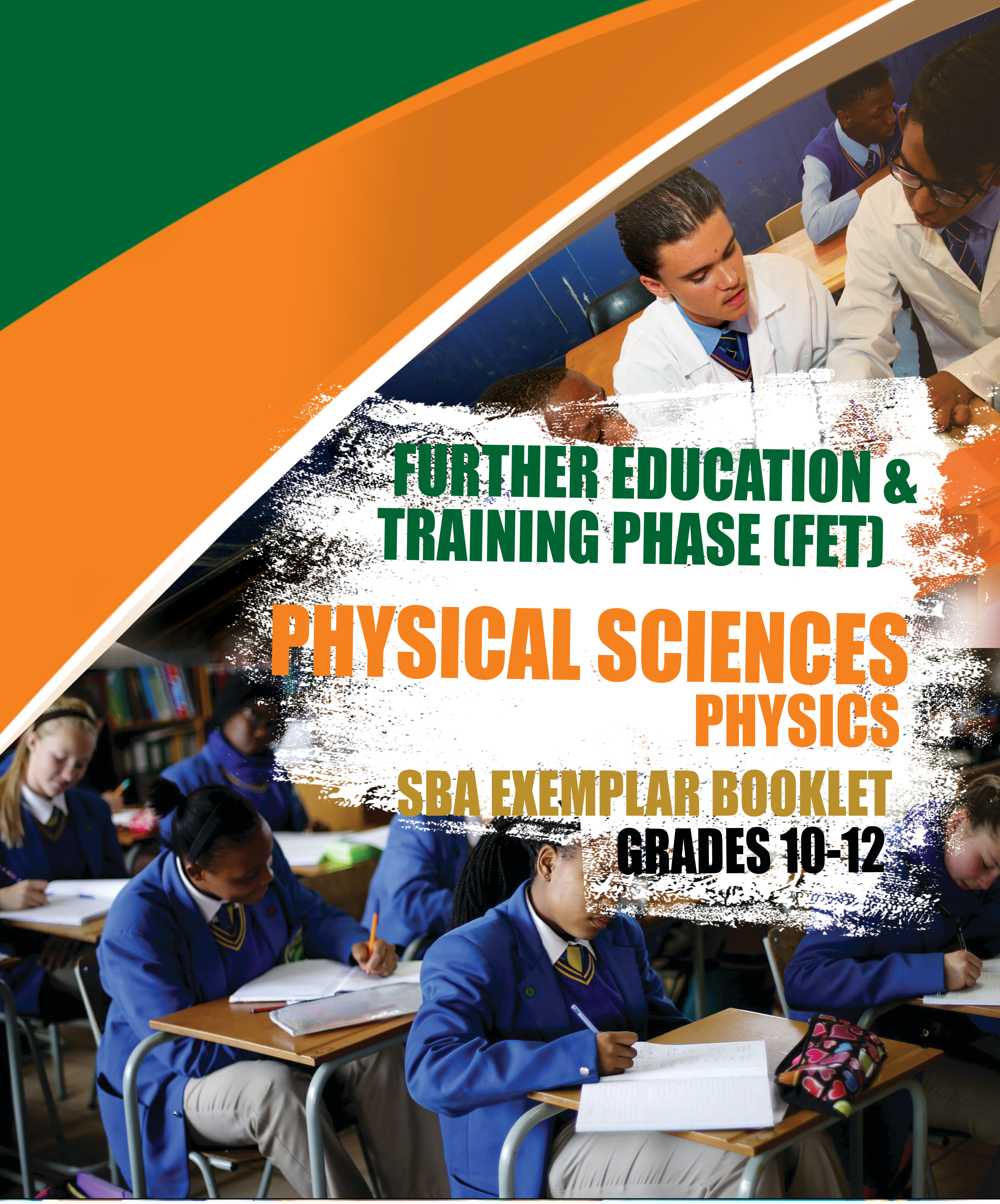


FURTHER EDUCATION & TRAINING PHASE (FET)

PHYSICAL SCIENCES

PHYSICS

SBA EXEMPLAR BOOKLET

GRADES 10-12

basic education
Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

Read to Lead
A Reading Nation is a Leading Nation

2030 NDP

FOREWORD

The Department of Basic Education has pleasure in releasing a subject exemplar booklet for School Based Assessment (SBA) to assist and guide teachers with the setting and development of standardised SBA tasks and assessment tools. The SBA booklets have been written by teams of subject specialists to assist teachers to adapt teaching and learning methods to improve learner performance and the quality and management of SBA.

The primary purpose of this SBA exemplar booklet is to improve the quality of teaching and assessment (both formal and informal) as well as the learner's process of learning and understanding of the subject content. Assessment of and for learning is an ongoing process that develops from the interaction of teaching, learning and assessment. To improve learner performance, assessment needs to support and drive focused, effective teaching.

School Based Assessment forms an integral part of teaching and learning, its value as a yardstick of effective quality learning and teaching is firmly recognised. Through assessment, the needs of the learner are not only diagnosed for remediation, but it also assists to improve the quality of teaching and learning. The information provided through quality assessment is therefore valuable for teacher planning as part of improving learning outcomes.

Assessment tasks should be designed with care to cover the prescribed content and skills of the subject as well as include the correct range of cognitive demand and levels of difficulty. For fair assessment practice, the teacher must ensure that the learner understands the content and has been exposed to extensive informal assessment opportunities before doing a formal assessment activity.

The exemplar tasks contained in this booklet, developed to the best standard in the subject, is aimed to illustrate best practices in terms of setting formal and informal assessment. Teachers are encouraged to use the exemplar tasks as models to set their own formal and informal assessment activities.

MR HM MWELI

DIRECTOR-GENERAL

DATE: 13/09/2017

PHYSICAL SCIENCES: PHYSICS

ABSTRACT

Physics is the study of the natural world. It is very exciting to conduct experiments and investigations and to do projects, especially because these activities can lead us into a better understanding of the physical laws that govern the universe. These activities can also sharpen our skills to become the innovators and discoverers of the future who will find solutions that create a more productive and successful society.

Department of Basic Education

PHYSICS EXEMPLAR SBA TASKS

Contents

1. Introduction

Physical Sciences investigates physical and chemical phenomena. This is done through scientific inquiry, application of scientific models, and theories and laws in order to explain and predict events in the physical world.

The purpose of Physics is to make learners aware of their environment and to equip learners with investigating skills relating to physical phenomena. Examples of some of the skills that are relevant for the study of Physics are classifying, communicating, measuring, designing an investigation, drawing and evaluating conclusions, formulating models, hypothesising, identifying and controlling variables, and inferring, observing and comparing, interpreting, predicting, problem-solving and reflective skills.

Physics promotes knowledge and skills in scientific inquiry and problem solving; the construction and application of scientific and technological knowledge; an understanding of the nature of science and its relationships to technology, society and the environment.

In order for the teaching of Physics to be effective and the aims to be achieved, it is necessary to have a large variety of material and to resort frequently to experimentation.

In Physical Sciences there are “practical activities” such as practical demonstrations, experiments or projects. These practical activities must be integrated with theory to strengthen the concepts being taught.

“Experiment” in the context of this curriculum refers to a set of outlined instructions for learners to follow in order to obtain results to verify established theory and “practical investigations” will require learners to go through the scientific process. Experiments and projects are part of the formal assessment tasks in Physical Sciences.

The purpose of this booklet is to provide information and instruction and advice in a simple and convenient form to assist Physical Sciences teachers in implementing School-Based Assessment effectively as required in the Curriculum and Assessment Policy Statement (CAPS).

It is realised that schools across the country will differ in the apparatus chosen for the experiments, but it is envisaged that the exemplars will act as direct guides or, in the experiments where this does not apply, as assistance in understanding the general principles to be applied using the apparatus available.

2. How to use this booklet

- All formal experiments have the following documents:
  - the worksheet to conduct the experiment and questions to be answered under formal conditions
  - marking guideline/memorandum for the teacher
- In the case where there is insufficient apparatus, experiments can be performed in groups, but if there is sufficient apparatus, smaller groups can be formed or learners can perform the experiments in pairs or **individually**.
- Each learner should record his/her own data or observations individually.
- **Each learner should have his/her own worksheet.**
- **Each learner should analyse the data, draw conclusions and answer the questions individually under exam conditions**.
- If it is not possible to perform the experiment and complete the theoretical and analytical part of the worksheet on the same day, the data collected by learners should be kept at school by the teacher. A suitable time should be found for learners to complete the theoretical and analytical part of the worksheet.
- All formal experiments should be marked, and recorded by the teacher ONLY and moderated internally.
- The experiment on conservation of momentum should be conducted in term 1, assessed in term 1 and recorded in the teachers’ record book. BUT it will be recorded for SBA in term 2 as part of the term 2 SBA marks.
- The teacher should first perform the formal experiments with their own apparatus and record their own results. The results/data provided in the marking guidelines are only exemplar results.
- For the Momentum experiment, the teacher can decide to vary the masses or the distances of the trolleys for each group. In this way learners have different data to work on and this reduces the challenges of similar data for all groups.

- **Note: Ensure that sample results given in the marking guidelines/memoranda are not given to learners. If it is found that learners have these figures in their results, then it will be regarded as an irregularity, and that learner report will be awarded a zero mark**

NB: Learners should work individually on all theoretical and analytical parts of the worksheets.

3. Aims and objectives of this booklet

Provide quality-assured exemplars of assessment tasks, including marking guidelines and explanations to capacitate teachers in the setting of SBA tasks.

Provide guidance to teachers about the setting of SBA tasks.

4. Assessment Tasks

Assessment tasks in this booklet include experiments and projects on Physics topics.

The assessment tasks included focus on Grades 10 - 12 and on the practical component of the subject.

5. Quality Assurance Process

Follow a process that will ensure that all assessments are:

- valid – accuracy of assessment that should be ensured at each stage of the assessment process
- reliable
- equitable and fair

Guidelines towards quality tasks

- Know the curriculum and its requirements to identify the knowledge, understanding and skills which are to be assessed
- Ensure that the assessment allows learners to show that they have the required knowledge, understanding and skills to meet the national standards
- Ensure that the scenarios or contexts are open and comprehensible to all learners
- Ensure that no part of the assessment has an adverse impact on specific groups of learners, e.g. learners with barriers to learning
- Ensure that all illustrative material reflects an inclusive view of society and promotes equality
- Consider time

Construction features when setting practical tasks, tests and examinations

- The language used in the task should not be a barrier
- The weighting given to a particular part of the tasks reflects its relative importance
- Sampling is systematic but unpredictable to avoid question 'spotting'
- The level of difficulty of the individual questions is appropriate
- The mark available for each question must match the demands of the task and the test specification
- The cognitive demands contained in the task are appropriate, i.e. include lower-order, middle-order and higher-order demands aligned to requirements in CAPS
- The level of difficulty of the overall task must be appropriate to the level of the grade
- The marking instructions must allow for a range of valid answers for open-ended questions
- Use different types of questions

6. Conducting Experiments

In the context of this curriculum, experiment is used to test/verify a known theory and it must follow the following structure:

- Title
- Aim
- Theory/Background (that is going to be verified)
- Apparatus
- Safety measures/Precautions
- Variables (dependent, independent, controlled)
- Method
- Observation and results (list of measurements (tables) and results)
- Analysis and interpretation of the results (graphs and laws obtained)
- Conclusions (these should include the answer to any question contained in the object of the experiment).

