*					
Thickness (cm)					

B) VERNIER CALIPER READINGS

Using the Vernier caliper measure the diameter of sphere/ or outer diameter of the cylindrical pipe.

Parameter measured	Main scale reading				Vernier scale reading				Zero correction	Measurement (Reading ±Error)
	1st Trial	2nd Trial	3rd Trial	Average	1st Trial	2nd Trial	3rd Trial	Average		
Sphere / or Cylindrical pipe										

C) MICROMETER SCREW GUAGE

Write something about the micrometer srew guage and what it can be used for

1. **ELECTRONIC BALANCE**

Using an electronic balance, measure the mass of the flat plate/or metal block

Parameter measured	Reading				Experiment reading
Mass *M*	1^{st} Trial	2^{nd} Trail	3^{rd} Trail	Average	

PART 3: Using the data obtained in part A and D above, calculate the mean, the mean deviation, the standard deviation, and the standard error.

Give a single result, including the uncertainty, for the thickness of the metal block. How do the mean deviation and the standard deviation, which are both measures of the uncertainty in a single reading, compare with the number you gave as the experimental uncertainty for the Venier caliper?

(i) Weigh the metal block on a balance, take its length, thickness and height respectively and calculate its volume. Divide the mass by the volume to determine the density and identify the material used to make the meta block. How many significant figures can you give for the density?

Density of flat plate.…. . . . . g/cm^3 (. . . . . Significant figures).

Density of metal block…….. . . . . g/cm^3 (. . . .. . . Significant figures).

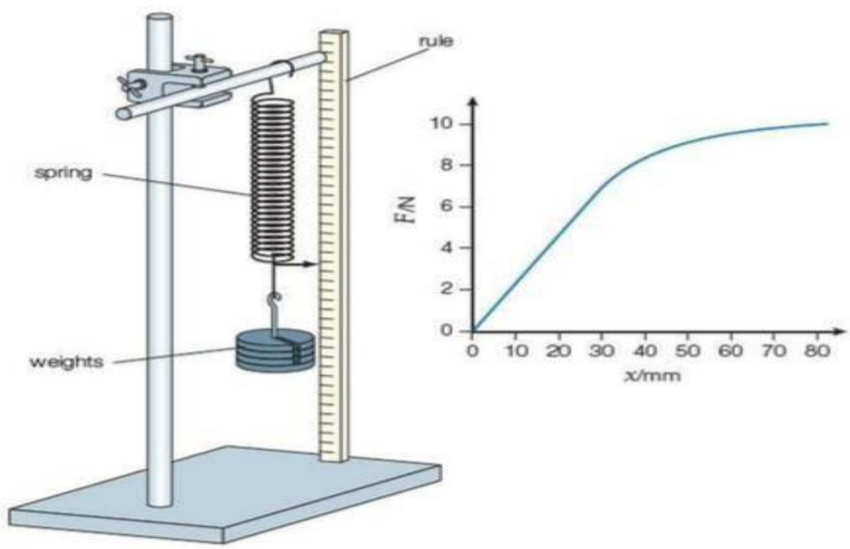
<u>Calculate the percentage of error</u> :

(iii) Did you come across any contribution due to systematic errors. If so give details.

Experiment 3: Hokes's law

3.1. Introduction

When a string or an elastic material is pulled, it extends in proportion to the force exerted until the elastic limit is exceeded. In response to the pulling force, a restoring force is equal to the compression or extension force. The direction of force, that is, compression or stretching force determines the sign on the equation.



In essence, the restoring force is equal and in opposite direction to the force exerted on the elastic material.

- F=kx ………………………………………………………………………. (3.1)
- F=-kx ……………………………………………………………………… (3.2)

The first equation represents extension/stretching, while the second equation represents compression. These equations are only valid for as long as the force exerted does not exceed the material's elastic limit (Mazur, 2014). In the equations above, F represents the force exerted, k is the spring constant given in N/M, and x is the extension or compression given by the difference between the new and original lengths of the material.

3.1.1. Objectives

- ❖ To experimentally determine the relationship between the force exerted on a spring and the extension or compression produced
- ❖ To determine the spring constant from graphical data

3.2. **Materials**

- ❖ A vertically-hanging spring
- ❖ Different masses
- ❖ A ruler Graph paper

3.3. Preliminary Set Up and Questions

Different elastic materials have different spring constants, implying that they react differently to forces exerted on them. Again, one may not easily tell the value of a material's spring constant since many are not labeled. For this reason, an experiment on Hooke's law enables one to generate mass vs. extension/compression change and plot a graph. The graph's slope can then be calculated to give the spring constant. The three main elements studied in this experiment are mass, force, spring constant, and extension.

Element	Description	SI unit
mass	Is defined as how heavy a given material is. It is the amount of matter in an object.	Kg
force	Force is the weight of an object due to gravitational acceleration. It is given by the product of mass and the average gravitational acceleration.	N
Spring constant	The spring constant defines the spring's resistance to change.	N/M^2
Extension/compression	The difference between the original and new length.	m

3.4. Procedure

1. Hang the spring on a vertical plane
2. Measure its initial length
3. Hang one mass
4. Record the new length
5. Calculate the difference between the initial and new lengths
6. Repeat the procedure with different masses while recording the new lengths
7. Record the extension by subtracting the new length from the initial in each measurement
8. Plot a graph of the extension, x, FORCE (LOAD)
9. Calculate the spring constant from the slope of the graph

10. Determine strain energy from the graph
11. State four sources of errors in this experiment.
12. Suggest four improvements in this experiment.
13. Prepare a typed lab report and plot all graphs on excel.

TRIAL	FORCE / N	LENGTH / m	EXTENSION / m
1			
2			
3			
4			
5			
6			
7			

EXPERIMENT 4: TORQUE AND EQUILIBRIUM

AIM: To investigate the turning effect of forces (torque) using a pivoted meter rule and known unequal masses, and to use these to determine a value for the mass of the rule by applying the conditions for static equilibrium.

Apertometer rule, string, clamp stand, known masses and spring balance.

THEORY:

The torque of a force about a point 0 is the product of magnitude of the force and the perpendicular distances (d) between the point 0 and the line of action of the force.

$T=f.d$………………………………………………….. (4.1)

For a body to be in equilibrium under the action of two or more forces;

1. The vector sum of the forces must be zero, and
2. The sum of the torques about any point in the clockwise direction is equal to the sum of the torque about the same point in the anti-clockwise direction.

The weight of a mass is the force exerted by the earth on the mass and this weight acts vertically downwards. The magnitude of the forces is

$W = Mg$ ……………………………………………………. (4.2)

Where M is the mass in Kg, g is the acceleration due to gravity in ms^{-2} (9.8 ms^{-2}), and W is weight in Newton. Note that in many experiments it is not always necessary to calculate the Mg since g will often cancel out from both sides of the equation.

PROCEDURE

For all parts of the experiment, the meter rule should be placed on the pivot with the scale side facing you. The known masses M_1 and M_2 (**$M_1 > M_2$**), made of small slotted weights, are to be hung under the metre rule.

1. Place the metre rule on the pivot and determine its centre of gravity (G). Record your result.
2. Pivot the metre rule at its centre of gravity. Hang M_1at a distance x_1,and M_2 at a distance x_2 from the centre of gravity G to obtain a balance. Record the values of M_1, x_1, M_2, and x_2.

Calculate and compare the torques.

