PHYSICS LABORATORY MANUAL

A MANUAL OF PHYSICS LABORATORY EXPERIMENTS AND MARK SCHEMES APPROPRIATE FOR CSEC

COMPILED BY:

THE PHYSICS TEACHERS

AND THE MINISTRY OF

EDUCATION, NATIONAL RECONCILIATION AND

INFORMATION OF ST. VINCENT AND THE GRENADINES

Table of Contents

Overview of the Lab Manual Development Project

Recent CSEC SBA moderation reports revealed that teachers of Biology, Chemistry, Physics and Integrated Science continue to have challenges developing laboratory exercises and designing appropriate mark schemes.

In light of this, the Ministry of Education facilitated the development of moderator-approved lab manuals and mark schemes in each of the four disciplines aforementioned.

This project involved 39 science teachers from schools across St. Vincent and the Grenadines, divided into four panels representative of the four (4) subject areas: Biology, Chemistry, Physics and Integrated Science. Workshops and meetings were held with the science teachers over a period of two weeks to facilitate the development of these resources.

Following the development of these resources, each manual was then vetted by local CSEC moderators to approve the content and validate the resource as one which is suitable for use in CSEC SBA preparations. Use of these manuals is expected to**:**

1. Improve overall SBA performance in secondary schools.
2. Aid teachers in preparations for CSEC moderation process.
3. Guarantee more favourable moderation reports in the future.

Teachers are encouraged to make use of this resource as they make preparations for future SBA moderation exercises.

Juanita Hunte-King
Education Officer for Science
Curriculum Development Unit
Ministry of Education, National Reconciliation and Information
St. Vincent & the Grenadines

Introducing the Physics Lab Manual

The purpose of this manual is to provide Physics teachers with a resource of reliable laboratory experiments and mark schemes suitable for use in SBA preparation. This manual was prepared by a panel of Vincentian Physics teachers and approved by local CSEC SBA moderators.

The Physics Panel Members are:

- Chaz Cato
- Douglas Ryan
- Lenski Adams
- Nikisha Primus

Moderator:

Jennifer Daniel

The resource contains over forty laboratory experiments and sample mark schemes as well as tips for developing Investigative Projects. It is aligned with the current CSEC Physics syllabus and includes topics and skills as required for CSEC SBAs.

It is the hope of the panel that this resource will improve confidence in preparing for the moderation process, as we work collectively to improve Science education in SVG.

Skills

Planning and Designing (PD)

Student's ability to:

1. Ask questions: how, what, which, why or where. (Students must be guided by their teachers to ask scientific questions).

   Example: How does the length of the simple pendulum affect its period of swing?

2. Construct a hypothesis: The hypothesis must be clear, concise and testable.

   Example: There is direct correlation between the length of the pendulum and period of the swing.

3. Design an experiment to test the hypothesis. Experimental report must include the following:
   (i) problem statement;
   (ii) hypothesis
   (iii) aim;
   (iv) list of materials and apparatus to be used;
   (v) identification of variables;
   (vi) clear and concise step by step procedure;
   (vii) display of expected results;
   (viii) use of results;
   (ix) possible sources of error/precaution;
   (x) possible limitations.

Measurement and Manipulation (MM)

(a) Student's ability to handle scientific equipment competently.
    (i) The list of equipment is:
        a. Bunsen burner;
        b. Vernier callipers;
        c. measuring cylinder;
        d. beakers;
        e. thermometer;
        f. ruler;
        g. stopwatch/clock;
        h. balance;
        i. micrometer screw gauge;
        j. voltmeter;
        k. ammeter & Multimeter;
(b) Student's ability to take accurate measurements.
(c) Student's ability to use appropriate units.

Observation, Reporting and Recording (ORR)

a. Recording

a. Student's ability to record observations and to collect and organise data; observations and data may be recorded in:
    i. Prose   Written description of observations in the correct tense.
    ii. Table Numerical: physical quantities with symbols and units stated in heading, significant figures.
    iii. Graph Title axes labelled, correct scales, accurate plotting fine points, smooth curves/best fit lines.
    iv. Calculations must be shown with attention paid to units.

b. Reporting
    a. Student's ability to prepare a comprehensive written report on their assignments using the following format.
        (i) Date (date of experiment).
        (ii) Title
        (iii) Aim (what is to be accomplished by doing the experiment).
        (iv) Apparatus and Materials (all equipment and materials used in the experiment must be listed).
        (v) Method/Experimental Procedure (step by step procedure written in the past tense).
        (vi) Results and Observations (see (a) above: Recording).
        (vii) Discussion
        (viii) Conclusion (see Analysis and Interpretation).

<u>Analysis and Interpretation (AI)</u>

Student's ability to:

(a) make accurate calculations;
(b) identify patterns and trends, cause and effect, and stability and change;
(c) compare actual results with expected results if they are different;
(d) identify limitations and sources of error and error ranges if appropriate;
(e) suggest alternative methods or modification to existing methods;
(f) draw a conclusion justified by data.

Section A: Mechanics

Density

Contributed by: D. Ryan
Suggested Skill(s) Tested: MM, ORR

TITLE: Density

AIM: Determine the density of tap water

Materials and apparatus:

50cm^3 measuring cylinder, electronic balance, tap water, thermometer

METHOD

1. Record the room temperature using a thermometer.
2. Measure the mass of a dry 50 cm^3 measuring cylinder.
3. Add 5 cm^3 of tap water to measuring cylinder and record the new mass.
4. Repeat step 3 until there are at least 10 readings.
5. Record all results in a table of results.
6. Calculate the mass of water (mass of cylinder and water - mass of empty dry cylinder).
7. Plot a graph of mass vs. volume of tap water.