They can also include:

- Constructive criticism of the apparatus used
- Comments on the accuracy of the measurements
- Comments on the graphs
- Comparison of results with the generally accepted values

- Control questions (on the topic of the experiment for enrichment). The control questions allow the teacher to check the degree of learners' theoretical preparation in the given topic.

For each experiment, each learner will be required to write a neat and accurate report that includes the following headings:

1. Title
2. Aim
3. Theory/Background
4. Apparatus
5. Safety measures / Precautions
6. Variables
7. Method
8. Observations and recording of the results
    - Table
    - Calculations
9. Analysis and interpretation of the results
    - Graph
    - Laws obtained
10. Conclusions
11. Answers to control questions

7. The Scientific Method

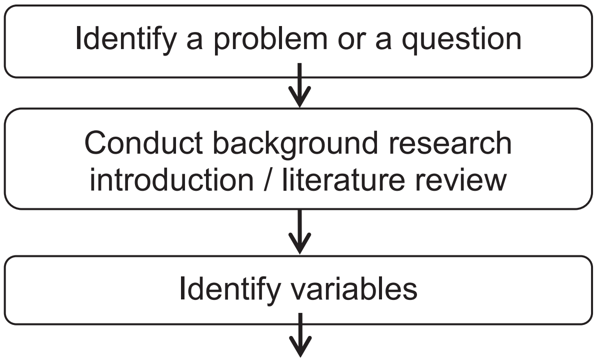
The difference between a practical investigation and an experiment in the context of this curriculum is that an experiment is conducted to verify or test a known theory, whereas an investigation is an activity that is conducted to test a hypothesis, i.e. the result or outcome is not known beforehand. During an investigation the scientific method must be applied.

Scientific method refers to a set of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge.

STEPS OF THE SCIENTIFIC METHOD

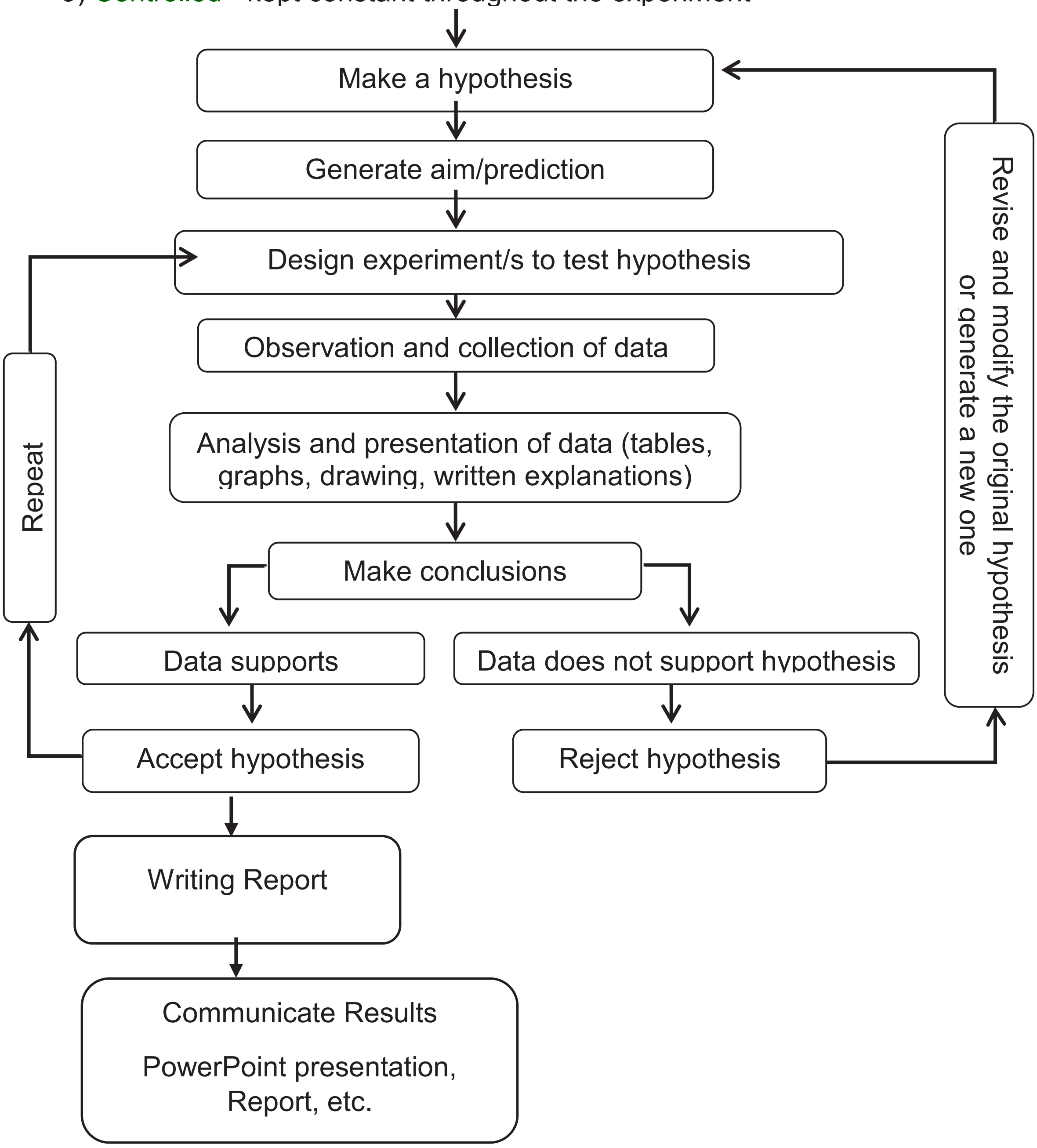
1. Make an **Observation**. Scientists are naturally curious about the world.
2. Formulating an investigative **question** from the observation. After making an interesting observation, a scientific mind itches to find out more about it
3. Formulating the **hypothesis**
4. **Testing** of the hypothesis. This refers to the designing of the experiment to find out if the hypothesis is true or not.
5. **Results**
6. **Conclusions**. This is a report that includes the analysis of the results and what has been learnt during the investigation.

FORMAT OF A SCIENTIFIC INVESTIGATION



Three types of variables

1) Independent - changed by the investigator
2) Dependent - changes according to the independent variable
3) Controlled - kept constant throughout the experiment



The final report is done according to the type of project developed and should include all of the elements of the project, including but not limited to the points of the Scientific Method.

The written report should include the following headings (criteria) in A4 format.

- List of content
- Abstract/ Summary
- Background
- Objective/ Aim
- Problem statement/ Question
- Hypothesis
- Materials
- Method/ Procedure
- Results
- Discussion/ Analysis of the results
- Conclusions
- Limitation
- Bibliography
- Acknowledgment

8. Notes for the teacher regarding experiments on electric circuits

Safety:

1. Avoid water when working with electricity, especially if a transformer is used.
2. The conducting wires should be insulated to prevent any short-circuit that could occur.
3. Make sure the batteries do not leak, as the acid they contain may be hazardous.
4. Do not touch any live conducting wires.
5. Open all switches when changing components in a circuit.

Learners must include a drawing of their circuit diagrams.

Each group must do the experiment in the presence of the teacher.

Observations

1. It is important to measure the emf across the three batteries in series, since the value might not be exactly 3 x 1,5 V – the batteries may be old, batteries often under normal conditions don't have exactly the same emf appearing on its label, it may be different batteries with each having a slightly different emf, etc. So it is important to obtain the actual reading.

   Readings could be rounded off.

   Compare results of all the groups and guide learners to the required conclusion.

2. Take the readings of the current through and potential difference across each resistor to ensure the exact values.

   Readings could be rounded off to arrive at a conclusion

   Compare results of all the groups and guide learners to the required conclusion.

3. **Some possible experimental sources of errors:**

- Incorrect calibration: The voltmeters and ammeters could have been incorrectly calibrated. Use the same kind of ammeters and voltmeters. (Learners should know how to take readings before doing the experiment.)
- Initially the voltmeter and ammeter should be connected on the highest scale. The connections should then be moved to lower scales as the need arises.
- Temperature: Take readings as quickly as possible to avoid overheating. Temperature affects the resistance.
- Error of parallax: Avoid the error of parallax when taking readings on the meters.
- The same learners should take the readings on the same meters for an experiment. Control sources of human error. Minimise errors.

9. Grade 10 Experiments

9.1 Worksheet: Experiment: Equivalent Resistance in a series-parallel network

PHYSICAL SCIENCES

FORMAL ASSESSMENT

Total marks: 50

Time: 2 hours

School: ______________________________

Name & Surname: ______________________________ **Class: 10**_____

FORMAL EXPERIMENT 2: *"ELECTRIC CIRCUITS WITH RESISTORS IN SERIES AND PARALLEL MEASURING POTENTIAL DIFFERENCE AND CURRENT"*

Aims:

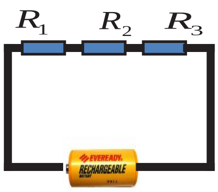
- Test what happens to the current and the voltage in series circuits when additional resistors are added.
- Test what happens to the current and the voltage in parallel circuits when additional resistors are added.

Theory/Background

Resistors in series

When resistors are connected in series:

- They are connected end-to-end so that the same current is carried by each of them.

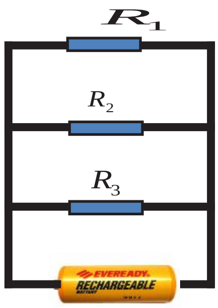


- There is only one path for current to flow, which ensures that **the current is the same at every point in the circuit**.
- The voltage is divided across the resistor. The voltage across the battery in the circuit is equal to the sum of the voltages across the series resistors. $\boldsymbol{V_{battery} = V_1 + V_2 + \cdots + V_n}$
- The resistance to the flow of the current increases. The total resistance is given by: $R_s = R_1 + R_2 + \cdots + R_n$

Resistors in parallel

When resistors are connected in parallel:

They are placed side by side with their corresponding ends connected together so that the current branches.



- The voltage is the same across the resistors. The voltage across the battery in the circuit is equal to the voltage across each parallel resistor: $V_{battery} = V_1 = V_2 = V_3 = \cdots$
- There are more paths for current to flow, which ensures that current splits across the different paths. $I_T = I_1 + I_2 + I_3$ (Resistors act as current dividers.)
- The resistance to the flow of current decreases. The total resistance R_P is given by $\frac{1}{R_E} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

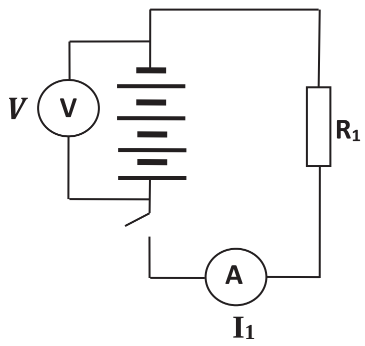
Apparatus:

- Four 1,5 V batteries
- A voltmeter
- An ammeter
- Connecting wires
- Three resistors with the same resistance
- One switch

Method:

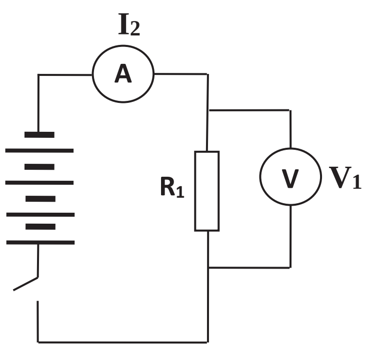
Part I (Series circuit)

1. Set up the following circuit (circuit 1 (I)).



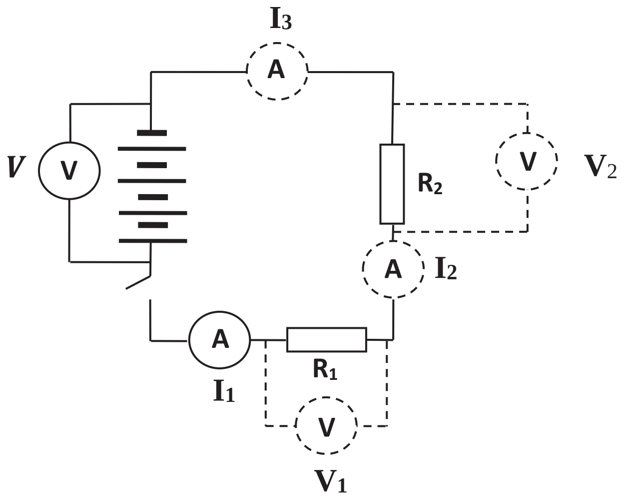
Series: Circuit 1 (I)

2. Close the switch and take the reading of the voltmeter (**V**) and the ammeter (**I_1**).
3. Open the switch and change the position of the ammeter and the voltmeter as shown in the circuit diagram below.