3. With the arrangement as in part 2 (Figure a), double the distance x_1 and find the new position of M_2 which gives equilibrium. How does the new value compare with the value found in part 2? **Explain your findings.** Or, if your value of x_1 in part 2 was so large that you can't double it, then half x_1 and find out what happens to the position of M_2.
4. Pivot the rule at a point O a distance d from the centre of gravity G (Figure b). Find the position of M_1 which will give equilibrium. Taking torques about O:

   $(M_1g)x_1 = (Mg)d$ (4.3)

   Where M is the mass of the metre rule and M_1 is the mass of the mass hanged on the rule

   Hence measure x_1 and d, and find a value of M. Repeat for 5 other values of d (and hence x_1) so that you end up with six separate determinations of M. Record the data in a table such as given below:

   Table 4.0: Table of values for step four (4)

Position of O cm	Position of G cm	Position of M_1 cm	d cm	x_1 cm	M g

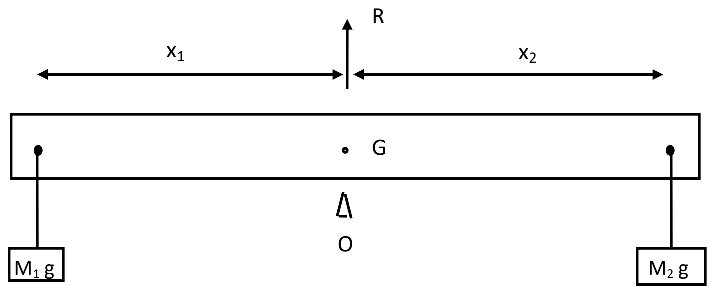


Figure a

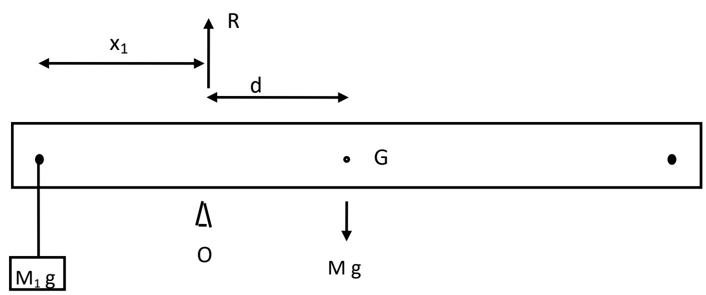


Figure b

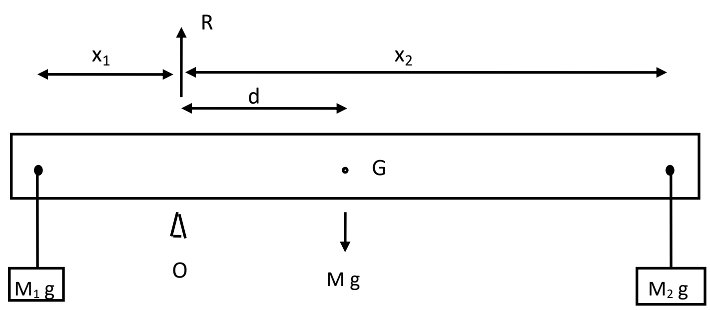


Figure c

O = pivot

G =centre of gravity of the metre rule

R = force exerted on the rule by the pivot

M = mass of the metre rule.

5. Calculate the mean and also the mean deviation, maximum deviation and standard deviation.

6. Pivot the metre rule again at a distance d from the center of gravity of the metre rule and now use the masses M_1 and M_2. Find the positions for these two masses which give equilibrium (figure c). With the arrangement in equilibrium, take torques about the pivot O:

$$(M_1 g)x_1 = Mgd + M_2 g x_2 \qquad (4.4)$$

Hence from your values of x_1, x_2 and d calculate a value for M, the mass of the rule. If you have time, it is always best to take repeated readings. Comment on the agreement with the value of M from part4.

Table 4.1: table of values for step six (6)

Position of G cm	Position of M_1 cm	d cm	x_1 cm	x_2 cm	M g	M_2 g

7. In each arrangement, (Figure a, b, and c) the pivot exerts an upward force on the metre rule, R. To find the value of this force, suspend the rule from a spring balance and position M_1 and M_2 on the rule such that the rule and the masses are in equilibrium for each arrangement and record the value of R from the spring balance.

Table 4.2: table of values for step seven (7)

Position of G cm	Position of M_1 cm	d cm	x_1 cm	M g	R (N

Determine a value of M from these measurements and compare with the values from 4 and 5.

EXPERIMENT 5: COEFFICIENTS OF STATIC FRICTION

AIM: To determine the coefficient of static friction

APPARATUS: A horizontal plane, a frictionless pulley fixed at one end, trays with different surfaces, weight box, scale pan and string.

THEORY:

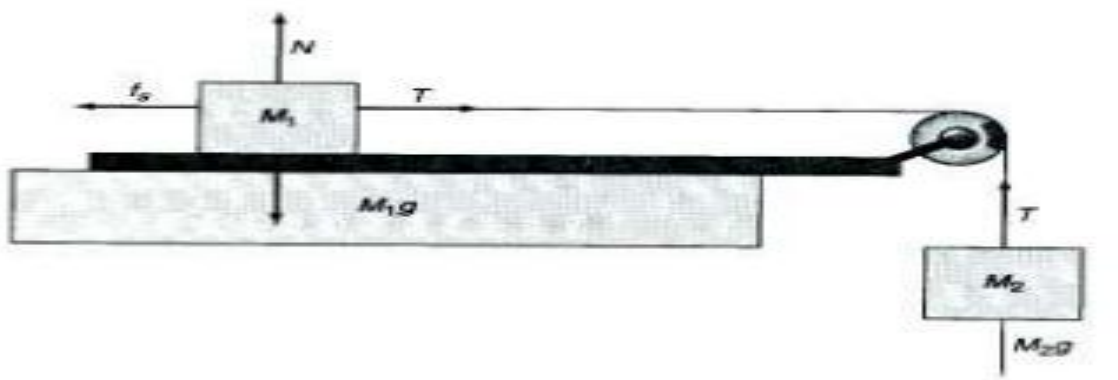
Friction is the resisting force encountered when one tries to slide one surface over another. This force acts along the tangent to the surface in contact. It is found experimentally that the force of friction is directly proportional to the normal force. The constant of proportionality is called the coefficient of friction. When a body lies at rest on a surface and an attempt is made to push it, the pushing force is opposed by a frictional force equal to

$$f = \mu_s F_N \qquad (5.1)$$

Where $\mu_s$is the coefficient of static friction and F_N is the normal force. When the pushing force is greater than the static friction force, the body begins to move. If the contacting surfaces are actually sliding one over the over, the force of friction is given by:

$$f = \mu_K F_N \qquad (5.2)$$

Here μ_k is the coefficient of kinetic friction.



PROCEDURE

Data collection procedure

1. Weigh the mass hanger and wooden surface tray separately and record them.
2. Tie the mass hanger and wooden surface tray using a 50cm string.
3. Place the wooden surface tray on the horizontal plane at the 30cm mark and allow the string to pass over the frictionless pulley so that the mass hanger is on the over side bellow the pulley.
4. Add weights on the mass hanger till the wooden surface tray just begins to slide. Note and record the weights on the mass hanger for two trials.
5. Repeat the experiment by adding weights of 50g, 100g, 150g, 200g in the wooden surface tray, each time starting from the same marked point on the plain.
6. Repeat steps 1 to 5 for the plastic and wool surfaced trays

Material	Trial	Weight on tray (x) N					Weight on hanger when tray slides (y) N				
Wooden surface tray	1	0									
	2	0									
Plastic surface tray	1	0									
	2	0									
Wool surface tray	1	0									
	2	0									

Data analysis Procedure

Table 5.1: Measurements for static friction (take *g* as *9.81N/kg*)

Material	Trial	Weight on tray (x) N					Weight on hanger when tray slides (y) N					Limiting friction $f = (S + y)$					Normal force $F_N = W + x$					Average coefficient for each weight on the block μ_S				
Wooden surface tray	1	0																								
	2	0																								
Plastic surface tray	1	0																								
	2	0																								
Wool surface tray	1	0																								
	2	0																								

Draw a graph of f vs F_N and calculate for the slope which gives an average value for the coefficient of static friction.