SAMPLE RESULTS TABLE

Volume (V) /cm^3	Mass of cylinder and water / g	Mass of water (m) /g
0		0

<u>Sample Mark Scheme</u>
Contributed by D. Ryan

Student received marks for adhering to the following best practices:

MEASURING CYLINDER.

- Rest flat on surface (1)
- Do not pour down the sides of cylinder (1)
- Read the meniscus at eye level (1)
- Read the bottom of the meniscus (1)
- Lower sample slowly to avoid splashing (1)

ELECTRONIC BALANCE.

- Clean surface of device with soft cotton (1)
- Zero reading before placing object on the balance (1)
- Allow reading to become stable (1)
- Turn off after use (1)
- Cover pan after use (1)

The Simple Pendulum

Contributed by: N. Primus
SUGGESTED SKILLS TESTED: MM, ORR, AI

TITLE: THE SIMPLE PENDULUM

AIM: To investigate how the length of a pendulum affects its period.

APPARATUS: retort stand, protractor, meter rule, stopwatch, bob, just over 1 m length of string

DIAGRAM:

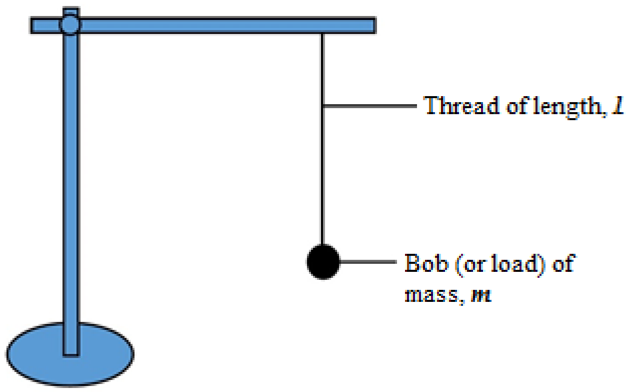


DIAGRAM OF A SIMPLE PENDULUM

METHOD:

1. Attach string to bob securely and measure from the centre of bob a length of 1 m.
2. Tie the string at the 1 m mark to a retort stand so that the pendulum swings freely.
3. Using a protractor, adjust the position of the pendulum to 10^{o} from resting position.
4. Release pendulum and start stopwatch when the pendulum has a steady swing.
5. Stop the stopwatch after 10 complete oscillations; record the time.
6. Repeat experiment six times adjusting the length of the pendulum to be 10 cm shorter each time.

VARIABLES:

- Controlled-
- Manipulated/Independent-
- Responding/dependent-

RESULTS:

TABLE SHOWING HOW LENGTH AFFECTS THE PERIOD OF A SIMPLE PENDULUM

Trial	Length of pendulum, l/m	Time for 10 oscillations, T_{10}/s	Time for 1 oscillation, T/s	T^2/s^2
1				
2				
3				
4				
5				
6				
7				

GRAPH: Plot a graph of l against T and l against T^2. Draw best-fit straight lines for each plot.

DISCUSSION:

Write background information including definitions and examples.

Analyse results, in this case the graph (compare slopes, what is the relationship between the variables?

What precautions did you take? List at least 2 sources of error, if any limitations to you experiment mention here. You may also make recommendations on how the lab could be improved.

CONCLUSION: State the relationship between the length of the pendulum and the period.

Acceleration Due to Gravity

Contributed by: L. Adams

SUGGESTED SKILL TESTED: ORR, AI

TITLE: Acceleration due to gravity

AIM: To determine the acceleration due to gravity using the simple pendulum

APPARATUS: metal bob, string, ruler, retort stand, stopwatch

DIAGRAM:

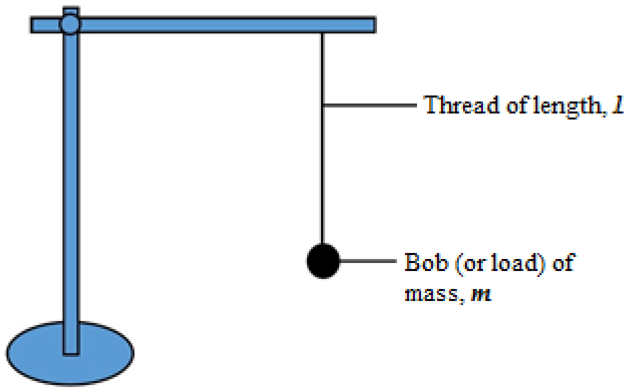


DIAGRAM OF A SIMPLE PENDULUM

METHOD:

1. Tie one end of a 30 cm long string to a retort stand and the other end to a metal bob to make a simple pendulum. Hold the pendulum in place about 10cm – 15cm away to one side from the position of the centre line when the pendulum is at rest.
2. Release the bob then after 2 oscillations, start the stopwatch and count the number of oscillations. After 20 oscillations, stop the timer then read and record its value.
3. Repeat the procedure for a second reading.
4. Then repeat the previous procedure for different lengths of string of 40cm, 50cm, 60cm, 70cm and 80cm. Tabulate the results recorded. Plot a graph of T^2 against length of string.

THEORY: Formula used to find the period of a simple pendulum: $T = 2\pi\sqrt{\frac{l}{g}}$

RESULTS:

Length/cm	time for 20 oscillations t_1/s	time for 20 oscillations t_2/s	average time for 20 oscillations t_3/s = $\frac{t_1+t_2}{2}$	Period T/s $T = \frac{t_3}{20}$	Time^2 T^2/s^2
30					
40					
50					
60					
70					
80					

GRAPH: Plot the graph of T^2/s^2 against L/m

CALCULATIONS:

- Rearrange the formula to find g: $T = 2\pi\sqrt{\frac{l}{g}}$
- Calculate the gradient of the graph.
- Use the gradient of the graph to determine the acceleration due to gravity.