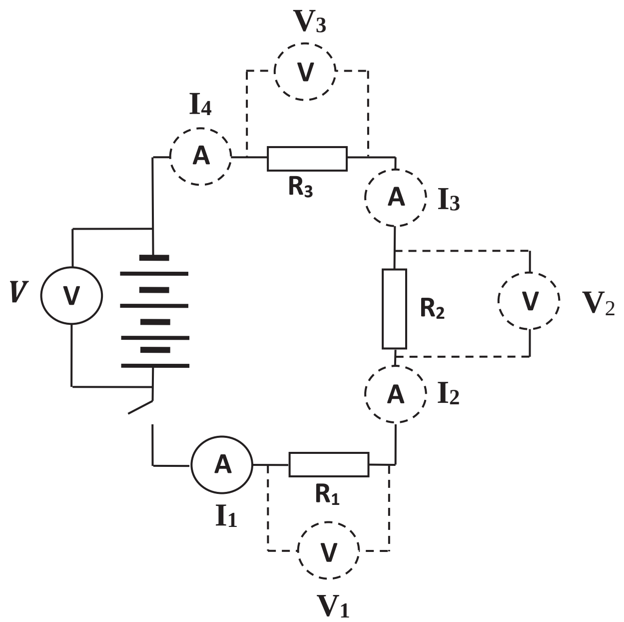
Series: Circuit 1 (II)

4. Close the switch and take the reading of the voltmeter (**V_1**) and ammeter (**I_2**).
5. Set up circuit 2 as show in the circuit diagram below.



Series: Circuit 2

6. Close the switch and take the reading of the voltmeter (**V**) and the ammeter (**I_1**).
7. Open the switch and change the position of the voltmeter and the ammeter so you can take the readings (**V_1**) and (**I_2**).
8. Close the switch and take the readings (**V_1**) and (**I_2**).
9. Open the switch and change the position of the voltmeter and the ammeter again so you can take the readings (**V_2**) and (**I_3**).
10. Close the switch and take the readings (**V_2**) and (**I_3**).
11. Set up circuit 3 by just adding one resistor to circuit 2 as shown in the circuit diagram below.



Series: Circuit 3

12. Close the switch and take the reading of the voltmeter (**V**) and the ammeter (**I_1**).
13. Open the switch and change the position of the voltmeter and the ammeter so you can take the readings (**V_1**) and (**I_2**).
14. Close the switch and take the readings (**V_1**) and (**I_2**).

15. Open the switch and change the position of the voltmeter and the ammeter again so you can take the readings (**V_2**) and (**I_3**).

16. Close the switch and take the readings (**V_2**) and (**I_3**).

17. Open the switch and change the position of the voltmeter and the ammeter again so you can take the readings (**V_3**) and (**I_4**).

18. Close the switch and take the readings (**V_3**) and (**I_4**).

Result (**13 marks)**

19. Draw a table like the one below and record your results for the series circuit.

	SERIES CIRCUIT								
	Voltage (V)					**Current (A)**			
	V	**V_1**	**V_2**	**V_3**	**$V_1 + V_2 + V_3$**	**I_1**	**I_2**	**I_3**	**I_4**
Circuit 1									
Circuit 2									
Circuit 3									

Analysis of the result: **(4 marks)**

With the result recorded in the tables, do a qualitative analysis of the results.

20. Compare the sum of the voltages across all the resistors in each of the circuits.

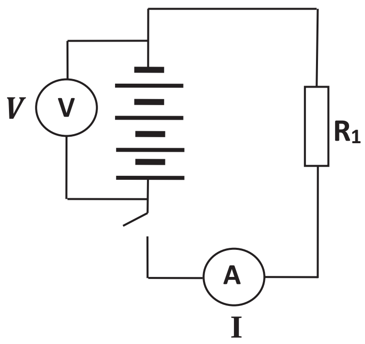
21. Compare the various current measurements within the same circuit.

Conclusion: **(4 marks)**

Write down the conclusion for the experiment.

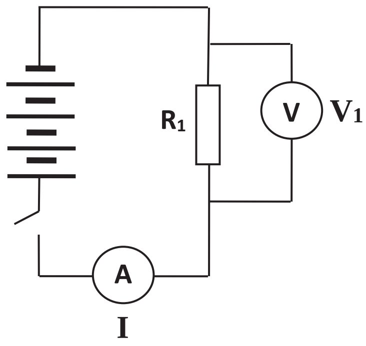
Part II (Parallel circuit)

1. Set up the following circuit as shown in circuit diagram below (circuit 1 (I)). Same as in Part I series circuit).



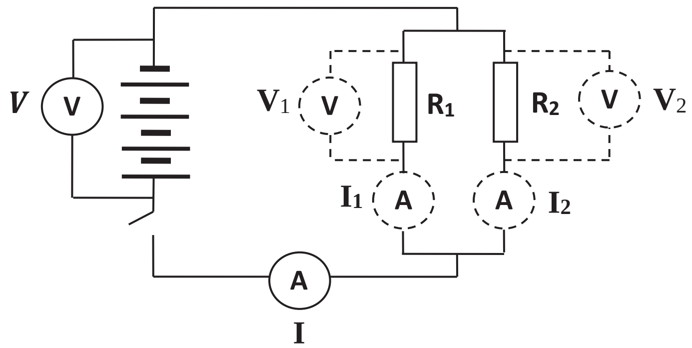
Parallel: Circuit 1 (I)

2. Close the switch and take the reading of the voltmeter (**V**) and the ammeter (**I_1**).
3. Open the switch and change the position of the voltmeter.



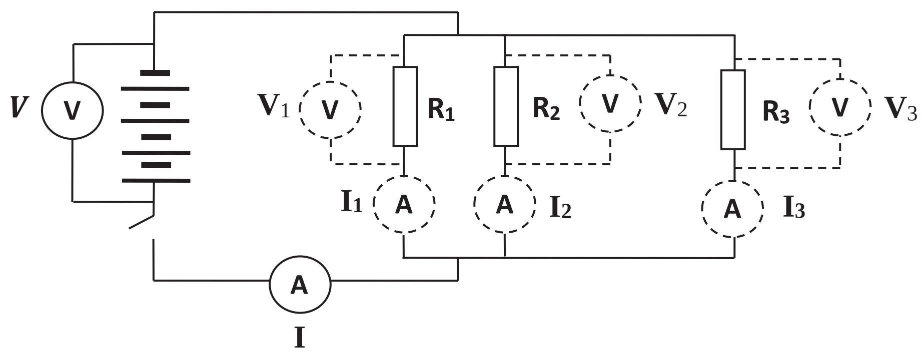
Parallel: Circuit 1 (II)

4. Close the switch and take the reading of the voltmeter (**V_1**).
5. Set up circuit 2 as shown in the circuit diagram below.



Parallel: Circuit 2

6. Close the switch and take the reading of the voltmeter (**V**) and the ammeter (**I**).
7. Open the switch and change the position of the voltmeter and the ammeter so you can take the readings (**V_1**) and (**I_2**).
8. Close the switch and take the readings (**V_1**) and (**I_2**).
9. Open the switch and change the position of the voltmeter and the ammeter again so you can take the readings (**V_2**) and (**I_2**).
10. Close the switch and take the readings (**V_2**) and (**I_2**).
11. Set up circuit 3 by just adding one resistor to circuit 2 as shown in the circuit diagram below.



Parallel: Circuit 3

12. Close the switch and take the reading of the voltmeter (**V**) and the ammeter (**I**).

13. Open the switch and change the position of the voltmeter and the ammeter so you can take the readings (**V_1**) and (**I_1**).
14. Close the switch and take the readings (**V_1**) and (**I_1**).
15. Open the switch and change the position of the voltmeter and the ammeter again so you can take the readings (**V_2**) and (**I_2**).
16. Close the switch and take the readings (**V_2**) and (**I_2**).
17. Open the switch and change the position of the voltmeter and the ammeter again so you can take the readings (**V_3**) and (**I_3**).
18. Close the switch and take the readings (**V_3**) and (**I_3**).

Result: **(13 marks)**

19. Draw a table like the one below and record your result for the parallel circuit.

	PARALLEL CIRCUIT								
	Voltage (V)				Current (A)				
	V	**V_1**	**V_2**	**V_3**	**I**	**I_1**	**I_2**	**I_3**	**$I_1 + I_2 + I_3$**
Circuit 1									
Circuit 2									
Circuit 3									

Analysis of the result: **(4 marks)**

With the result recorded in the tables, do a qualitative analysis of the results.

20. Compare the currents through individual resistors with each other.
21. Compare the sum of the currents through individual resistors with the current before the parallel branches.
22. Compare the various voltage measurements across the parallel resistors.

Conclusion: **(4 marks)**

Write down the conclusion for the experiment.

Rubric:

Following the instruction and manipulation **(8 marks)**

Criteria	High (4)	Medium (3)	Low (2)	None (0)
Accurately following a sequence of written/verbal instructions	Following a sequence of instructions including branched instructions	Can complete an experiment by following a sequence of instructions	Able to follow a single written, diagrammatic or verbal instruction	Unable to follow a single written, diagrammatic or verbal instruction
Manipulative skills include correct and safe handling of apparatus and materials	Able to use all apparatus and materials correctly and safely	Uses most of the apparatus and materials safely	Able to use only the most basic equipment	Unable to use only the most basic equipment

Report:

The experiment must be presented in a report form; where the following heading must be presented:

1. **School name**
2. **Name, surname, grade and class.**
3. **Aim**
4. **Apparatus**
5. **Method**
    - The rubric must be included in the method, so you may cut and paste it in your report. (8)
6. **Results**
    - Series circuit (13)
    - Parallel circuit (13)
7. **Analysis of the results**
    - Series circuit (4)
    - Parallel circuit (4)
8. **Conclusions**
    - Series circuit (4)
    - Parallel circuit. (4)

[50]

9.2 Memorandum: Equivalent Resistance in a series-parallel network

MARKING TOOL (EXAMPLE)

School:______________________________

Name & Surname: ______________________________ **Class: 10**_____

FORMAL EXPERIMENT 2: *"ELECTRIC CIRCUITS WITH RESISTORS IN SERIES AND PARALLEL MEASURING POTENTIAL DIFFERENCE AND CURRENT"*

Aims:

- Test what happens to the current and the voltage in series circuits when additional resistors are added.
- Test what happens to the current and the voltage in parallel circuits when additional resistors are added.