Compare the values obtained from the graph and the average of the values you calculated from the obtained data.

EXPERIMENT 6: COEFFICIENTS OF KINETIC FRICTION

AIM: To determine the coefficient of kinetic friction

APPARATUS: A horizontal plane, a frictionless pulley fixed at one end, trays with different surfaces, weight box, scale pan and string.

THEORY:

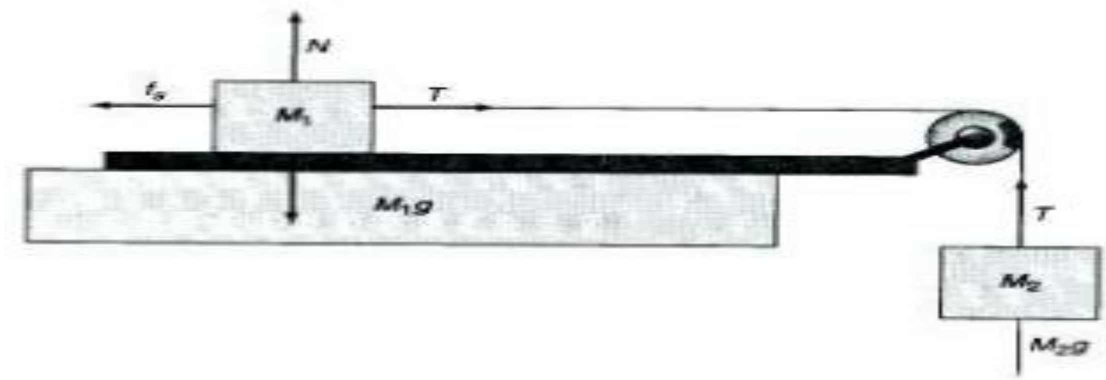
Friction is the resisting force encountered when one tries to slide one surface over another. This force acts along the tangent to the surface in contact. It is found experimentally that the force of friction is directly proportional to the normal force. The constant of proportionality is called the coefficient of friction. When a body lies at rest on a surface and an attempt is made to push it, the pushing force is opposed by a frictional force equal to

$$f = \mu_s F_N \qquad (6.1)$$

Where $\mu_s$is the coefficient of static friction and F_N is the normal force. When the pushing force is greater than the static friction force, the body begins to move. If the contacting surfaces are actually sliding one over the over, the force of friction is given by:

$$f = \mu_K F_N \qquad (6.2)$$

Here μ_k is the coefficient of kinetic friction.



PROCEDURE:

Data collection procedure

1. Place a weight on the mass hanger and give the block a slight push towards the pulley.
2. Increase weights on the mass hanger and give the block a slight push until it is found to continue moving with steady small velocity.
3. Record the corresponding weights on the mass hanger.
4. Repeat the experiment by adding weights of 50g, 100g, 150g, 200g on top of the wooden block, starting always from the small position on the wooden plane.
5. Repeat steps 1 to 5 for the plastic and wool surfaced trays

Material	Trial	Weight on tray (x) N					Weight on hanger when tray slides (y) N				
Wooden surface tray	1	0	0.5	1	1.5	2					
	2	0	0.5	1	1.5	2					
Plastic surface tray	1	0	0.5	1	1.5	2					
	2	0	0.5	1	1.5	2					
Wool surface tray	1	0	0.5	1	1.5	2					
	2	0	0.5	1	1.5	2					

Data analysis Procedure

Table 15.1: Measurements for kinetic friction

Material	Trial	Weighton tray (x) N					Weight on hanger when tray slides (y) N					Kinetic friction f =(S + y)					Normal force F_N = W + x					Average coefficient for each weight on the block μ_k				
Wooden surface tray	1	0	0.5	1	1.5	2																				
	2	0	0.5	1	1.5	2																				
Plastic surface tray	1	0	0.5	1	1.5	2																				
	2	0	0.5	1	1.5	2																				
Wool surface tray	1	0	0.5	1	1.5	2																				
	2	0	0.5	1	1.5	2																				

1. Draw a graph of F Vs F_N and calculate for the slope which gives an average value for the coefficient of kinetic friction.
2. Compare the values obtained from the graph and the average of the values you calculated from the obtained data.

EXPERIMENT 7. COMPOSITION OF FORCES

AIM :*To verify the law of parallelogram of forces, triangle law of forces, and Lami's theorem.*

APPARATUS : Gravesand's apparatus (a wooden vertical board fitted with two frictionless pulleys), slotted weights with hangers, mirror strip, thread, spring balance, and set squares (bring your own).

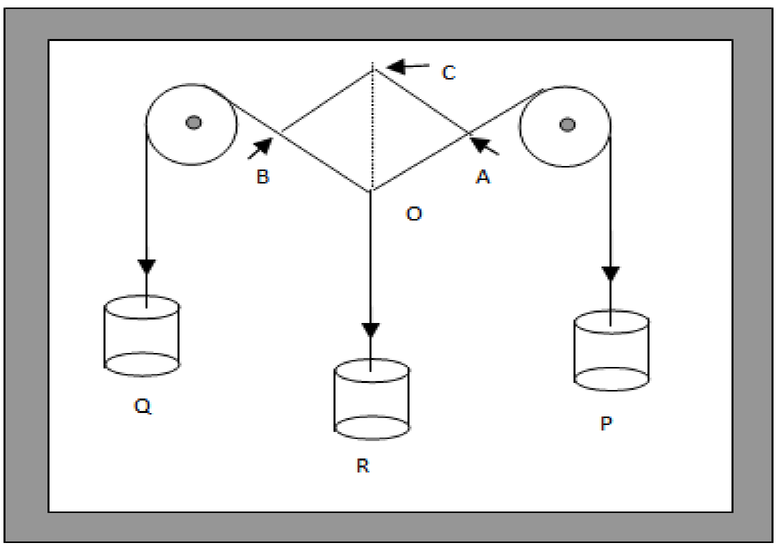
THEORY

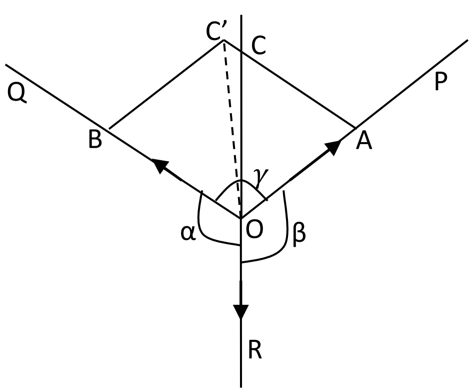
Law of parallelogram of forces : If two forces acting simultaneously on a point object are represented in magnitude and direction by the two adjacent sides of a parallelogram, then the resultant of these two forces is represented in magnitude and direction by the diagonal of the parallelogram at the same point.

Law of triangle of forces: If two forces acting simultaneously on a point object are represented in magnitude and direction by the two sides of a triangle taken in order, then the third side taken in the opposite order completely represents in magnitude and direction the resultant of these two forces.

If three forces P, Q, and R act upon a point object such that the object is at rest or in equilibrium, then the three forces are completely represented by the three sides of a closed triangle.