DISCUSSION:

- Discuss the acceleration due to gravity.
- Discuss the use of the pendulum method to determine the acceleration due to gravity.
- State the trends in your observations.
- Explain what the straight-line graph means about proportionality.

ERRORS:

Explain each error which occurred.

CONCLUSION:

- State the value of the acceleration due to gravity.

- State if the value of acceleration due to gravity is acceptable. Explain why or why not.

Hooke's Law

Contributed by: N. Primus

SUGGESTED SKILL TESTED: ORR, AI

TITLE: HOOKE'S LAW

AIM: To determine if Hooke's law is obeyed with a rubber band.

APPARATUS: retort stand, meter rule, elastic band, assorted masses

DIAGRAM:

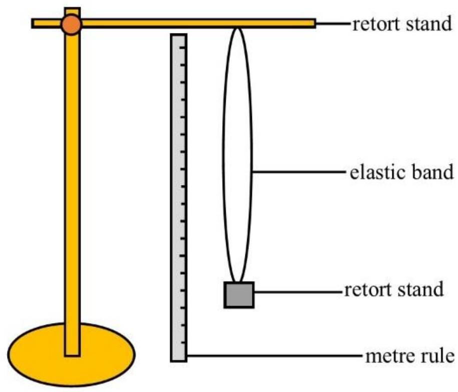


DIAGRAM SHOWING SET UP OF APPARATUS

METHOD:

1. Elongate the rubber band without stretching and find its length.
2. Set up the apparatus as shown in the diagram first using the 100 g mass.
3. Note the new length of the rubber band.
4. Remove the mass and re-measure the length of the rubber band.
5. Repeat the experiment using 200 g, 300 g, 400 g and 500 g masses or until the rubber band burst.

VARIABLES:

- Controlled-
- Manipulated/Independent-
- Responding/dependent-

RESULTS: <u>TABLE SHOWING THE LENGTH OF THE RUBBER BAND AT DIFFERENT POINTS.</u>

Mass applied/ kg	Force (*F*)/ N	Length of rubber band before/ cm	Extension (*x*)/ m	Length of rubber band after/ cm
0	0			-
0.1	1			
0.2	2			
0.3	3			
0.4	4			
0.5	5			

GRAPH: Plot a graph of *Force* against *Extension.* Draw best-fit straight line where appropriate and show the elastic limit.

CALCULATIONS: Find the force constant of the rubber band using $k = \frac{F}{x}$

DISCUSSION:

Background info: state any laws or definition that will help in understanding the results.
Analyse the graph: State and explain the trends seen on the graph.
Precautions/sources of error/limitations

CONCLUSION: State what can be determined by the result.

<u>Sample ORR Mark Scheme (One Mark Each)</u>

By N. Primus

- All sections are present in the correct order
- Past tense-passive voice used
- Method logical
- Neat and correctly labelled diagram
- Neat, enclosed table with title above the table
- Table indicates correct units with headings
- Axes of graph correct and labelled
- Appropriate scales chosen and indicated
- Best fit straight line drawn
- Conclusion is appropriate.

<u>Sample AI Mark Scheme</u>

By D. Ryan

BACKGROUND:

- Define Hooke's law (1) and elastic limit (1)
- Explain the concepts of elastic (1) and plastic deformation (1)

CALCULATION:

- Calculate the gradient (3) one mark for each step used in the calculation.
- Unit of gradient correctly stated (1)

EXPLAINATION:

- Explain using graph (1) the relationship between force and extension (1)
- Link gradient to spring constant (1)

CONCLUSION:

- State a valid conclusion (1) that is related to the aim (1)

LIMITATION:

- State (1) and Explain (1) one limitation /precaution/source of error/assumption

Momentum:

Contributed by: N. Primus
SUGGESTED SKILL TESTED: P&D

TITLE: Momentum

OBSERVATION: Jack noticed that while playing marbles, when a small marble hits another small marble, they both move off in different directions, but sometimes when a small marble hits a big marble, the bigger marble does not move. Plan and design an experiment to determine why this may happen.

HYPOTHESIS: (Make a statement based on the observation supporting what you think is going to happen)

AIM: To determine…

APPARATUS/MATERIALS: (list all the materials that will be needed to carry out the lab)

METHOD: (write a series of steps for which an experimenter must do in order to carry out the experiment. Write in future tense or present tense)

VARIABLES:

- CONTROLLED: (state what variable/s is kept constant throughout the entire experiment)
- INDEPENDENT/MANIPULATED- (state what variable/s can be changed by the experimenter)
- DEPENDENT/RESPONDING- (state the variable/s changes as the experiment progresses as a result of another variable.)

DISPLAY OF RESULTS: (Display how the results will be presented, whether in a table format or listed out.)

TREATMENT OF RESULTS: (Show the formulas that will be used to calculate results and sketches of any graphs that should be drawn)

INFERENCES: (indicate the results /conditions that will cause the hypothesis to be accepted or rejected)

ASSUMPTIONS:(state any assumptions that were made in order for the experiment to be carried out)

EXPECTED RESULTS: Say what is expected to happen.

PRECAUTIONS: (state any conditions for which the experimenter has to be cautious about in carrying out experiment)

POSSIBLE SOURCES OF ERROR: (state any possible sources of errors than may occur during the experiment.

LIMITATIONS: (state any conditions that could have prevent another cautious experimenter from obtaining the same or similar results).