Apparatus:

- Four 1,5 V batteries.
- A voltmeter
- An ammeter
- Connecting wires
- 3 resistors with the same resistance
- One switch.

Method: **(8 marks)**

Rubric:

Teacher's marks on the rubric (example)

Criteria	High (4)	Medium (3)	Low (2)	None (0)
Accurately following a sequences of written/verbal instructions	Following a sequence of instructions including branched instructions	Can complete an experiment by following a sequence of instructions	Able to follow a single written, diagrammatic or verbal instruction	Unable to follow a single written, diagrammatic or verbal instruction
Manipulative skills include correct and safe handling of apparatus and materials	Able to use all apparatus and materials correctly and safely	Uses most of the apparatus and materials safely	Able to use only the most basic equipment	Unable to use even the most basic equipment

Part I (Series circuit)

Result **(13 marks)**

	SERIES CIRCUIT										
	Voltage (V)						Current (A)				
	V	V_1	V_2	V_3	$V_1 + V_2 + V_3$		I_1	I_2	I_3	I_4	
Circuit 1	6	6			6	✓✓	0,6	0,6			✓✓
Circuit 2	6	3	3		6	✓✓	0,3	0,3	0,3		✓✓
Circuit 3	6	2	2	2	6	✓✓	0,2	0,2	0,2	0,2	✓✓
	✓										

Analysis of the result: **(4 marks)**

The sum of all the voltages across all the resistors is the same for all circuits, which is equal to the voltage across the battery. ✓✓

The current is the same at every point in the circuit, but decreases when the number of resistors connected in series increases. ✓✓

Conclusion: **(4 marks)**

In a series circuit the current is the same at every point in the circuit ✓ but depends on the number of resistors connected in series – when the number of resistors connected in series increases the current decreases. ✓The voltage is divided across the resistors but the sum of all the voltages across all the resistors is equal to the voltage across the battery. ✓ Series circuits are voltage dividers, while current is the same at every point. ✓

Part II (Parallel circuit)

Result: **(13 marks)**

	PARALLEL CIRCUIT										
	Voltage (V)					Current (A)					
	V	V_1	V_2	V_3		I	I_1	I_2	I_3	$I_1 + I_2 + I_3$	
Circuit 1	6	6			✓✓	0,6				0,6	✓✓
Circuit 2	6	6	6		✓✓	1,2	0,6	0,6		1,2	✓✓
Circuit 3	6	6	6	6	✓✓	1,8	0,6	0,6	0,6	1,8	✓✓
						✓					

Analysis of the result: **(4 marks)**

The current splits across the different paths (branches). ✓

The sum of the current through the individual resistors is equal to the current before the parallel branches (total current in the circuit). ✓ When the number of resistors increases the total current increases too. ✓

The voltage is the same across the resistors connected in parallel and it is equal to the voltage across the battery. ✓

Conclusion: **(4 marks)**

In a parallel circuit the voltage is the same across all the resistors, ✓ however the current splits across the different paths but the sum of the current through the individual resistors is equal to the current before the parallel, branches (total current in the circuit). ✓ When the number of resistors connected in parallel increases, the current also increases. ✓Parallel circuits are current dividers, while potential difference (voltage) remains constant. ✓

10. Grade 11 Experiments

10.1 Newton's Second Law Option 1

10.1.1 Worksheet: Experiment: Grade 11: Newton's Second Law: Option 1

Experiment 1 (Mechanics)
GRADE 11

Experiment 1 (Mechanics)

THE RELATIONSHIP BETWEEN RESULTANT FORCE AND ACCELERATION (NEWTON'S SECOND LAW)

INTRODUCTION

We studied Newton's second law of motion and we know that it states that:

If a resultant force acts on a body, it will cause the body to accelerate in the direction of the resultant force. The acceleration of the body will be directly proportional to the resultant force and inversely proportional to the mass of the body. **The mathematical representation is:**

$$\vec{F}_R = m\vec{a}$$

Or

$$\vec{a} = \frac{\vec{F}_m}{m}$$

DEVELOPMENT

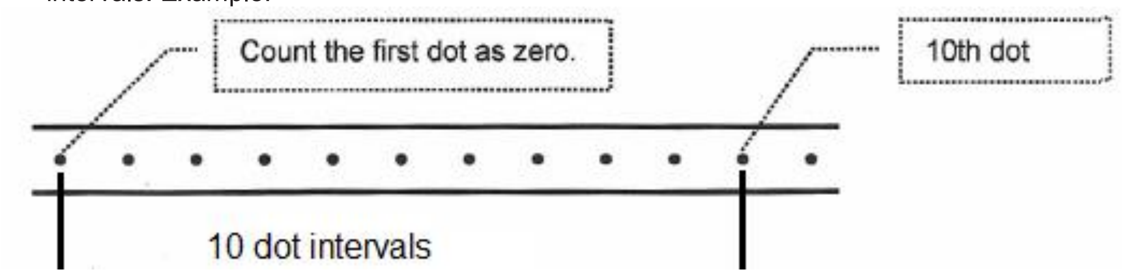
Aim to investigate the relationship between resultant force and acceleration.

Apparatus

- Trolley with frictionless wheels that run on a smooth runway
- Ticker-timer and tape
- Batteries or transformer for the ticker-timer
- 3 or 4 elastic bands of the same length
- A metre ruler

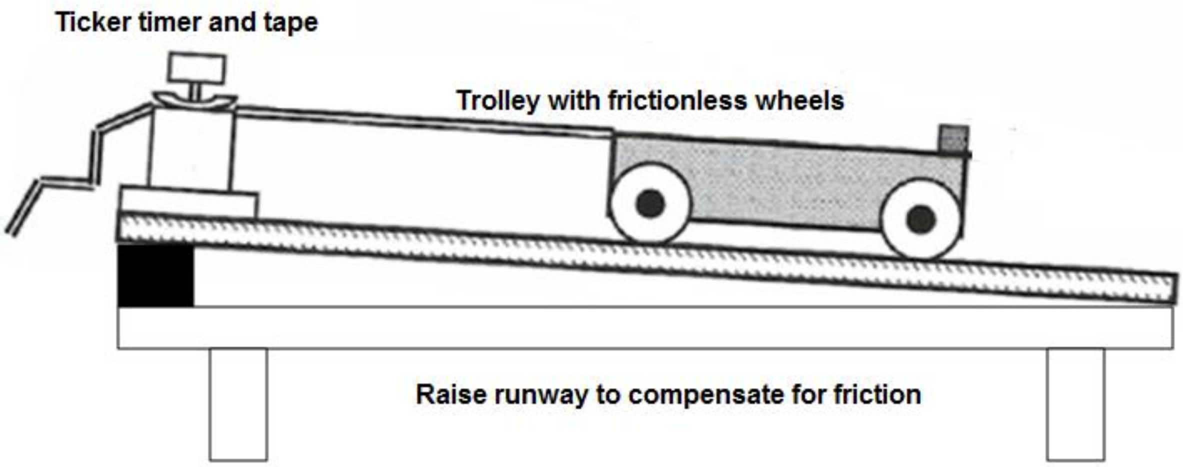
Method:

1. Write down the independent, dependent and controlled variables for the experiment. **(3 marks)**
2. Select in the ticker-timer a frequency of 25 Hz or 50 Hz. Determine the period of the ticker-timer. **(3 marks)**
3. Determine the time for eleven dots (10-tick intervals) (t=n x T) where **n** is the number of ticks or intervals. Example:



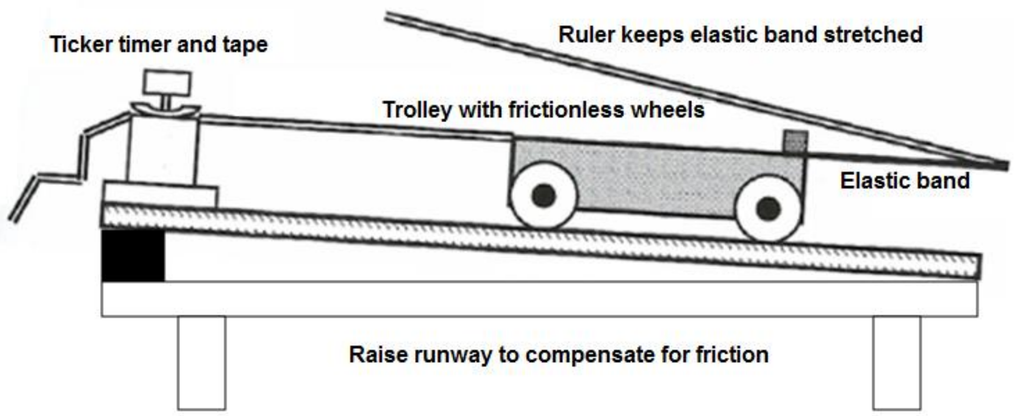
(2 marks)

4. Place a trolley on a runway and adjust the runway to compensate for friction on the trolley wheels (incline the runway until the trolley runs with constant velocity – see figure below).



(2 marks)

5. Attach one end of an elastic band to the trolley and the other end of the elastic band to the end of the ruler. Let a partner hold onto the trolley while you stretch the elastic band until the 800 mm mark on the ruler is in line with the front of the trolley. Signal your partner to release the trolley and move forward with the trolley, keeping the elastic band stretched by the same amount. Practise this a few times.



6. Pass the tape through the timer and attach it to the end of the trolley. Make sure the tape has no slack between the trolley and the timer. Start the timer, stretch the elastic as before (800 mm) and move forward, keeping the elastic band stretched by the same amount to apply a constant force. Take the applied force with the unit of rubber bands. What is the applied force? **(1 mark)**

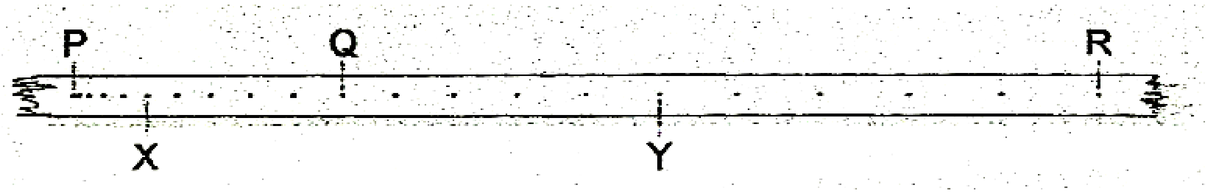
7. At the end of the motion remove the tape from the trolley and timer. Note the frequency of the timer and mark 10 dot intervals on the tape, starting close to the beginning of the tape where the dots are clearly visible.