Lami'stheorem : $\dfrac{P}{\sin\alpha} = \dfrac{Q}{\sin\beta} = \dfrac{R}{\sin\gamma}$





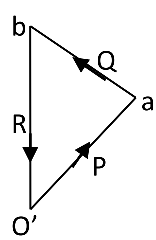


Figure 6.1Gravesand's apparatus

***PROCEDURE*:**

Data collection procedure

1. Place the Gravesand's apparatus on the table; see that its board is vertical.
2. The pulleys should be as free from friction as possible and should be able to move freely. Fix a sheet of white paper on the board.
3. Take a long thread and tie two hangers at its two ends. Tie the third hanger at the end of another thread. The other end of this second thread is connected to the centre of the first thread.
4. Place the threads over the pulleys as shown in Figure 6.1
5. Add slotted weights to the hangers of **different masses**. P is the weight on the right hand side, Q is the weight on the left hand side, and R is the weight at the centre. Adjust the weights such that the knotted point O lies somewhere in the middle of the sheet of paper. The weights should not touch the board. The values of the weights should not be less than 20g.
6. Mark a point O on the paper just close to the meeting point of the threads.
7. Point a touch to the threads so that a shadow of the threads is cast on the white paper.
8. At the point O the three forces are in equilibrium. Mark two points on the paper in line with the shadows of the three threads OP, OR and OQ then join these points with a line. The three lines will meet at the point O.
9. Remove the thread and the hangers.
10. Find the weights of P, Q, and R and tabulate the values.

No.	Forces (N)		
	P	Q	**R**
1			
2			
3			

Precautions:

01. The board should be vertical.
02. The pulleys should be frictionless.
03. The hangers should hang freely, without touching the board.
04. Weights P, Q, R should be weighed properly and tabulated correctly on proper sides.
05. Scale selected should be such that a parallelogram that is neither too large nor too small is formed.
06. Angles should be measured correctly.
07. Show arrowheads representing the direction of forces.

Data analysis Procedure

11. Choose a suitable scale to represent a certain weight by a certain length (say, 2cm = 25g). Let the line OA represent P, and the line OB represent Q. Complete the parallelogram OAC'B. Then OC' represents the resultant and should be equal to the equilibrant R. **Measure OC'** from the parallelogram.
12. Measure the anglesα, β, and γ.
13. Repeat the experiment twice with different values of P, Q, and R.

DATA :

Scale in grams (say 25g =1cm therefore P grams = …….cm)

(*Student to give table number and title*)

No.	Forces (N)			Lengths (cm)			Resultant	Difference
	P	Q	**R**	P/x=OA	Q/x=OB	R/x=OC	**R'**=x.OC'	**R – R'**
1								
2								
3								

If the experiment is perfect, RO extended should pass through C. Due to experimental error, this may not be so.

In that case, let it pass through C'. Measure OC'. It represents R'.

Result : It is found that R = R' within the limits of experimental error. Therefore R' is the resultant of P and Q. Here R is the equilibrant.

(b) Law of triangle of forces.

Take O'a parallel and equal to OA, ab parallel and equal to OB, and bO' equal and parallel to OC.

No.	Forces (N)			Lengths (cm)			$\frac{P}{O'a}$	$\frac{Q}{ab}$	$\frac{R}{bO'}$
	P	Q	R	O'a	ab	bO'			
1									
2									
3									

Result : It is found that $\frac{P}{O'a} = \frac{Q}{ab} = \frac{R}{bO'}$ within the limits of experimental error.

(c) Lami's theorem.

No.	Forces (N)			Angles			$\frac{P}{\sin\alpha}$	$\frac{Q}{\sin\beta}$	$\frac{R}{\sin\gamma}$
	P	Q	R	α	β	γ			
1									
2									
3									

Result : It is found that $\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$ within the limits of experimental error.

EXPERIMENT8: SPECIFIC HEAT CAPACITY OF A METAL BLOCKS

AIM: to determine the specific heat capacity of metal blocks.

APPARATUS: Metal block D, thermometer, lagging C, calorimeter cup, and Stop watch.

THEORY

The Specific Heat of a substance, usually indicated by the symbol c, is the amount of heatrequired to raise the temperature of one gram of the substance by 1° C (or 1 K). From thedefinition of the calorie, it can be noted that the specific heat ofwater is 1.0 cal/g K. If an object is made of a substance with specific heat equal to c_{sub},then the heat, ΔH, required to raise the temperature of that object by an amount ΔT is:

$$\Delta H = (\text{mass of object})\,(c_{sub})\,(\Delta T) \qquad (8.1)$$

PROCEDURE:

Data collection procedure

1. Measure M_{cal}, the mass of the calorimeter you will use (it should be empty and dry). Record your result in Table 8.1.
2. Measure the mass of the aluminum block. Record these masses in Table 8.1 in the row labeled M sample.
3. Measure the temperature $T_{hot}$of the boiling water and record the value.
4. Attach a thread to the metal sample and suspend the samples in boiling water. Allow a few minutes for the samples to heat thoroughly.
5. Fill the calorimeter approximately 1/2 full of cool water use enough water to fully cover the metal sample.
6. Measure T_{cool}, the temperature of the cool water. Record your measurement in the table.
7. Immediately following your temperature measurement, remove the metal samples from the boiling water, quickly wipe it dry, then suspend it in the cool water in the calorimeter (the sample should be completely covered but should not touch the bottom of the calorimeter).
8. Stir the water with the thermometer and record T_{final}, the highest temperature attained by the water as it comes into thermal equilibrium with the metal sample.
9. Immediately after taking the temperature, measure and record M_{total}, the total mass of the calorimeter, water, and metal sample.
10. Repeat steps 1 to 9 for the copper and lead samples.

	Copper	Lead	Aluminum
M_{cal}			
M_{sample}			
T_{hot}			
T_{cool}			
T_{final}			
$T_{(boiling\ water)}$			
M_{total}			

Data analysis Procedure

For each metal tested, use the equations shown below to determine

M_{water}, the mass ofthewater used,

ΔT_{water}, the temperature change of the water when it came into contact withthe metal sample, and

ΔT_{sample}, the temperature change of the metal sample when it cameinto contact with the water. Record your results in Table 8.1.

$$M_{water} = M_{total} - (M_{cal} + M_{sample})$$
$$\Delta T_{water} = T_{final} - T_{cool}$$
$$\Delta T_{sample} = T_{(boiling\ water)} - T_{final}$$

From the law of energy conservation, the heat lost by the metal sample must equal the heatgained by the water:

Heat lost by sample = (M_{sample}) (c sample) (ΔT_{sample}) = (M_{water}) (c water) (ΔT_{water}) = Heat gained by water
c_{water} is the specific heat of water, which is 1.0 cal/g K.

Table 8.1: Data and Calculations (Part 1)

	Copper	Lead	Aluminum
M_{water}			
ΔT_{water}			
ΔT_{sample}			
c			

Use the above equation, and your collected data, to solve for the specific heats of aluminum, copper, and lead. Record your results in the bottom row of Table 8.1.

Questions

1. How do the specific heats of the samples compare with the specific heat of water?
2. Discuss any unwanted heat loss or gain that might have affected your results?

<u>EXPERIMENT9: THE THIN LENS FORMULA</u>

AIM: To determine the focal length of a thin convex lens.

NOTE: In optical experiments, always arrange the optical centres of mirrors or lenses to be in line with the object used.

APPARATUS: light source, convex lens, lens holder, screen, metre rule, object.