Sample Mark Scheme (One Mark for each)
Contributed by N. Primus

- Hypothesis is clearly stated
- Hypothesis is testable
- Aim related to hypothesis
- Appropriate materials and apparatus
- Method suitable/feasible
- At least one manipulated/responding variable given
- Controlled variable stated
- Reasonable expected results
- All appropriate formulas listed under treatment of results/ how to analyze results indicated.
- At least one assumption/ precaution/ sources of error/ limitation given.

Section B: Thermal Physics and Kinetic Theory

Specific heat capacity

Contributed by: N. Primus
SUGGESTED SKILL TESTED: MM, ORR

TITLE: SPECIFIC HEAT CAPACITY

AIM: To calculate the specific heat capacity of a metal mass using the method of mixing.

APPARATUS: 100-200g metal object, 250-300 ml glass beaker, tripod and gauze, Bunsen burner, Styrofoam cup, thermometer, triple beam balance, 200 ml water, 200 ml measuring cylinder

METHOD:

1. Find the mass of the metal object using a triple beam balance.
2. Place the object into the glass beaker with approximately 150-200 ml of water.
3. Heat the beaker over a Bunsen burner until the water begins to boil.
4. Measure 100 ml of water and pour it into a Styrofoam cup.
5. Note the initial temperature, T_i, of the water in the Styrofoam cup using the thermometer.
6. Note the final temperature, T_f, of the boiling water as the temperature of the metal object and then quickly transfer the object to the Styrofoam cup.
7. Gently stir the water in the cup with a stirrer and record the constant temperature as the final temperature of both the metal object and the water.

RESULTS:

TABLE SHOWING…(complete this statement to give the table a descriptive name)

	Metal Object	Water
Mass/ kg		
Final temperature, T_f/ ^oC		
Initial temperature, T_i/ ^oC		
Temperature change, $\Delta\theta$/ ^oC		

CALCULATIONS:

$E_{H(water)} = m\ c\ \Delta\theta$
Assume E_H gained by water = E_H lost by metal
Therefore $E_{H(iron)} = E_{H(water)}$
$c = \frac{E_{H(iron)}}{m\ \Delta\theta}$

DISCUSSION:

- Background
- explanation of results
- possible type of metal
- assumptions made
- precautions and sources of error

CONCLUSION: State the specific heat capacity calculated from the experiment.

Sample Mark Scheme (One Mark Each)
Contributed by: N. Primus

Triple beam

- Ensure balance pan is clean/clear of debris
- Make sure riders are in their respective zero notches.
- Adjusted riders so balance is again at zero.
- Read scale while standing in front of it.
- Accurate reading obtained.

Bunsen Burner

- Closed air hole.
- Light match immediately after turning on gas.
- Slowly open-air hole to luminous flame.
- Control flame size by adjusting gas supply.
- Turned gas off when finished.

Thermometer

- Immersed bulb completely in liquid.
- Ensure bulb is not in contact with beaker.
- Allowed for thermal equilibrium.
- Reading taken while bulb was immersed.
- Read at eye level.
- Accurate reading obtained.

Latent Heat of Fusion

Contributed by: L. Adams

SUGGESTED SKILL TESTED: P&D

TITLE: Specific latent heat of fusion

PROBLEM STATEMENT: "Matthew believes that the specific latent heat of fusion of ice will change if impurities are present, while Flora argues that it will not".

HYPOTHESIS: (Make a statement based on the observation/problem statement supporting what you think is going to happen)

AIM: (Write an aim that relates to the hypothesis.)

APPARATUS: (list all the materials that will be needed to carry out the lab)

PROPOSED METHOD: (write a series of steps for which an experimenter must do in order to carry out the experiment. Write in future tense or present tense)

VARIABLES:

- **Manipulated:** (state what variable/s can be changed by the experimenter)
- **Controlled:** (state what variable/s is kept constant throughout the entire experiment)
- **Responding:** (state the variable/s changes as the experiment progresses as a result of another variable.)

EXPECTED RESULTS: (State what is expected to be the outcome of the experiment, in relation to the hypothesis)

TREATMENT OF RESULTS: (Show the formulas that will be used to calculate results)

INFERENCES: (Explain three situations in which the hypothesis can either be accepted or rejected)

ASSUMPTIONS: (state any assumptions that were made in order for the experiment to be carried out)

LIMITATIONS: (state any conditions that could have prevented the experiment from occurring).

SOURCES OF ERRORS: (state any possible sources of errors)

PRECAUTIONS: (state any conditions for which the experimenter has to be caution about in carrying out experiment)

Section C: Waves and Optics

Refraction

Contributed by: N. Primus
Suggested Skill Tested: AI, ORR, MM

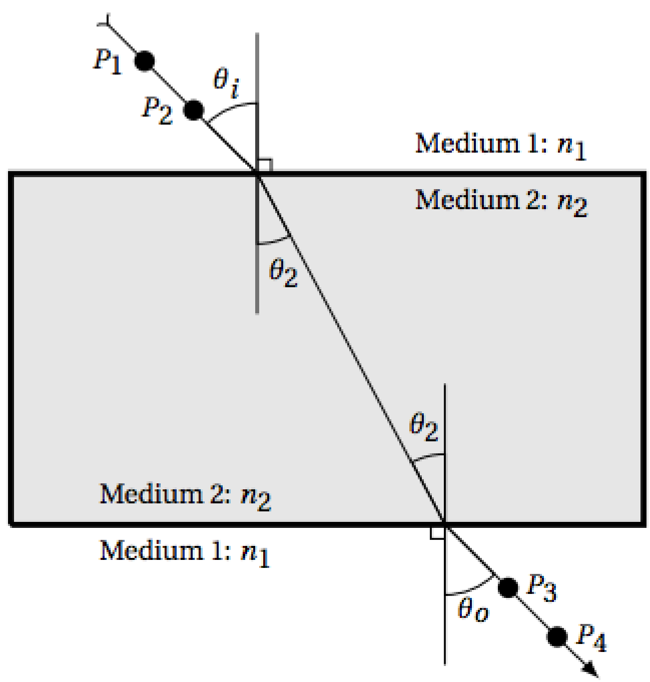
TITLE: REFRACTION

AIM: To investigate the behavior of rays passing through a glass block

APPARATUS: glass block, cardboard, 4 common pins/optical pins, plain paper, protractor

DIAGRAM:

There is no need to draw this diagram in your report. It is for illutrative purposes. The actual diagram you obtain from carrying out the experiment should be place in the results section along with the table.