8. Repeat steps 6 and 7.

   8.1 Start the timer, stretch the elastic twice as before (1600 mm) and move forward keeping the elastic band stretched by the same amount to apply a constant force. What is the applied force now? **1 mark**

   8.2 Start the timer, stretch the elastic three times as before (2400 mm) and move forward, keeping the elastic band stretched by the same amount. What is the applied force now? **1 mark**

9. Analyse the tape for each case (trial) to determine the acceleration and record your results in table 1. **(18 marks)**



Example

Velocity at dot X

$$V_X = \frac{\Delta X}{\Delta t} = \frac{PQ}{0{,}4}$$

Velocity at dot Y

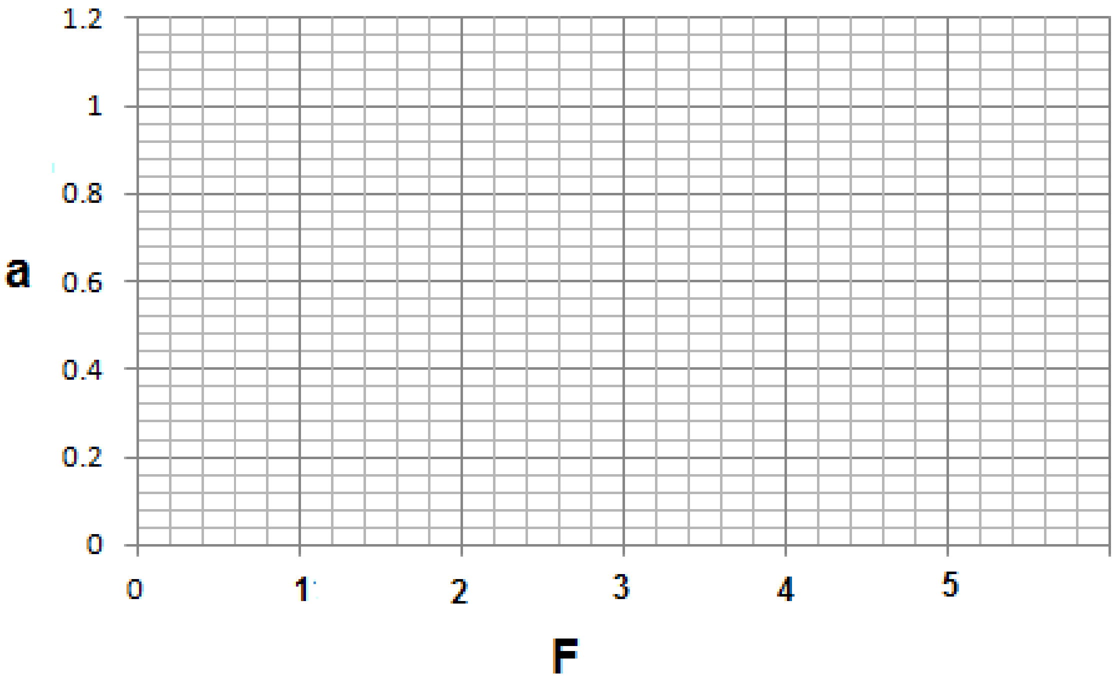
$$V_y = \frac{\Delta X}{\Delta t} = \frac{QR}{0{,}4}$$

Use equations of motion to calculate acceleration.

$$a = \frac{v_Y - v_x}{\Delta t} = \frac{v_y - v_x}{0{,}4}$$

Trial Number	Resultant force F (number of elastic bands)	PQ (m)	v_x ($m.s^{-1}$)	QR (m)	v_y ($m.s^{-1}$)	a ($m.s^{-2}$)	F/a
1							
2							
3							

10. Plot a graph of resultant force against acceleration. **(4 marks)**



11. Do the analysis and interpretation of your results (table and graph). **(3 marks)**

12. Write down ONE possible significant error in this experiment. **(1 mark)**

13. How have you eliminated these errors? **(1 mark)**

CONCLUSION

14. Write the conclusion for this experiment. **(4 marks)**

The following instructions and manipulation will be assessed with a rubric **(6 marks)**.

Total 50 Marks

Report:

The experiment must be presented in a report form and the following headings must be present:

i. **Aim**

ii. **Apparatus**

iii. **Variables**

iv. **Method**

- All the calculations must be shown.
- The rubric must be included in the method, so you may cut and paste it in your report.

v. **Recording of the results**

- Table
- The calculations must be shown.
- Graph

vi. **Analysis of the results**

vii. **Possible bias or experimental errors**

viii. **Conclusions**

Experiment 1 (Mechanics)
GRADE 11

PHYSICAL SCIENCES

ASSESSMENT TOOL EXPERIMENT 1 GRADE 11

MEMORANDUM

1. **VARIABLES**

   Independent: net force ✓

   Dependent: acceleration ✓

   Controlled: mass of the object✓ **(3 marks)**

2. To determine the period of the ticker-timer (**3 marks**)

$$T = \frac{1}{f} ✓$$
$$T = \frac{1}{40} ✓$$
$$T = 0{,}025 \text{ s} ✓$$

OR

$$T = \frac{1}{f} ✓$$
$$T = \frac{1}{50} ✓$$
$$T = 0{,}02 \text{ s} ✓$$

3. To determine the time **(2 marks)**

t= n x T
t= 10 x 0,025 s✓
t= 0,25 s✓

OR

t= n x T
t= 10 x 0,02 s✓
t= 0,2 s✓

4. Compensate for friction by raising the end of the runway. ✓ **(2 marks)**

6. The force applied by the elastic band is constant as long as the length of the band is constant.✓ **(1 mark)**

8.1 The force applied by two elastic bands is constant and twice the time of that applied by one elastic band.✓ **(1 mark)**

8.2 The force applied by three elastic bands is constant and three times the time of that applied by one elastic band.✓ **(1 mark)**

9. Completion of the table with the analysis of the tape. **(18 marks)**

Trial Number	Resultant force F (number of elastic bands)	PQ (m)	v_x (m.s^{-1})	QR (m)	v_y (m.s^{-1})	a (m.s^{-2})	F/a
1		✓	✓	✓	✓	✓	✓
2		✓	✓	✓	✓	✓	✓
3		✓	✓	✓	✓	✓	✓

An example of the tabular column

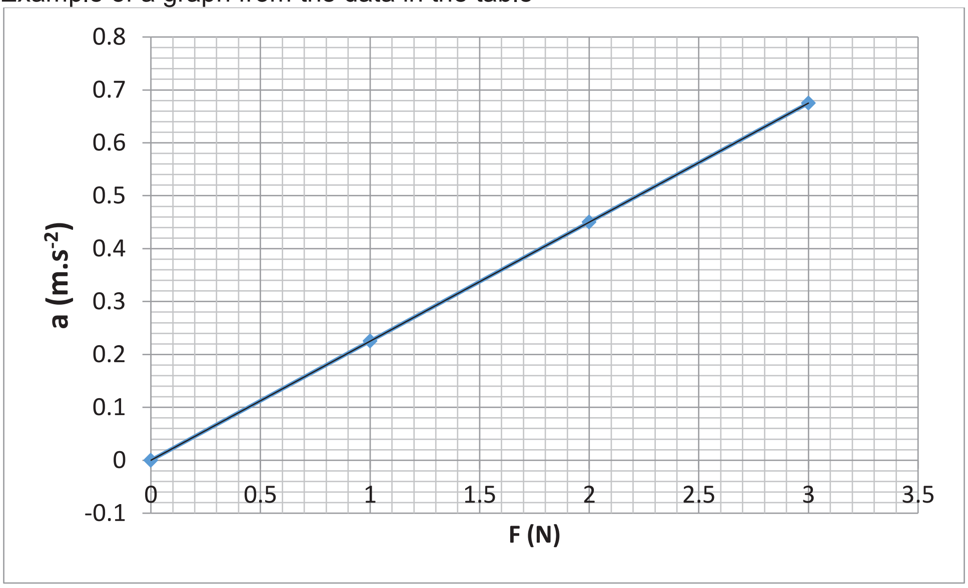
(Results)

Tape	**Resultant force/**	**PQ (m)**	**v_x (m.s^{-1})**	**QR (m)**	**v_y (m.s^{-1})**	**a ((m.s^{-2})**	**F/a**
1	1	0,064	0,16	0,100	0,25	0,225	4,44
2	2	0,132	0,33	0,204	0,51	0,45	4,44
3	3	0,190	0,48	0,298	0,75	0,675	4.44

10. Marking criteria for the graph **(4 marks)**

Criteria	Mark
F-axis correctly identified (in x-direction) with label and unit	✓
A-axis correctly identified with label (in y-direction) and unit	✓
Plotting correctly done	✓
Correct shape (straight line)	✓

Example of a graph from the data in the table



11. Analysis and interpretation of the results. **(3 marks)**

$\frac{F}{a}$ is constant✓ and the graph is a straight line✓ then a α F✓.

12. Possible errors **(1 mark)** (at least one, for example friction)

13. How were the errors eliminated? **1 mark**

14. Conclusion **(4 marks)**

Dependent variable (1 mark) acceleration

Independent variable (1 mark) force

Constant variable (1 mark) mass

Relationship (1 mark) directly proportional

Example

When the mass of an object is constant, the acceleration thereof is directly proportional to the force that produces it.

RUBRIC

1.1 Following instructions and manipulation **(6 marks)**.

Criteria	High (3)	Medium (2)	Low (1)	None (0)
Accurately follows a sequence of written/verbal instructions	Follows a sequence of instructions, including branched instructions	Can complete an experiment by following a sequence of instructions	Able to follow a single written, diagrammatic or verbal instruction	Unable to follow a single written, diagrammatic or verbal instruction
Manipulative skills include correct and safe handling of apparatus and materials	Able to use all apparatus and material correctly and safely	Uses most of the apparatus and materials safely	Able to use only the most basic equipment	Unable to use only the most basic equipment

Total **50 marks** (converted to 20).

Formal experiment is 20% of SBA.

10.2 Newton's Second Law Option 2

10.2.1 Worksheet: Experiment: Newton's Second Law: Option 2

Experiment 1 (Mechanics)
GRADE 11

FORMAL EXPERIMENT 1: *"RELATIONSHIP BETWEEN RESULTANT FORCE AND ACCELERATION" (NEWTON'S SECOND LAW)*

INTRODUCTION

We studied Newton's second law of motion and we know that it states that:

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$$\vec{F}_R = m\vec{a}$$

Or

$$\vec{a} = \frac{\vec{F}_m}{m}$$

DEVELOPMENT

Aim: To investigate the relationship between resultant force and acceleration

Apparatus

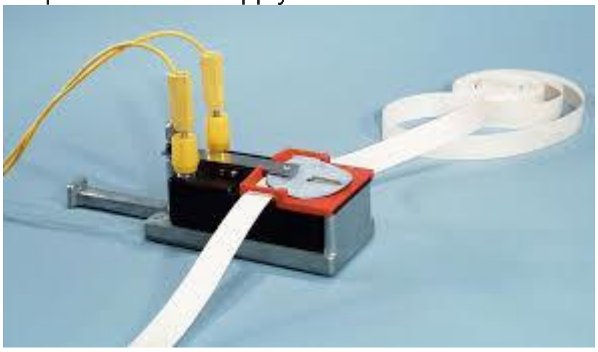
- Trolley
- Track for the trolley
- Ticker-timer and tape
- Batteries or transformer for the ticker-timer
- String
- Pulley
- Thread
- Mass pieces

VARIABLES

- **Independent: net force**
- **Dependent: acceleration**
- **Controlled: mass of the object**

Method

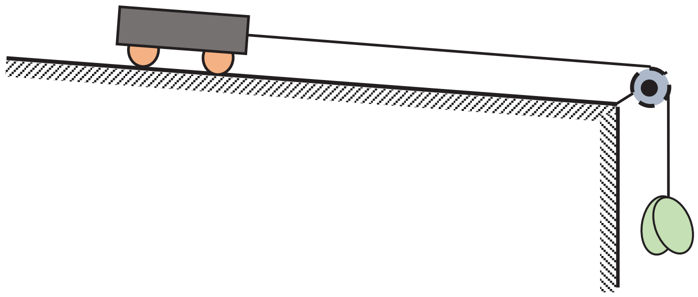
1. Mount the ticker-time on the track (rail).
2. Attach a carbon disc to the ticker-timer.
3. Connect the ticker-timer to a power source supply of 6 V



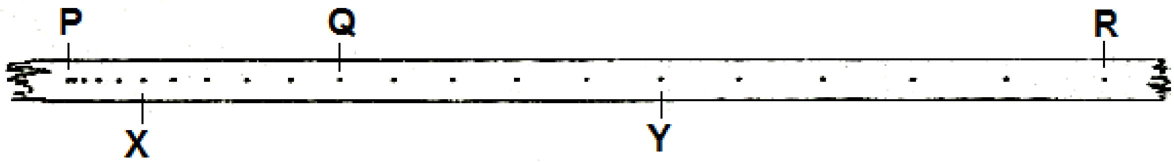
4. Select in the ticker-timer the frequency (number of dots in one second) of 40 Hz or 50 Hz.
5. Determine the period of the ticker-timer. **(2 marks)**

$T = \frac{1}{f}$

6. Calculate the time between the 10 dots. ($\Delta t = n \times T$). **(2 marks)**
7. Place a trolley on a runway and adjust the runway to compensate for friction on the trolley wheels (incline the runway until the trolley runs with constant velocity).
8. Pass a piece of string with a 20 g mass hanging on one end over a pulley (figure below). Attach the other end to the trolley so that, when the mass is released, it causes the trolley to accelerate. Choose a length of string such that the mass does not touch the ground until the trolley nearly reaches the pulley.