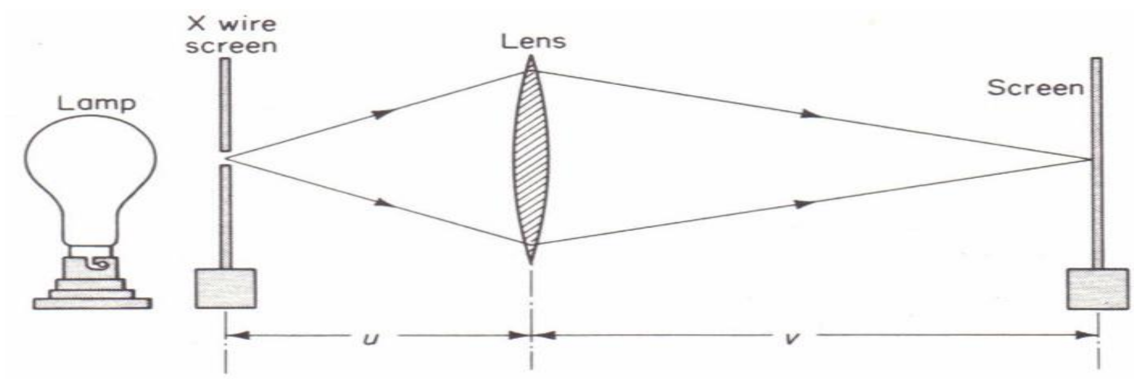


Figure 9.1

THEORY

The lens equation is

$$\frac{1}{u}+\frac{1}{v}=\frac{1}{f} \qquad (9.1)$$

Given that an object placed a distance u from a lens forms an image at distance v away from the lens. The magnification m is given by

$$m=\frac{v}{u} \qquad (9.2)$$

PROCEDURE

Data collection procedure

1. Step up the apparatus as shown in the figure above
2. Mount the lens in the lens holder and move either the lens or screes until you get a sharp, diminished and inverted image on the screen.
3. Measure the distance u and v. repeat the procedure for eight more different distances between the object and the screen. Record the values in table 9.1
4. Now set up the lens holder until you get a sharp, magnified and inverted image on the screen. Again measure the distance u and v. repeat the procedure for eight moredifferent distances between the object and the screen.Record the values in another as shown in table 9.1.

   Tbale: 9.1: values of v and u for reduced image and magnified image

Object distance u(cm)	Image distance v(cm)

Data analysis procedure

5. Calculate the focal length f and magnification for each reading.

6. Calculate the mean value <f>, the mean deviation, the standard deviation, and the standard error from the calculated values of f. express the final result with an error, i.e, <f>±△f.

Table 9.2 Measurements for reduced image

Object distance u(cm)	Image distance v(cm)	m = $^{v}/_{u}$	$^{1}/_{u}$ (cm^{-1})	$^{1}/_{v}$(cm^{-1})	f (cm)

Table 9.3 Measurement for magnified image

Object distance u(cm)	Image distance v(cm)	m = $^{v}/_{u}$	$^{1}/_{u}$(cm^{-1})	$^{1}/_{v}$ (cm^{-1})	f (cm)

Question:

1. Explain why it was necessary to have an inverted image.
2. Draw using graph paper images, with the help of a ray diagram, for an object in all the three cases.
   i. Between f and 2f,
   ii. Beyond 2f, and
   iii. Between f and the lens.
3. What will be the nature of the image and magnification when an object is located:

EXPERIMENT10: DEVIATION BY A GLASS PRISM

AIM: to determine the refractive index and angle of minimum deviation fo a triangular glass prism.

APPARATUS: Light Source, Acrylic Trapezoid, White paper, 30 cm rule, protractor, drawing board, drawing pins, white sheet of paper.

THEORY

The deviation produced by a prism depends on the angle at which the light is incident on the prism. The deviation is minimum when the light passes symmetrically through the prism.

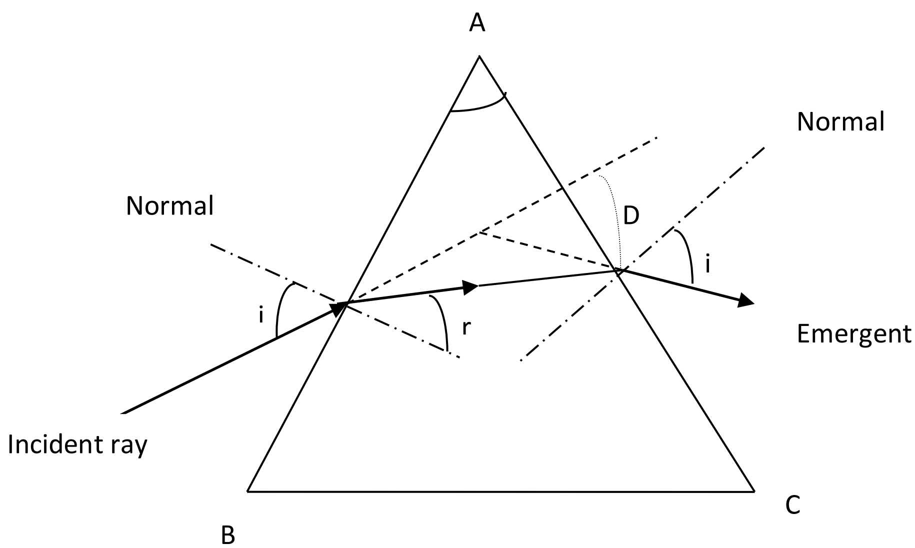


Figure15.1 Light incident on glass prism

In the figure above, the angles have the following relations:

$$D_m = 2i - 2r \qquad (10.1)$$

$$A = 2r \qquad (10.2)$$

$$i = \frac{A+D_m}{2} \qquad (10.3)$$

According to snell's law,

$$n_1 \sin i = n_2 \sin r \qquad (10.4)$$

If light is incident from air, n_1=1, the refractive index of the material into which light impinges is given by

$$n_2 = \frac{\sin(\frac{A+D_m}{2})}{\sin(\frac{A}{2})} \qquad (10.5)$$

PROCEDURE

PART A

Data collection procedure

1. Draw the outline of the prism on a white paper fixed on a drawing board and the label the edges ABC as in the figure 15.1
2. Draw a perpendicular bisector (normal) to side AB

3. Draw a line incident to the prism that makes an angle of 30^o below the normal and label two points P and Q on this ray.
4. Turn the wheel to select a single ray on the light source in ray-box mode and place it on the paper such that the single ray is in line with the incident ray.
5. Label two other points R and S on the emergent ray on the side AC.
6. Remove the prism from the paper and draw the line RS and extend these lines (**PQ and RS**) until they intersect at a **point O**. Extend further the line PQ and mark a point T on this line away from the point O.
7. Measure the angle<TOR. This is the angle of deviation.
8. Repeat the experiment by increasing the angle of incidence in steps of five and up to 60^o and each time measure the angle<TOR.

Table 10.1: angular measurements

Trial number	Angle of incidence i	Angle of deviation D

Data analysis procedure

9. Plot a graph of angle of deviation against the angle ofincidence.
10. Determine the angle of minimum deviation from the graph.
11. Use this value and the existing theory to calculate the refractive index of the glass prism.