METHOD:

1. Trace around the glass block on a page of plain paper.
2. Using a protractor, draw a normal in a position as shown in the diagram.
3. Draw an incident ray 20 degrees from the normal.
4. Place the paper onto a piece of cardboard and stick 2 common pins along the incident ray ensuring that the pins are far apart.
5. Place glass block back in its position and place the other 2 pins in front of the block so that they line up one in front of the other while looking through the block.

6. Mark the points at which the pins were placed and draw the ray emerging from the glass block.
7. Draw a normal at the point where the ray emerged and measure the angle.
8. Repeat steps 3-7 twice, changing the incident angle to 40 then 60 degrees.
9. Connect within the rectangular shape of the block the points where the ray enters the block and the point where the ray leaves the block.
10. Label the refracted, emergent and indicant rays.
11. Measure the refracted rays using the protractor.

RESULTS: TABLE SHOWING ANGLES OF INCIDENCE AND REFRACTION

$\hat{\imath}$/ *degree*	$\hat{r}$/ *degree*	Sin *i*	Sin *r*	$\frac{\sin i}{\sin r}$
20		0.34		
40		0.64		
60		0.87		

GRAPH: Plot a graph of sin *i* against sin *r*.

CALCULATIONS: Determine the refractive index of the glass by finding the gradient of the slope.

DISCUSSION:

- Background information
- explanation of results
- compare results with background information
- assumptions made
- precautions and sources of error

CONCLUSION: State briefly the observations made during the experiment with regards to the rays passing through the glass block.

Sample Mark Scheme
Contributed by D. Ryan

CALCULATIONS:

- Calculate the refractive index (3) one mark for each major step of calculation

BACKGROUND INFORMATION:

- DEFINE REFRACTION (1)
- DEFINE REFRACTIVE INDEX (1)

EXPLANATION OF RESULT

- Describe the path light takes through glass block (1)
- State the type of image formed (1)
- Explain why image is considered real or virtual (2)
- Make comparison of calculated and actual value of index (2)
- Comment on optical density of glass block (1)

CONCLUSION:

- Sate a valid conclusion (1) that is related to aim (1)

LIMITATION:

- Explain one limitation /precaution/source of error/assumption (2)

Section D: Electricity and Magnetism

Series and Parallel Circuits

Contributed by: N. Primus

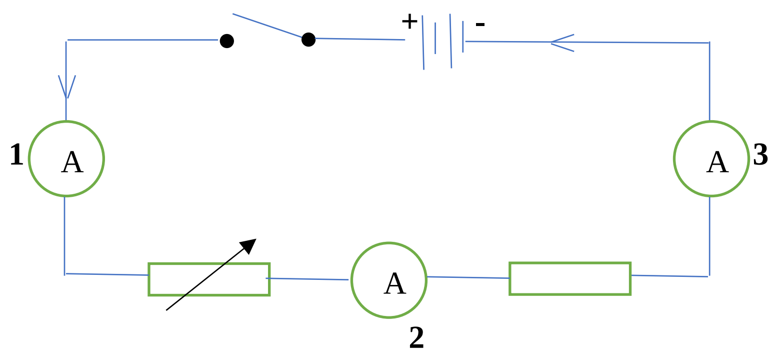
SUGGESTED SKILL TESTED: MM, ORR

TITLE: SERIES AND PARALLEL CIRCUITS

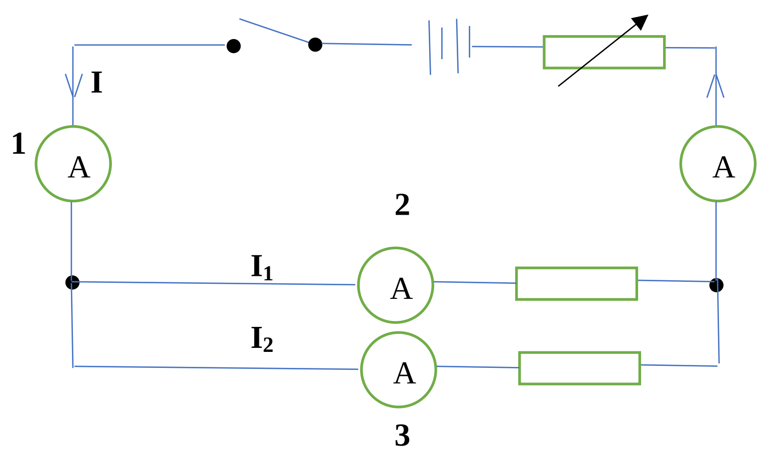
AIM: To determine if current varies at different points in series and parallel circuits.

APPARATUS: 3 ammeters, 2 fixed resistors, 1 variable resistor, switch, power source, connecting wires.

DIAGRAMS:



Series Circuit



Parallel Circuit

METHOD:

1. Set up circuits as shown in the diagrams.
2. Vary the resistance to obtain 3 sets of readings on each ammeter.
3. Record the current readings as I_1, I_2 and I_3.