9. Place the unused masses provided on the trolley. You are going to transfer them to the mass holder each time the accelerating force is increased. This ensures that the total mass experiencing acceleration remains constant throughout the experiment.
10. Start the timer and release the system, leaving it free to move with acceleration.
11. Remove the tape and select two displacements of ten intervals each (**PQ** and **QR**) from the starting point and measure the distance covered in each case (see the diagram below).



12. Count 5 dots of the first displacement **PQ** and mark with an **X**, count 5 dots for the second displacement **QR** and mark with a **Y**. See figure above.
13. Repeat the steps 11 and 12 but with hanging masses of 40 g and 60 g respectively, transferring them from the trolley.

Rubric: **(6 marks)**

Following instructions and manipulation

Criteria	High (3)	Medium (2)	Low (1)	None (0)
Accurately follows a sequence of written/verbal instructions	Follows a sequence of instructions, including branched instructions	Can complete an experiment by following a sequence of instructions	Able to follow a single written, diagrammatic or verbal instruction	Unable to follow a single written, diagrammatic or verbal instruction
Manipulative skills include correct and safe handling of apparatus and materials	Able to use all apparatus and materials correctly and safely	Uses most of the apparatus and materials safely	Able to use only the most basic equipment	Unable to use only the most basic equipment

Result:

Record your observations from the experiment in a table like the one below. **(18 marks)**

Trial Number	Resultant force: $(F_R = F_g = mg)$	PQ (m)	v_x (m·s^{-1})	QR (m)	v_y (m·s^{-1})		a (m·s^{-2})
1							
2							
3							

The velocity at point X and at point Y can be calculated as follows:

Velocity at dot X:

$$v_X = \frac{\Delta x}{\Delta t} = \frac{PQ}{\Delta t}$$

Velocity at dot Y:

$$v_Y = \frac{\Delta x}{\Delta t} = \frac{QR}{\Delta t}$$

Use equations of motion to calculate acceleration.

$$a = \frac{v_f - v_i}{\Delta t} = \frac{v_y - v_x}{\Delta t}$$

Note: Show all calculations in your reports.

With the result recorded in the table, plot a graph of acceleration vs. resultant force and draw the line of best fit. **(4 marks)**

Analysis of the results:

Using the graph to do the analysis of the result of the experiment. **(3 marks)**

Conclusion:

Write the conclusion for the experiment. **(2 marks)**

Possible bias or experimental errors:

1. What are possible errors that can occur in this experiment? **(1 mark)**
2. How can the errors be eliminated? **(1 mark)**

Applications

Question 1:

To investigate how acceleration depends on mass if force is constant.

A single elastic band was used to accelerate first one, then two, then three identical trolleys stacked on top of each other. The mass of a single trolley is 800 g. The results are given below.

m (kg)	$1/m$	$v_i (m \cdot s^{-1})$	$v_f (m \cdot s^{-1})$	$\Delta t\ (s)$	$a = \frac{v_f - v_i}{\Delta t}$	ma
0,8		0,31	0,43	0,4		
1,6		0,24	0,3	0,4		
2,4		0,21	0,25	0,4		

1.1 In this experiment:

1.1.1 Name the independent variable. (1)

1.1.2 Name the dependent variable. (1)

1.1.3 Name the control variable. (1)

1.2 Complete the table given above. (3)

1.3 What does the value of *ma* indicate about the relationship between *m* and *a*? (1)

1.4 How much force is exerted by one elastic band? (1)

1.5 On graph paper, draw the graph of *a* against 1/m. (3)

[11]

Total 50 marks

Report

The experiment must be presented in a report form and the following headings must be present:

1. **Aim**
2. **Apparatus**
3. **Variables**
4. **Method**
   - All the calculations must be shown. (4)
   - The rubric must be included in the method, so you may cut it and paste it in your report. (6)
5. **Recording of the results**
   - Table (18)
   - The calculations must be shown.
   - Graph (4)
6. **Analysis of the results** (3)
7. **Conclusions** (2)
8. **Possible bias or experimental errors** (2)
9. **Questions** (11)

[50]

Name: ____________________________________ Class: ___________

Acceleration vs. resultant force

Experiment 1 (Mechanics)
GRADE 11

Report and marking tool

FORMAL EXPERIMENT 1: *"RELATIONSHIP BETWEEN RESULTANT FORCE AND ACCELERATION" (NEWTON'S SECOND LAW)*

Aim: To investigate the relationship between resultant force and acceleration

Apparatus

- Trolley
- Track for the trolley
- Ticker-timer and tape
- Batteries or transformer for the ticker-timer
- String
- Pulley
- Thread
- Mass pieces

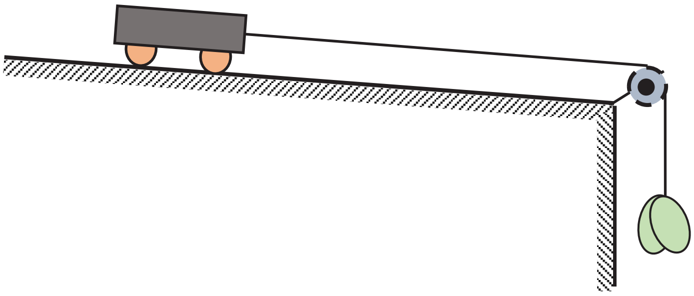
Variables

- **Independent: net force**
- **Dependent: acceleration**
- **Controlled: mass of the object**

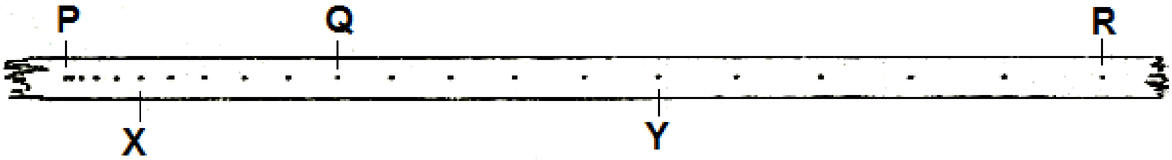
Method

1. Mount the ticker-time on the track (rail).
2. Attach a carbon disc to the ticker-timer.
3. Connect the ticker-timer to a power source supply of 6 V

4. Select in the ticker-timer the frequency (number of dots in one second) of 40 Hz or 50 Hz.
5. Determine the period of the ticker-timer. **(2 marks)**
   $T = \frac{1}{f} = \frac{1}{50} \checkmark = 0,02\ s\checkmark$
6. Calculate the time between the 10 dots.
   $\Delta t = n \times T = (10)(0,02)\checkmark = 0,2\ s\checkmark$ **(2 marks)**
7. Place a trolley on a runway and adjust the runway to compensate for friction on the trolley wheels (incline the runway until the trolley runs with constant velocity).
8. Fix a thread to the trolley and pass it through the pulley and hang 20 g mass pieces as shown in figure bellow.



9. Start the timer and leave the system free to move with acceleration.
10. Remove the tape and select two displacements of ten intervals each (**PQ** and **QR**) from the starting point and measure the distance covered in each case (see the diagram below).



11. Count 5 dots of the first displacement **PQ** and mark with an **X**, count 5 dots for the second displacement **QR** and mark with a **Y**. See figure above.
12. Repeat the steps 11 and 12 but with hanging masses of 40 g and 60 g respectively.

Rubric: **(6 marks)**

Following instructions and manipulation

Criteria	High (3)	Medium (2)	Low (1)	None (0)
Accurately follows a sequence of written/verbal instructions	Follows a sequence of instructions, including branched instructions	Can complete an experiment by following a sequence of instructions	Able to follow a single written, diagrammatic or verbal instruction	Unable to follow a single written, diagrammatic or verbal instruction
Manipulative skills include correct and safe handling of apparatus and materials	Able to use all apparatus and materials correctly and safely	Uses most of the apparatus and materials safely	Able to use only the most basic equipment	Unable to use only the most basic equipment

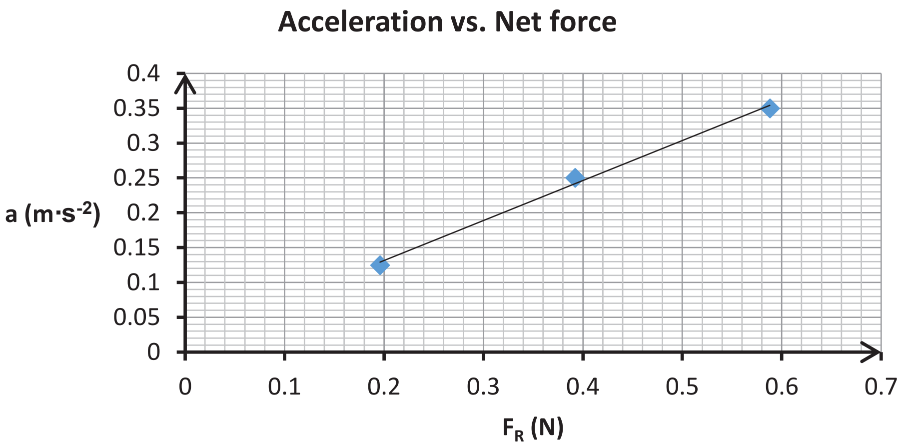
Results:

Record your observations from the experiment in a table like the one below.