PART B

Data collection procedure

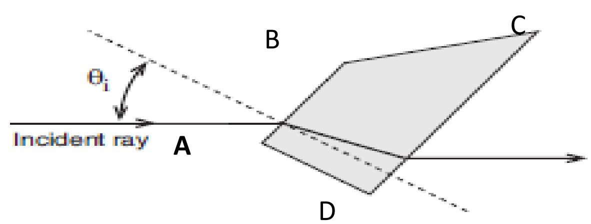


Figure 10.2

1. Draw the outline of the trapezoid on a white paper fixed on a drawing board and the label the edges ABCD as in the figure 10.2
2. Drawa perpendicular bisector (normal) to side AB
3. Draw a line incident to the trapezoid and below the normal that makes an angle of 10^o below the normal.
4. Turn the wheel to select a single ray on the light source in ray-box mode and place it on the paper such that the single ray is in line with the incident ray.
5. Trace three dots on the side DC to outline the refracted ray. Remove the trapezoid from the paper and draw a line passing through the three dots. Indicate the incoming and the outgoing rays with arrows in the appropriate directions. Carefully mark where the rays enter and leave the trapezoid.
6. Draw a line on the paper connecting the points where the rays entered and left the trapezoid. This line represents the ray inside the trapezoid.
7. Measure the angle of incidence (θ_i) and the angle of refraction (θ_r) with a protractor. Both ofthese angles should be measured from the normal. Record these angles in Table 10.1.
8. On new sheets of paper, repeat steps 1–7 for four (4) different angles of incidence.

Trial No.	Angle of incidence (θ_i)	Angle of refraction (θ_r)
1	10	
2	20	
3	30	
4	40	
5	50	

Data analysis procedure

Table 10.2 Relation between angle of incidence and angle of refraction

Trial No.	Angle of incidence (θ_i)	Angle of refraction (θ_r)	$sin\theta_i$	$sin\theta_r$	Refractive index of acrylic ($n_{acrylic} = \frac{sin\theta_i}{sin\theta_r}$)
1	10				
2	20				
3	30				
4	40				
5	50				

1. Draw a graph of$sin\theta_i$against$sin\theta_r$. Is Snell's law verified?
2. Determine the refractive index of the acrylic from the graph.
3. Compute the mean the calculate values of the refractive index of the acrylic $< n_{acrylic} >$ and compare with the value obtained from the graph.

<u>EXPERIMENT 11: ELECTRICAL CIRCUITRY</u>

APPARATUS:

– AC/DC Electronics Lab Board: Wire Leads
– D-cell Battery
– Multimeter
– Graph Paper

AIM:investigate the three variables involved in a mathematicalrelationship known as Ohm's Law.

PART A: OHM'S LAW

PROCEDURE

1. Choose one of the resistors that you have been given. Using the chart on the next page, decode the resistance value and record that value in the first column of Table 11.1.
2. **MEASURING CURRENT:** Construct the circuit shown in Figure 11.1a by pressing theleads of the resistor into two of the springs in the Experimental Section on the Circuits.

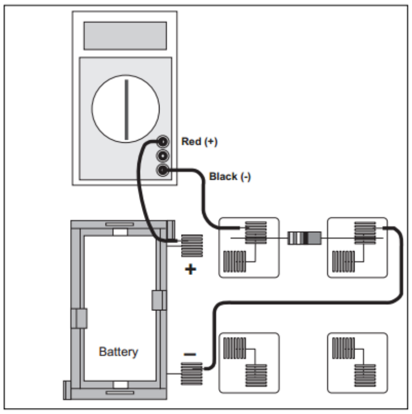


Figure 11.1a

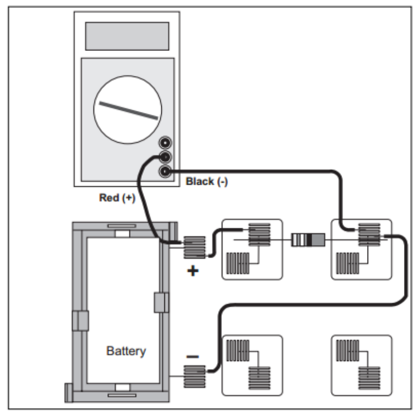


Figure 11.1b

3. Set the Multimeter to the mA range, noting any special connections needed for measuringcurrent. Connect the circuit and read the current that is flowing through the resistor. Record thisvalue in the second column of Table 11.1.
4. Remove the resistor and choose another. Record its resistance value in Table 11.1 then measureand record the current as in steps 2 and 3. Continue this process until you have completed all ofthe resistors you have been given. As you have more than one resistor with the same value, keepthem in order as you will use them again in the next steps.

5. **MEASURING VOLTAGE:** Disconnect the Multimeter and connect a wire from the positivelead (spring) of the battery directly to the first resistor you used as shown in Figure 11.1b. Changethe Multimeter to the 2 VDC scale and connect the leads as shown also in Figure 11.1b. Measurethe voltage across the resistor and record it in Table 11.1.
6. Remove the resistor and choose the next one you used. Record its voltage in Table 11.1 as in step
7. Continue this process until you have completed all of the resistors.

Data Analysis

8. Construct a graph of Current (vertical axis) vs Resistance.
9. For each of your sets of data, calculate the ratio of Voltage/Resistance. Compare the valuesyou calculate with the measured values of the current.

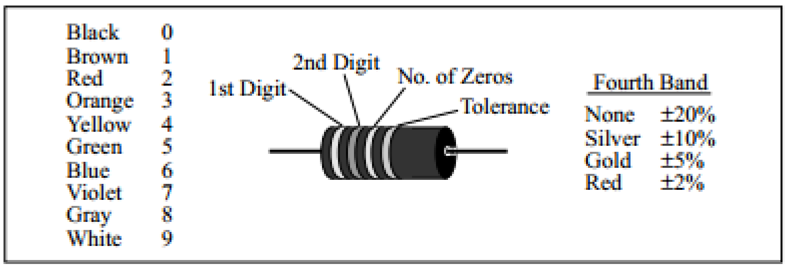
Table 11.1

Resistance Ω	Current, amp	Voltage, v	Voltage/Resistance

Discussion

1. From your graph, what is the mathematical relationship between Current and Resistance?
2. Ohm's Law states that current is given by the ratio of voltage/resistance. Does your dataconcur with this?
3. What were possible sources of experimental error in this lab? Would you expect each tomake your results larger or to make them smaller?

Reference



PART B: Resistances in Circuits

Procedure

1. Choose three resistors. Enter those sets of colors in Table 11.1 below. We willrefer to one as #1, another as #2 and the third as #3.
2. Determine the coded value of your resistors. Enter the value in the column labeled "CodedResistance" in Table 11.1. Enter the Tolerance value as indicated by the color of the fourth bandunder "Tolerance."
3. Use the Multimeter to measure the resistance of each of your three resistors. Enter these valuesin Table 11.1.
4. Determine the percentage experimental error of each resistance value and enter it in the appropriate column.

Experimental Error = [(|Measured - Coded|) / Coded] x 100%.

Table 11.1

	Colors 1^{st} 2^{nd} 3^{rd} 4^{th}	Coded Resistance	Measured Resistance	% Error	Tolerance
#1					
#2					
#3					

5. Now connect the three resistors into the SERIES CIRCUIT, figure 11.1, using the spring clips onthe Circuits Experiment Board to hold the leads of the resistors together without bending them.
6. Measure the resistances of the combinations as indicated on the diagram by connecting the leadsof the Multimeter between the points at the ends of the arrows.