RESULTS: CURRENT IN A SERIES CIRCUIT

Trial	Current/A		
	I_1	I_2	I_3
1			
2			
3			

CURRENT IN A PARALLEL CIRCUIT

Trial	Current/A		
	I_1	I_2	I_3
1			
2			
3			

DISCUSSION:

- Background information
- explanation of results
- compare results to background information
- assumptions made
- precautions and sources of error

CONCLUSION: State if current varies at different points in series and parallel circuits and why

I-V Relationships

Contributed by: N. Primus

Suggested Skill Tested: AI, ORR, MM

TITLE: I-V RELATIONS

AIM: To investigate ohm's law

APPARATUS: wires, voltmeter, ammeter, fixed resistor, variable resistor, power source, switch

DIAGRAM:

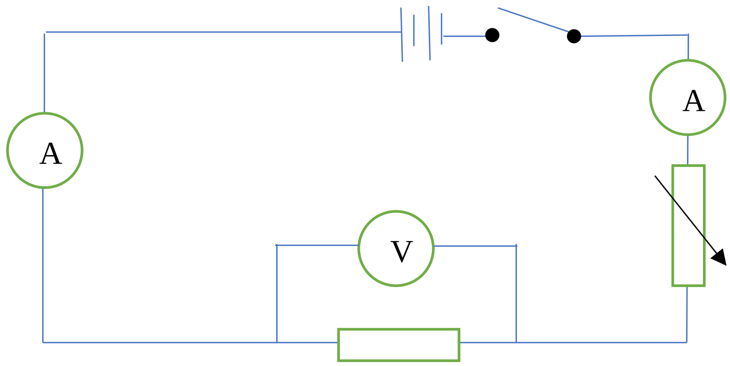


DIAGRAM SHOWING SET UP OF CIRCUIT

METHOD:

1. Connect the apparatus as shown in the diagram.
2. Turn on the switch and note the values for the current and potential difference in the circuit.
3. Vary the resistance in the circuit by adjusting the variable resistor to obtain at least 5 sets of readings.
4. Plot a graph of potential difference against current and find the gradient of the slope.

RESULTS:

Trail	Potential difference/V	Current/A
1		
2		
3		
4		
5		

GRAPH: Plot a graph of potential difference versus current OR current versus potential difference.

CALCULATIONS: Calculate the gradient of the slope (*This gradient is equal to the resistance in the circuit*).

If current versus potential difference was plotted the reciprocal of the gradient should also be calculated (*The reciprocal of this gradient will be equal to the resistance in the circuit*).

DISCUSSION:

- Background information
- explanation of results

- compare results to background information
- assumptions made
- precautions and sources of error

CONCLUSION: State the results determined from the experiment.

Electromagnets

Contributed by: N. Primus

Suggested Skill Tested: ORR

TITLE: <u>ELECTROMAGNETS</u>

AIM: To investigate the strength of a homemade electromagnets.

APPARATUS: iron nail, copper wire, battery, metal paperclips

DIAGRAM:

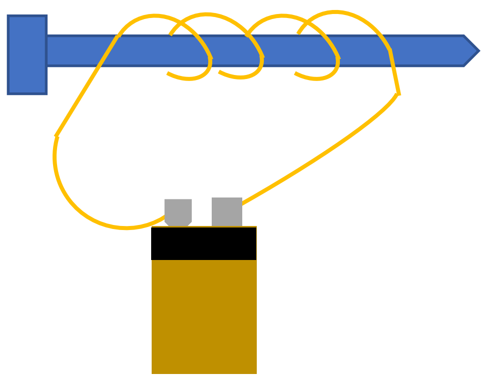


DIAGRAM SHOWING SET UP OF APPARATUS

METHOD:

1. Wrap copper wire around the iron nail several times as shown in the diagram.
2. Connect each end of the wire to opposite ends of the battery.
3. Place the nail next to metal paper clips and record the number of clips that could be picked up.
4. Wrap the wire around the nail an additional 2 turns and record how many clips the electromagnet can now pick up.
5. Keep adding two turns until the maximum about of clips are picked up.

RESULTS:

Number of turns							
Number of clips							

GRAPH: Plot number of clips vs number of turns

DISCUSSION:

- Background information
- explanation of results
- compare results to background information
- assumptions made
- precautions and sources of error

CONCLUSION: State final results that can be made from experiment.

Sample Mark Scheme (One Mark for each):
Contributed by N. Primus

- All sections are present in the correct order
- Correct content under each heading
- Past tense-passive voice used
- No more than 2 grammatical errors
- Method logical
- Title of table present and at top of table.
- Title of graph present and at the bottom.
- Axes labelled.
- Scales present and at top right-hand corner.
- Conclusion answers the aim

Radioactivity Decay (Simulation)

Contributed by: N. Primus
Suggested SKILL TESTED: AI

TITLE: RADIOACTIVE DECAY

AIM: To demonstrate using skittles/M&Ms/identical coins that radioactive decay is random but can be estimated.

APPARATUS: 100 pieces of skittles/M&M's/identical coins, bag, wide clean container for skittles/M&M's, flat surface for coins.

METHOD:

1. Place 100 pieces of skittles/M&M's/identical coins into a plastic bag and shake well.
2. Toss onto counter top or into clean container.
3. Remove and count the pieces with the face side up (S, M or heads). These are the decayed atoms.
4. Replace the "un-decayed atoms" into the plastic bag and repeat steps 2-3 until all the pieces are removed.
5. Record results in a table.
6. Plot a graph of un-decayed atoms against the trial number.
7. From the graph determine the half-life of the "radioactive substance".