Trial	Resultant force: $(F_R = F_g = mg)$	PQ (m)	v_x (m·s⁻¹)	QR (m)	v_y (m·s⁻¹)	a (m·s⁻²)
1	$F_{R1} = mg$ $F_{R1} = 0,02 \times 9,8$ $F_{R1} = 0,196\ N$ ✓	0,037✓	$v_X = \frac{PQ}{\Delta t}$ $v_X = \frac{0{,}037}{0{,}2}$ $v_X = 0,185$ ✓	0,042✓	$v_Y = \frac{QR}{\Delta t}$ $v_Y = \frac{0{,}042}{0{,}2}$ $v_Y = 0,21$ ✓	$a = \frac{v_y - v_x}{\Delta t}$ $= \frac{0{,}21-0{,}185}{0{,}2}$ $= 0,125$ ✓
2	$F_{R2} = mg$ $F_{R2} = 0,04 \times 9,8$ $F_{R2} = 0,392\ N$ ✓	0,036✓	$v_X = \frac{PQ}{\Delta t}$ $v_X = \frac{0{,}036}{0{,}2}$ $v_X = 0,18$ ✓	0,046✓	$v_Y = \frac{QR}{\Delta t}$ $v_Y = \frac{0{,}046}{0{,}2}$ $v_Y = 0,23$✓	$a = \frac{v_y - v_x}{\Delta t}$ $= \frac{0{,}23-0{,}18}{0{,}2}$ $= 0,25$ ✓
3	$F_{R3} = mg$ $F_{R3} = 0,06 \times 9,8$ $F_{R3} = 0,588\ N$ ✓	0,056✓	$v_X = \frac{PQ}{\Delta t}$ $v_X = \frac{0{,}056}{0{,}2}$ $v_X = 0,28$ ✓	0,07✓	$v_Y = \frac{QR}{\Delta t}$ $v_Y = \frac{0{,}07}{0{,}2}$ $v_Y = 0,35$✓	$a = \frac{v_y - v_x}{\Delta t}$ $= \frac{0{,}35-0{,}28}{0{,}2}$ $= 0,35$ ✓

(18 marks)

Graph:



Criteria	Mark
F-axis correctly identified (in x-direction) with label and unit	✓
A-axis correctly identified with label (in y-direction) and unit	✓
Plotting correctly done	✓
Correct shape (straight line)	✓

(4 marks)

Analysis of the results:

$\frac{F}{a}$ is constant✓ and the graph is a straight line✓ then a α F✓ **(3 marks)**

Conclusion:

When the mass of an object is constant ✓the acceleration thereof is directly proportional to the (net) force that produces it. ✓ **(2 marks)**

Possible bias or experimental errors:

1. Friction is not really zero **(1 mark)**
2. Putting oil in the wheels of the trolley **(1 mark)**

Question:

1.1

1.1.1 Mass ✓ (1)

1.1.2 Acceleration ✓ (1)

1.1.3 Force ✓ (1)

1.2

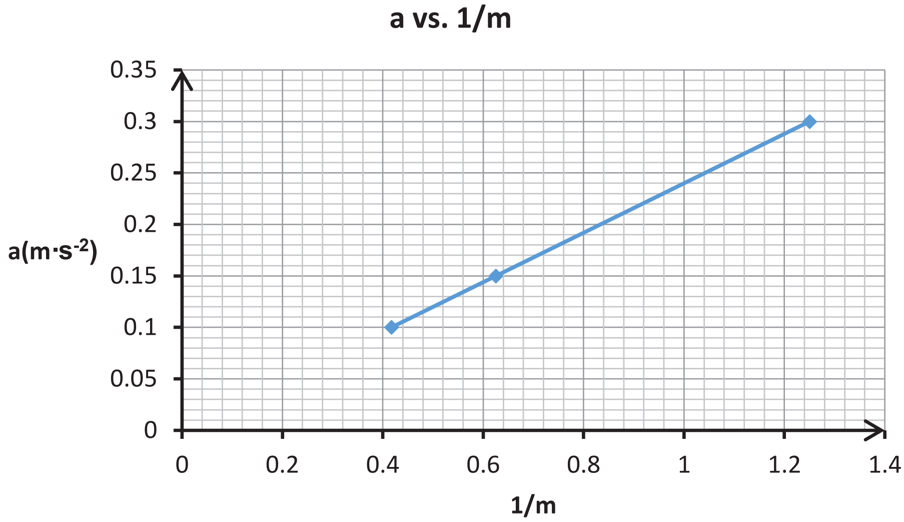
m (kg)	$^1/_m$	$v_i(m \cdot s^{-1})$	$v_f(m \cdot s^{-1})$	$\Delta t\ (s)$	$\boldsymbol{a = \frac{v_f - v_i}{\Delta t}}$	ma	
0,8	**1,25**	0,31	0,43	0,4	**0,3**	**0,24**	✓
1,6	**0,625**	0,24	0,3	0,4	**0,15**	**0,24**	✓
2,4	**0,416**	0,21	0,25	0,4	**0,1**	**0,24**	✓

(3)

1.3 $\boldsymbol{ma}$ is constant therefore $\boldsymbol{a} \propto \frac{\boldsymbol{1}}{\boldsymbol{m}}$ ✓ (1)

1.4 $F = 0{,}24\ N$ ✓ (1)

1.5



Criteria	Mark
Both axes correctly identified with label and unit	✓
Plotting correctly done	✓
Correct shape (straight line)	✓

(3)

11 marks.

Total 50 marks

11. Grade 12 Experiments

11.1 Momentum

11.1.1 Worksheet: Conservation of Linear Momentum

Grade 12 Physical Sciences – Formal Prescribed Experiment
Duration: 1 hour
Marks: 50 **Name: ……………….................**

THE CONSERVATION OF LINEAR MOMENTUM

Aim: In this experiment we verify the law of conservation of linear momentum

A. INTRODUCTION

Momentum (p) of the body is the product of its mass (m) and its linear velocity (v), measured in kg·m.s^{-1}, p = mv

Law of conservation of momentum: The total linear momentum of an isolated system remains constant (conserved).

The total momentum before the collision = the total momentum after the collision

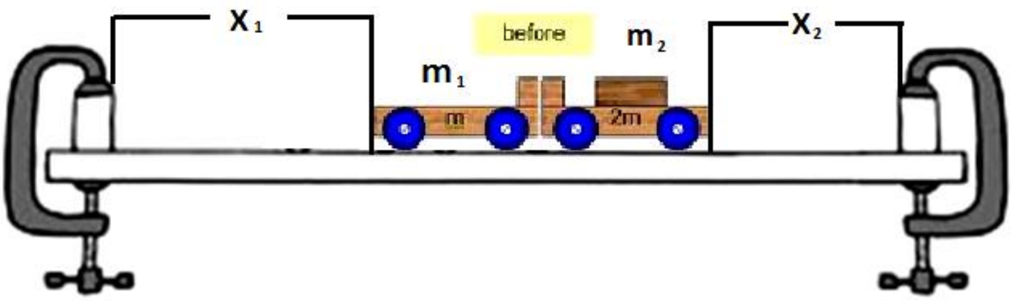
$$(m_A + m_B)v_i = m_A v_{Af} + m_B v_{Bf}$$

APPARATUS:

- Two spring-loaded trolleys
- Stopwatch
- Meter stick
- Two barriers

B. PROCEDURE:

1. Measure the masses of the two trolleys and write down your results.
   m_1....................................... m_2…………………………….. (2)
2. Set up apparatus as indicated in the diagram.



3. Predict which trolley will reach the barrier first if the spring is released. (1)
   …………………………………………………………………………………………
4. Give a reason for your prediction. (2)
   …………………………………………………………………………………………
   …………………………………………………………………………………………
   …………………………………………………………………………………………
   …………………………………………………………………………………………
5. Release the spring and write down your observations. (2)
   …………………………………………………………………………………………
   …………………………………………………………………………………………
   …………………………………………………………………………………………

6. Put the two trolleys back on the track in a position that will make them hit the barrier at the same time. Mark this position.

7. What is the velocity of the trolleys before the collision?
Trolley 1 ………………………… Trolley 2 ……………………….. (2)

8 Motivate your answer in 7.

………………………………………………………………………………………….. (1)

9 Repeat the procedure in 6 and measure the distances covered x_1 and x_2 (2)

x_1 …………………………. x_2 ………………………………

10. Record your results in the following table (with correct SI units) (4)

After the collision			
m_1	$\frac{\Delta x_1}{\Delta t} = v_1$	m_2	$\frac{\Delta x_2}{\Delta t} = v_2$

11. Repeat the experiment by using different masses m_3 & m_4 and complete the table.

12. Take one of the set of values and determine the following:

a. The momentum of trolley 1 after the collision (4)
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………

b. The momentum of trolley 2 after the collision (3)
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………

c. What is the total linear momentum of the trolleys after the spring is released? (2)
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………

B. CONCEPTUAL QUESTIONS (control questions)

1 What is the total linear momentum of the trolleys before the spring is released? Give a reason for your answer. (2)

…………………………………………………………………………………………………..
…………………………………………………………………………………………………..

2 Explain in your own words why it is acceptable to take the displacements of the trolleys x_1 and x_2 as a measure of the velocity of the trolleys. Use suitable equations to motivate your answer. (3)

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

3 Why must the wheels of the trolleys and the runway be frictionless? (2)

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

4 List TWO precautions that should be taken to ensure accurate results. (2)

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

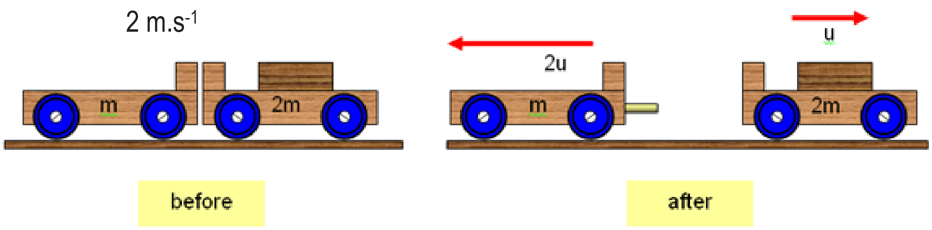
5 Explain the importance of the directions of x_1 and x_2 in the experiment. (2)

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

6 What conclusion can you reach from the experiment? (2)

………………………………………………………………………………………………
………………………………………………………………………………………………

7 Two fully loaded train carts with given masses move at a velocity of 2.m.s^{-1} to the right. The carts are connected with an small blasting charge that is activated to separate the carts, so the velocity of B will increase from 2.m.s^{-1} to 6.m.s^{-1} .



7.1 Name the law or principle that enables you to calculate the new velocity of Cart A immediately after the two carts were separated. (1)

……………………………………………………………………………………………...

7.2 Calculate the new velocity of cart A. (4)

……………………………………………………………………………………………...
……………………………………………………………………………………………...
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……………………………………………………………………………………………...
……………………………………………………………………………………………...
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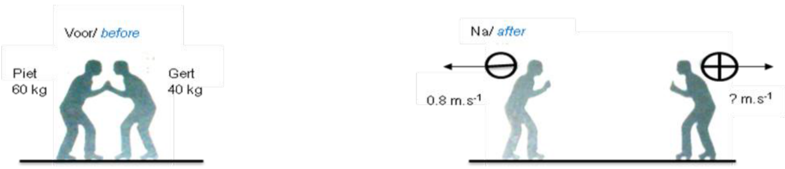
……………………………………………………………………………………………...

8. Two boys, Peter and Gert, each on roller skates, put their hands together and push. They move in opposite directions as shown in the figure below. (Choose to the right as positive.)



8.1 According to the law of conservation of momentum, the total momentum before a collision or explosion is equal to the total momentum after the collision or explosion. In this situation, the total momentum of the two boys at the beginning is ZERO. How is it possible that the total momentum of the two boys, after they pushed each other and moved, is zero? (2)

……………………………………………………………………………………………...
……………………………………………………………………………………………...

8.2 Explain why the rate of change in velocity of Gert will be larger than that of Peter? (2)

……………………………………………………………………………………………...
……………………………………………………………………………………………...
……………………………………………………………………………………………...
……………………………………………………………………………………………...