Series

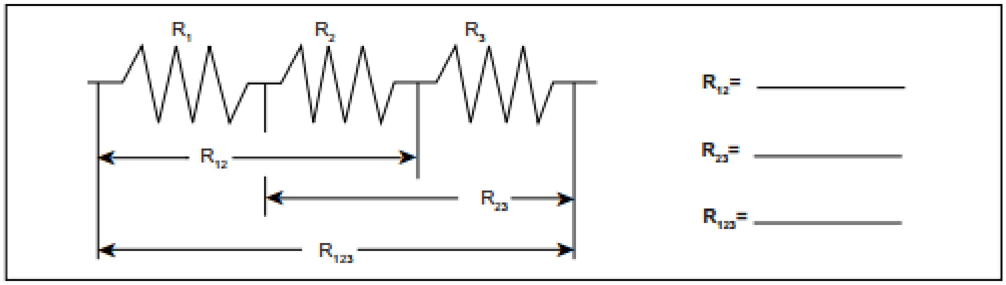
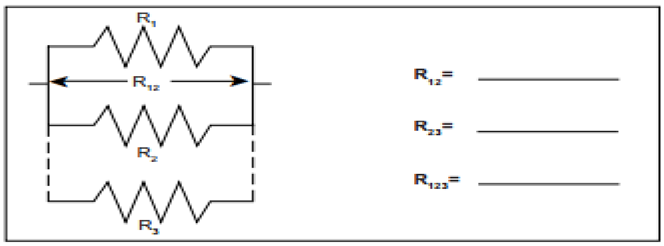


Figure 11.1

7. Calculate the values of R_{12}, R_{23}, and R_{123}. Compare them to the measured values
8. Construct a PARALLEL CIRCUIT, first using combinations of two of the resistors, and thenusing all three. Measure and record your values for these circuits.

Parallel



NOTE: Include also R13 byreplacing R2 with R3.

9. Calculate the values of R_{12}, R_{13}, R_{23}, and R_{123}. Compare them to the measured values
10. Connect the COMBINATION CIRCUIT below and measurethe various combinations ofresistance. Do these followthe rules as you discoveredthem before?
11. Calculate the values of R_{23}, and R_{123}. Compare them to the measured values

Combination

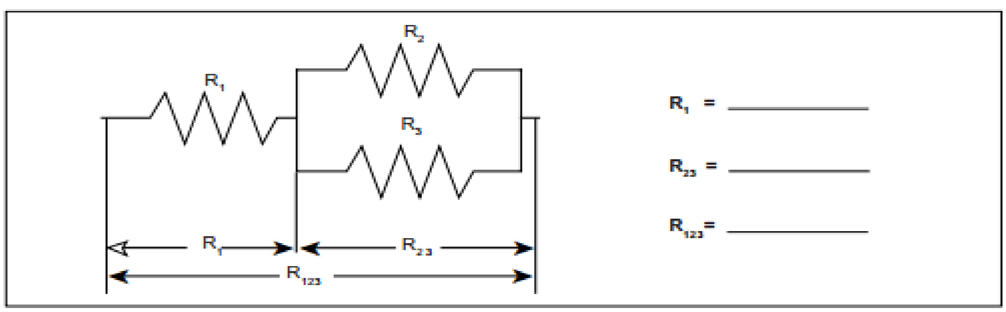


Figure 11.3

Discussion

12. How does the % error compare to the coded tolerance for your resistors?
13. What is the apparent rule for combining equal resistances in series circuits? In parallelcircuits? Cite evidence from your data to support your conclusions.
14. What is the apparent rule for combining unequal resistances in series circuits? In parallelcircuits? Cite evidence from your data to support your conclusions.
15. What is the apparent rule for the total resistance when resistors are added up in series? Inparallel? Cite evidence from your data to support your conclusions.

EXPERIMENT 12: SIMPLE PENDULUM

AIM: To investigate***:***

(i)The relationship between the length of a simple pendulum and its period of oscillation,

(ii) If the period of oscillation depends upon the mass of the bob, and

(iii) If the period of oscillation depends upon the amplitude of the oscillation.

APPARATUS

Length of string, masses to act as bobs, stop clock, vernier calipers, angle indicator, stand and clamp.

THEORY

If the mass of the pendulum is concentrated into a size which is much smaller than the distance from the mass to the support (Figure 12.1), and if the supporting string is light, then the pendulum is called a *simple pendulum*. The angular distance of the pendulum from the equilibrium position (string vertical) is called the displacement, and the maximum displacement is called the *amplitude* of the oscillation. For small amplitudes (e.g. less than or equal to 10^o) the *period* (time for one complete oscillation) is given by:

$$T = 2\pi\sqrt{(L/g)} \qquad (12.1)$$

Where T is the period in seconds, L is the length in meters and g is the acceleration of gravity in ms^{-2}. The theory thus predicts three properties of the simple pendulum which you will investigate in this experiment:

The period T is directly proportional to √L. squaring both sides:

$$T^2 = 4\pi^2\left(\frac{L}{g}\right) \text{i.e., T2 is proportional to L.} \qquad (12.2)$$

Since the mass of the bob does not appear in the equation, equation (i) therefore, predicts that the period is independent of the mass of the bob.

In the derivation of the equation it is necessary to assume that the amplitude of oscillation is small. Equation (12.1) then predicts that the period T is independent of the amplitude of oscillation. Is the period T of the pendulum independent of the amplitude for all values of amplitude? Or is the period T of the pendulum independent of the amplitude only if the amplitude is small?

In part A, when investigating the variation of period with length it will be necessary to keep the angular amplitude small and the mass constant throughout the experiment, so that any variations due to mass or amplitude would not interfere with the investigation of period with length. Likewise, to investigate the variation of period with mass, the length should be kept constant, the amplitude being small (less than 5 degrees).

PROCEDURE:

(A) Period and Length

Data collection procedure

1. Make L as large as possible and tie the bob at its end. Tie the string to a clamp and set the pendulum into oscillations, the amplitude being small (<u>θ less than 10 degrees</u>).
2. Measure the time (t) for 20 complete oscillations. (Use two stop watches to maximize on time).
3. Repeat the measurement. If these two timings agree within a reasonable amount, then note down these two values in the table for this L. If the two values of t differ significantly, then you should repeat your observations for this L until you get consistent values.

Length L (cm)	Time for 20 Oscillations	
	t_1 (s)	t_2 (s)

Data analysis procedure

4. Calculate the mean value of t. Determine mean t for at least five values of L, decreasing the value at regular intervals from the largest to the smallest, so that the smallest value of L is at least 30cm.
5. Calculate the period T (the time for one complete oscillation) for each L. Put your readings in a table.

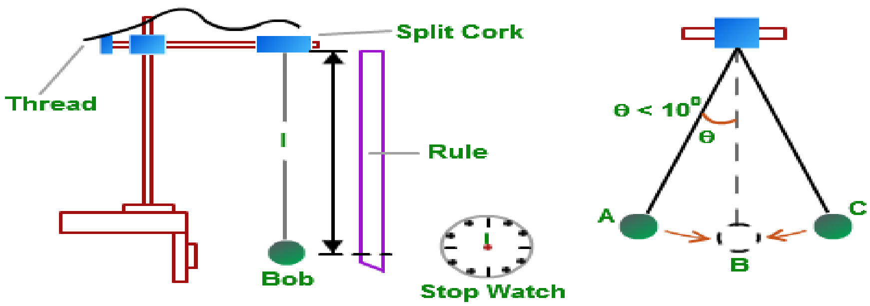


Figure 12.1

Note: Length L = length of the string + radius of the bob if it is spherical. Take L from 30cm to about 100cm.