RESULTS:

TABLE SHOWING RESULTS OBTAINED.

Trials	Number of "decayed atoms"	Number of "un-decayed atoms"
1		
2		
3		
4		
5		
6		
7		

GRAPH: Plot a graph of "un-decayed atoms" against trials.

CALCULATIONS:

Time taken for the 1^{st} half-life =
Time taken for the 2^{nd} half-life =
Time taken for the 3^{rd} half-life =
The average half-life of the substance =

DISCUSSION:

- Background info
- Graph analysis
- Why is it better to find an average for the half-life?
- Sources of error
- Precautions/limitations

CONCLUSION: Did the experiment demonstrate that half-life is random but can be estimated? If so how? If not why?

Sample Mark Scheme (One Mark Each)
Contributed by N. Primus

- Indicated half-life on graph with a dotted line
- Half-life is indicated in correct position
- Correct value with unit noted
- Definition of half-life stated
- At least one useful application of knowing half-life
- Appropriate quantity plotted
- Amount of undecayed atoms calculated correctly
- At least 5 shakes to represent time elapse was done.
- Conclusion confirms the randomness of radioactive decay
- Conclusion indicate an estimate of the half-life

Suggested Criteria to be used when developing SBA mark schemes

Planning and Designing (P/D)

		Mark(s)
a.	Development of hypothesis (if appropriate)	1
b.	Workable method outlined	1
c.	It should be clear	
	(i) Which variable(s) is/are to be kept constant	1 or more
	(ii) How the dependent variable is measured	1
	(iii) How the independent variable is measured	1
	(iv) Which other variable may affect measurements taken (see d(ii))	1

If the students perform the experiment, the points can be found in the results; if not the point should be found in the description of the method.

d. One or more points from the following:
   (i) Non-standard precautions used to improve accuracy
   (ii) Identification of sources of error which may affect the accuracy of the answer and could not be prevented
   (iii) Repetition and averaging of readings

A set of general criteria for assessing the Planning and Designing of electrical practicals is given below.

		Mark(s)
a.	Draws appropriate circuit diagram (symbols, arrangement)	2
b.	Shows how to take appropriate readings, i.e. how the variables are measured	2
c.	Shows how to change the variables e.g. reversing diode, adjusting rheostat, varying length of wire	1
d.	Shows how results either support or refute the hypothesis OR shows how the values can be substituted into the appropriate formula	1

Observation / Recording / Reporting (O/R/R)

a. Overall organization of work
   - (i) Appropriate sub-headings 1
   - (ii) Sub-headings in logical order 1
   - (iii) Subject matter under appropriate sub-headings 1

b. Diagram(s) (if needed)
   Adequate size (1) and fully labelled
   (3 marks maximum and one mark deducted for each significant label omitted or incorrect)

c. Report of method adopted
   - (i) Logical sequence in steps 1
   - (ii) Concise account (no irrelevant material) 1
   - (iii) Grammar and spelling:
     - i. Correct 2
     - ii. Only one or two errors 1
     - iii. Many errors 0

d. Recording of readings (when tabulation not suitable)
   - (i) Appropriate readings (where necessary) 1
   - (ii) Readings in line with expected results (accurate readings 1
   - (iii) Units on readings 1
   - (iv) Appropriate significant figures (consistent with instrument(s) used) 1
   - (v) Repetition and averaging of readings 1 or 2

e. Tabulation of sets of readings
   - (i) Neat table 1
   - (ii) Heading for tables labelled with quantity/symbol/unit 1
   - (iii) Appropriate significant figures in each column (consistent with instrument(s) used) 1 or 2
   - (iv) Good range of readings 1
   - (v) Adequate number of readings (usually six, and more when graph is curved) 1

f. Graph construction
   - (i) Correct quantities plotted on axes 1
   - (ii) Title of graph with axes labelled with quantity or symbol and unit (one mark deducted for each omission) 2
   - (iii) Suitable scale for each axis, 1 each (linear, adequate size, convenient) 1
   - (iv) Fine circled points or sharp crosses, thin line 1
   - (v) Accurate plotting of all readings (all points correct, one incorrect 2, two incorrect 1, three or more incorrect 0) up to 3
   - (vi) Line of best fit (curved or straight) 1

Manipulation and Measurement (M&M)

a. Use of a thermometer in a liquid
   Criteria for assessment:
   (i) Liquid is stirred to ensure even temperature
   (ii) Thermometer bulb completely immersed
   (iii) Bulb not in contact with container
   (iv) Immersion time is sufficient for thermal equilibrium

b. Use of measuring cylinder
   Criteria for assessment:
   (i) Appropriate size chosen (if relevant)
   (ii) Cylinder placed on horizontal surface
   (iii) Meniscus read to avoid parallax
   (iv) Bottom part of meniscus read

c. Use of ammeter / voltmeter
   Criteria for assessment
   (i) Ammeter / voltmeter of suitable range chosen (if appropriate)
   OR
   Appropriate scale on meter connected and read (if relevant)
   (ii) Ammeter/Voltmeter placed in correct positions, from circuit diagram
   (iii) Ammeter/voltmeter connected with correct polarity
   (iv) Zero error checked
   (v) Scale read to avoid parallax
   (vi) Connections tightened

d. Use of stopwatch/stop clock
   Criteria for assessment
   (i) Zero error checked
   (ii) Stop watch/stop clock correctly operated
   (iii) Count-down method used (if appropriate)
   (iv) Scale read to avoid parallax (if appropriate)

e. Use of a balance for mass determination
   Criteria for assessment
   (i) Balance placed level
   (ii) Zero error checked
   (iii) Balance used with care
   (iv) Scale read to avoid parallax (where appropriate)