Table 12.0:

Length L (cm)	Time for 20 Oscillations		Mean Time (s) $t=(t_1 + t_2)/2$	Period T ($T = \frac{t}{n}$)	T^2 (s^2)
	t_1 (s)	t_2 (s)			

6. Plot L (along Y-axis) against T^2 (along X-axis) and see if your data agree with the predicted relationship in equation (12.2). From the slope of your graph determine the value for the acceleration of gravity g.

$$g = 4\pi^2\left(\frac{L}{T^2}\right) = 4\pi^2 \times \text{slope of the graph.} \qquad (12.3)$$

Calculate the percentage of error in g. [Take g = 9.81 m/s^2]

(B) Period and Mass

1. Select a fixed L and determine the period T for three different masses of the bob.
2. Follow the same procedure as in Part A.
3. After allowing for the fact that each of your values of T has some experimental error, do your data agree with the prediction that the period is independent of the mass?

(C) Period and Amplitude

1. With the mass of the bob fixed and the length of the pendulum fixed at 50cm, measure the period for several widely different amplitudes (10°, 20°, 40°, 60° and 70°)
2. Comment on the variation of period with amplitude.

EXPERIMENT 13: CONVERTION OF ENERGY

Aim: to investigate,

a) How energy is converted from GPE to K.E during free fall.
b) How much energy is lost to the surrounding and the system

Apparatus; interface (spark), metre rule, rigid stand, steel ball, freefall adaptor

Theory

One dimensional kinematic motion assumesconstant acceleration for dense objects falling under short distance, equation 13.1 accurately predicts the motions.

$y = y_o + v_o t + \frac{1}{2}at^2$ 13.1

Since the object is initially at rest, then $v_o = 0$, if the initial position is taken as the reference point then $y_o = 0$. Thus equation 13.12 becomes

$y = \frac{1}{2}at^2$

The net work done by a non-conservative force external to the system is,

$W_{ext} = \Delta KE + \Delta GPE + \Delta TE$ 13.2

Where; W_{ext} is the external non-conservative force and ΔTE is the change in the internal energy

This energy will include air resistance for a freefalling body. If there is no external non-conservative force acting on the system, then equation 13.2 reduces to

$(KE_f - KE_i) + (GPE_f - GPE_i) + \Delta TE = 0$

Procedure

Data collection procedure

1. Arrange the apparatus as shown in figure 13.1.

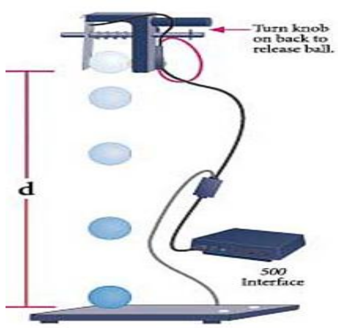


Figure 13.1. Freefall system setup

2. Measure the time taken for the steel ball to fall through the height (d=1.5m) and repeat the measurement for tenmore values of time;find the average of these values.Calculate the error in the time (t)

   Data analysis procedure

3. Calculate the value of the acceleration (a).
4. Calculate the velocity of the steel ball just when it strikes the ground, find its K.E.
5. Measure the mass of the steel ball and record it as “m”
6. Find G.P.E of the steel ball at height (d = 1.5m) using the theoretical value of “g”. Find the value of ΔTE
7. Account for the difference in the theoretical value of (g) and the experimental value.

EXPERIMENT 14: FORCES ON A BOOM

Aim: to calculate the tension in the cable

Apparatus: Statics Board, Mounted Spring Scale, Pulley Balance Arm and Protractors, Thread Mass and Hanger Set

Theory

Theory

A boom supported by a cable has a mass suspended at its upper end. The lower end of the boom is supported by a pivot. Assume that the cable is attached at the boom's center of mass and is at an angle relative to the boom. The boom is at an angle of 50° to the horizontal. For the boom to be in equilibrium, all of the translational forces (Fx and Fy) and all of the torques must add up to zero. One torque is produced by the tension in the cable. Another torque is produced by the weight of the beam. A third torque is produced by the weight of the hanging mass.

$$\sum \tau_{clockwise} = WL\cos\beta + \ WcmLcm\cos\beta = \sum \tau_{counterclockwise} = TLcm\cos\alpha \qquad 14.1$$

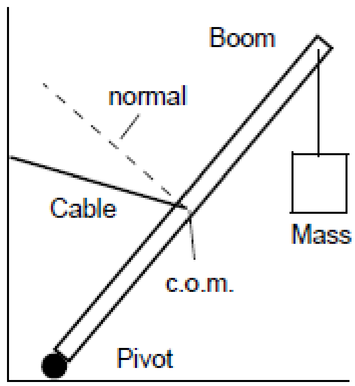


Figure: 15.1

where *W* is the weight of the hanging mass, *L* is the lever arm from the pivot point to the place where the hanging mass is attached, *Wboom*is the weight of the boom, *Lcm* is the lever arm from the pivot point to the center of mass, β is the angle of the boom, *T* is the tension in the cable, and α is the angle of the cable relative to the normal of the boom.

Procedure

1. Set up the Balance Arm with the pivot at one end, a protractor at the midpoint, and a second protractor at the other end. Mount the Balance Arm in a lower corner of the Statics Board.
2. Mount the Spring Scale and a Pulley on the board and use thread to attach the Spring Scale to the protractor at the midpoint of the beam.
3. Use thread to attach a hanging mass of 50g to the protractor at the end of the beam.
4. Make and record the necessary measurements, and fill the data sheet in table 14.2.

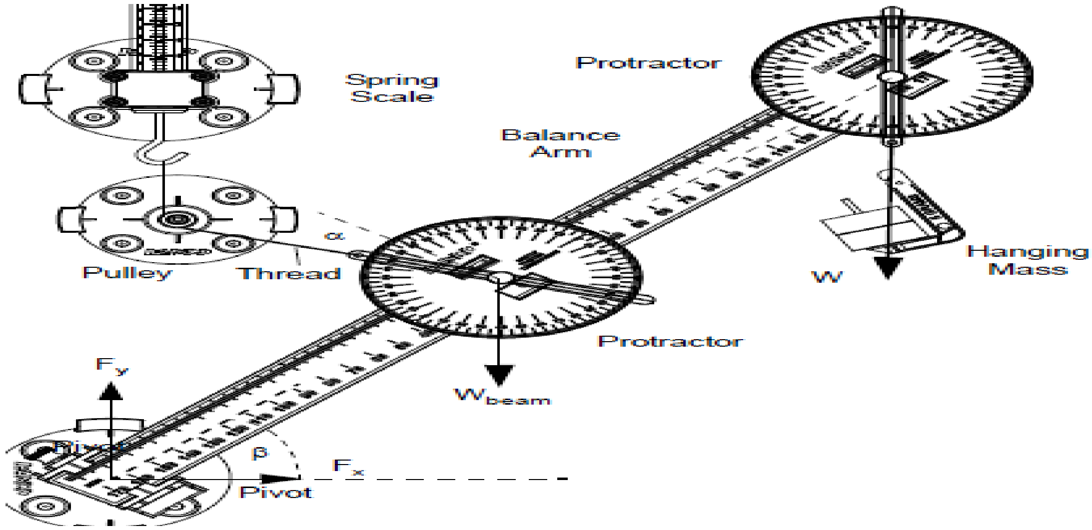


Figure: 14.2

Data sheet

Item	Value
Angle, β, of Balance Arm	
Angle, α, of thread	
Weight, W, of hanging mass	
Weight, W_{beam}, of beam	
Weight of protractor	
Lever arm, L_{cm}, pivot to c.o.m.	
Lever arm, L, to hanging mass	
Tension, T, in the thread	

Table: 14.1

Calculations

1. Calculate the sum of the clockwise torques about the pivot point.
2. Calculate the theoretical tension, T, in the thread.

Question

How does the force reading on the Spring Scale compare to the theoretical value for the tension in the cable?

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