f. Use of Bunsen burner
   Criteria for assessment
   (i) Bunsen burner attached properly to gas supply
   (ii) Air hole closed
   (iii) Match let before gas turned on
   (iv) Air hole adjusted
   (v) Gas supply adjusted

g. Use of micrometer
   Criteria for assessment
   (i) Zero error checked
   (ii) Micrometer closed gently (ratchet)
   (iii) Scale read to avoid parallax
h. Use of Vernier Calliper
   Criteria for assessment
   (i) Zero error checked
   (ii) Caliper closed gently
   (iii) Scale read to avoid parallax
i. Ray plotting
   Criteria for assessment
   (i) Pins placed far apart
   (ii) Pins placed vertically
   (iii) Positions of pins labelled/lines drawn appropriately
   (iv) Base line of protractor placed on line
   (v) Centre of protractor correctly positioned
j. Setting up of electrical circuit
   Criteria for assessment
   (i) Correct circuit diagram drawn (if necessary)
   (ii) Components correctly positioned, from circuit diagram
   (iii) Components connected with correct polarity
   (iv) Circuit wired with switch off
   (v) Rheostat (or other component to limit current) set at maximum
   (vi) Circuit switched off between readings
   (vii) Connections tightened
k. Use of a burette
   Criteria for assessment
   (i) Burette rinsed with liquid to be used
   (ii) Burette aligned vertically
   (iii) Funnel used correctly
   (iv) Tip filled with liquid
   (v) Air bubbles removed
   (vi) Hanging drops removed
   (vii) Meniscus read to avoid parallax
   (viii) Bottom of meniscus read

Analysis and Interpretation (A&I)

a. Intercept

(i) Accurate read-off to appropriate number of significant figures (based on a number of significant figures used in plotting graph) 1

(ii) Correct unit for intercept

(iii) Deduction of a quantity from intercept
Accurate answer, to correct number of significant figures, with unit 2

b. Slope or gradient

(i)	Large triangle	1
(ii)	Formula for gradient correct	1
(iii)	Accurate read-off (to appropriate number of significant figures, same as in the readings)	1
(iv)	Calculation of gradient accurate	1
(v)	Appropriate significant figures, and unit, for gradient	2
(vi)	Deduction of a quantity using gradient. Answer correct, appropriate number of significant figures, with unit	2

c. Calculations

(i)	Formula correct	1
(ii)	Substitution correct	1
(iii)	Answer with unit	1
(iv)	Answer to appropriate number of significant figures	1

d. Conclusion

(i)	Conclusion follows from data or graph	1
(ii)	Conclusion justified using data or graph	1
(iii)	Unavoidable source(s) of error / uncertainty in chosen method identified	1 or more

Criteria for Assessing the Investigative Report

Proposal (Planning and Design)

The maximum marks available for the Proposal is	10 marks
The format for this part is shown below	
Observation/Problem/Research question stated	
Hypothesis	2 marks
Aim	1 mark
Materials and Apparatus	1 mark
Method	2 marks
Controlled variables	1 mark
Expected Results	2 marks
Assumptions, Precautions/ Limitations	1 mark
TOTAL	**10 marks**

Implementation (Analysis and Interpretation)

The maximum marks available for the Implementation is 20 marks

The format for this part is shown below.

Method	1 mark
Results	4 marks
Discussion	5 marks
Limitation	3 marks
Reflection	5 marks
Conclusion	2 marks
TOTAL	**20 marks**

Reporting

PART A THE PROPOSAL (Planning and Design)

Statement of the Problem – Can be an observation, a problem

Hypothesis

Aim – Should be related to the hypothesis

Materials and Apparatus

Method – Should also include variables

Assumptions/Precautions

Expected Results

PART B THE IMPLEMENTATION (Analysis and Interpretation)

Method - Linked to Part A (change of tense)

Results

Discussion – Explanations/Interpretations/Trends

Limitations Reflections

Conclusion

Criteria for Assessing Investigating Skills

A. PLANNING AND DESIGN

HYPOTHESIS	**2**
• Clearly stated	1
• Testable	1
AIM	**1**
• Related to hypothesis	1
MATERIALS AND APPARATUS	**1**
• Appropriate materials and apparatus	1
METHOD	**2**
• Suitable	1
• At least one manipulated or responding variable	1
CONTROLLED VARIABLE	**1**
• Controlled variable stated	1
EXPECTED RESULTS	**2**
• Reasonable	1
• Link with method	1
ASSUMPTIONS/PRECAUTIONS/POSSIBLE SOURCES OF ERRORS	**1**
• Any one stated	1
TOTAL	**(10)**

B. ANALYSIS AND INTERPRETATION

METHOD

- Linked to Proposal, Change of tense 1

RESULTS **4**

- - Correct formulae and equations:
    - Accurate (2)
    - Acceptable (1)

2

- - Accuracy of data:
    - Accurate (2)
    - Acceptable (1)

2

DISCUSSION **5**

- Explanation
- Development of points:
    - Thorough (2)
    - Partial (1)

2

- Interpretation
    - Fully supported by data (2)
    - Partially supported by data (1)

2

- Trends:
    - Stated 1

LIMITATIONS –

- Sources of error identified 1
- Precautions stated 1
- Limitation stated 1

REFLECTIONS **5**

- Relevance between the experiment and real life (Self, Society or Environment) 1
- Impact of knowledge gain from experiment on self 1
- Justification for any adjustment made during experiment 1
- Communication of information 2
    - (Use of appropriate scientific language, grammar and clarity of expression all of the time (2); some of the time (1)

CONCLUSION **2**

- Stated 1
- Related to the aim 1

TOTAL **(20)**