8.3 If Peter moves with a velocity of 0.8 ms^{-1} to the left, calculate the speed at which Gert will move. (3)

……………………………………………………………………………………………...
……………………………………………………………………………………………...
……………………………………………………………………………………………...
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TOTAL: 50 MARKS

11.1.2 Memorandum: Conservation of Linear Momentum

Grade 12	Physical Sciences – Formal Prescribed Experiment
Marks 50	Memorandum

Law of conservation of linear momentum

C. *PROCEDURE:*

1. m_A ____________________ ✓ m_B ____________________ ✓ (2)

3. The one closest to the barrier✓ (1)

4. Both experience the same force (Newton's third law of motion) ✓
   The velocities at which they move away are the same ✓ (2)

5. The trolleys move away in opposite directions and the one closest to the barrier hits it first ✓ (2)

7. Trolley 1 ……………………✓ Trolley 2 ………………………..✓ (2)

8. Both are at rest before the collision✓ (1)

9. x_1 ………………………….. ✓ x_2 ………………………………✓ *(2)*

10

After the collision			
m_1	$\frac{\Delta x_1}{\Delta t} = v_1$	m_2	$\frac{\Delta x_2}{\Delta t} = v_2$
	✓		✓
	✓		✓

(4)

12.1 p = m v ✓
p = ( ) ( ) ✓
p = ………………
p = ……………✓ + direction✓ (4)

12.2 p = m v
p = ( ) ( )✓
p = ………………
p = ……………✓ + direction✓ (3)

12.3 $p_{T(aft)} = p_1 + p_2$

$= \ldots\ldots\ldots\ldots + \ldots\ldots\ldots\ldots$ ✓

$= \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ ✓ (2)

B ***CONCEPTUAL QUESTIONS (control questions)***

1. 0✓ *There is no movement*✓ (2)

2. The time that the trolleys hit the barrier is the same and therefore time can be taken as 1 s. ✓

$V = \Delta x / \Delta t$ ✓

$V = \Delta X / 1$ ✓

$V = \Delta X$ (3)

3 Isolated system is required ✓

No external forces to act on trolleys ✓ (2)

4. Frictionless surface ✓

Distances to be measured accurately ✓

Time for trolleys to hit barriers must be the same

Any (TWO) (2)

5 Velocity is a vector quantity, therefore momentum is also a vector quantity✓
Displacement is used as velocity in this experiment, therefore x must have direction that can be negative✓. (2)

6. The total linear momentum before the collision is equal to the total linear momentum after the collision. ✓✓ (2)

7.1 Conservation of momentum ✓ (1)

7.2

$p_{T(bef)} = p_{T(aft)}$ ✓

$(m + 2m)2$ ✓ $= m(v) + 2m(6)$ ✓

$6m = mv + 12m$

$-6m = mv$

$-6 \text{ m.s}^{-1} = v$

$V = 6 \text{ m.s}^{-1}$ to the left✓ (4)

8.1 Velocities are in opposite directions and therefore the sum of the momentums will be equal to zero ✓✓ (2)

8.2 Gert experiences the same force as Peter. (Newton's third law of motion). However, Gert has a smaller mass than Peter and according to Newton's second law of motion, Piet will experience less acceleration. ✓✓ (2)

8.3 $\Sigma p(\text{before}) = \Sigma p(\text{after})$ ✓

$0 = 60 \times (-0{,}8) + 40 \times v$ ✓

$V = 1{,}2 \text{ m.s}^{-1}$ ✓ (3)

TOTAL: 50 MARKS

11.2 Internal Resistance

11.2.1 Worksheet: Grade 12 Experiment 3

Example of an Experiment (Teachers can use his /her own experiment)

GRADE 12 Experiment 3 **Date:-------------**

Total Marks- 50
Time (2 hours)

Internal resistance and Series-Parallel networks

NAME OF LEARNER : …………………………………………………………….

SCHOOL : …………………………………………………………….

This experiment is carried out in two parts, Part 1 and part 2.

Part 1

Theory/Background

When the potential difference across the terminals of a battery is measured on its own it has different value to what is measured when it is in a complete circuit. The value will be less when the battery is included in a complete circuit. Sometimes the difference is called the *lost volts*. Nothing has actually been lost but energy has been transferred.

Real batteries are made from materials which have resistance. This means that real batteries are not just sources of potential difference (voltage), but they also possess ***internal resistance***. If the total potential difference source is referred to as the ***emf***, ε, then a real battery can be represented as an emf connected in series with a resistor ***r***. The internal resistance of the battery is represented by the symbol r.

Internal resistance is the resistance to current flow through a voltage source such as a battery which arises from the resistance of the materials from which the source is made.

The sum of the voltages across the external circuit plus the voltage across the internal resistance is equal to the emf:

$\varepsilon = V_{load} + V_{internal\ resistance}$

$\varepsilon = IR_{external} + Ir$

OR

$\varepsilon = IR + Ir$

Aim

- To determine the internal resistance of a battery

Precautions

1. Do not leave the switch closed at all times, change it when changing the components in the circuit. The battery will run flat. Close the switch only for taking the readings on the voltmeter and Ammeter. Take your readings accurately but fast avoid the battery to become hot.
2. Do not conduct the experiment with wet hands.
3. Make sure the batteries do not leak, as the acid they contain may be hazardous.
4. The conducting wires should be insulated to prevent any short circuit that could occur to the handler.
5. Do not touch any open ended conducting wires.

Apparatus

- 4 (Size RD) identical 1.5V cells
- Voltmeter
- Ammeter
- 10Ω Rheostat or Resistors
- Connecting wires
- Cell holder
- Switch

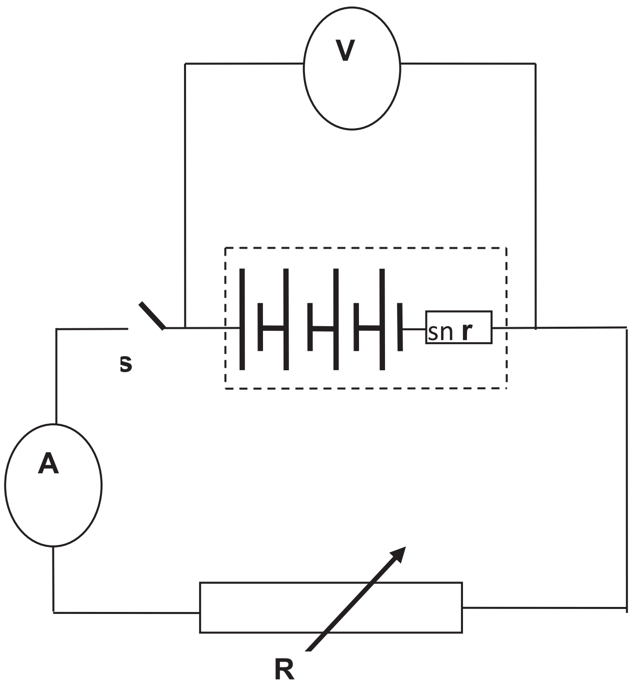
Variables(3 marks)

Write down the following variables for this experiment:

- Independent
- Dependent
- Controlled

Method

1. Set up the apparatus as in the circuit d*iagram below*.



2. Note the voltmeter reading when the switch**S** is open and record in the *Table 1*below.

TABLE 1

Trial No.	Ammeter reading (A)	Voltmeter reading [Terminal voltage] (V)	Marks
1			✓
2			✓
3			✓
4			✓
5			✓
			(5 marks)

3. Close the switch and change the resistance in the rheostat and take the ammeter and voltmeter readings (terminal voltage). (*Open the switch while recording the readings in order to spare the batteries' life span).*
4. Repeat step 3 at least 4 times.
5. Draw a graph of terminal voltage versus current **(3 marks)**
6. Do the analysis and interpretation of the result. **(3 marks)**
7. Use the graph to calculate the internal resistance of ONE CELL. **(3 marks)**
8. Write down a conclusion for part 1 of the experiment. **(3 marks)**

Total marks part 1 (20 marks)

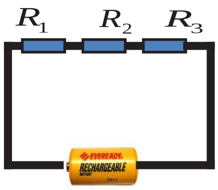
Part 2

Theory/Background

Resistors in series

When resistors are connected in series:

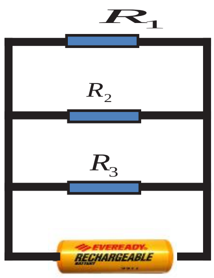
- They are connected end to end so that the same current is carried by each of them.



- There is only one path for current to flow which ensures that **the current is the same at every point in the circuit**.
- The voltage is divided across the resistor. The voltage across the battery in the circuit is equal to the sum of the voltages across the series resistors. $\boldsymbol{V_{battery} = V_1 + V_2 + \cdots + V_n}$
- The resistance to the flow of the current increase. The total resistance, is given by: $R_s = R_1 + R_2 + \cdots + R_n$

Resistors in parallel

They are placed side by side with their corresponding ends connected together so that the current branches.



- The voltage is the same across the resistors. The voltage across the battery in the circuit is equal to the voltage across each parallel resistor: $V_{battery} = V_1 = V_2 = V_3 = \cdots$
- There are more paths for current to flow which ensures that current splits across the different paths. $I_T = I_1 + I_2 + I_3$ (resistors act as current dividers)
- The resistance to the flow of current decreases. The total resistance, R_P is given by $\frac{1}{R_E} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Ohm's Law

The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature.

$$R = \frac{V}{I}$$

Aim

1. To determine the equivalent resistance in a Series-parallel network electrical circuit.
2. To compare the experimental values of the equivalent resistance to the theoretical values.

Apparatus

- 4 (Size RD) identical 1.5V cells
- Voltmeter
- Ammeter
- 3 Resistors of known values
- Connecting wires
- Cell holder
- Switch

Variables (3 marks)

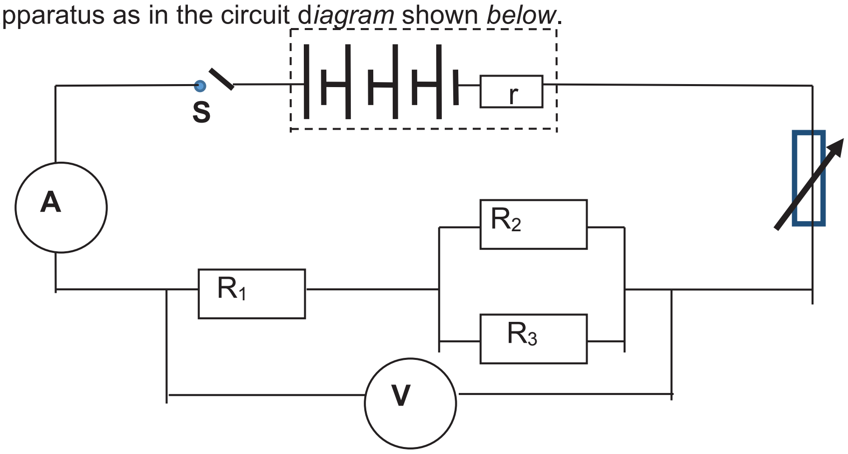
.

Write down the following variables for this experiment:

- Independent
- Dependent
- Controlled

Method

1. Set up the apparatus as in the circuit d*iagram* shown *below*.



2. Close the switch and change the resistance in the rheostat and take the ammeter and voltmeter (terminal voltage) readings and record in T*able 2*. (*Open the switch while recording the readings in order to spare the batteries' life span).*
Repeat step 10 two more times.

3. Calculate the **equivalent external resistance of the circuit** for each measurements and write down the values in table 2.

4. Calculate the average values of potential difference, current and **equivalent external resistance of the circuit** and write down the values in table 2.

TABLE 2

R_1 (Ω)	R_2 (Ω)	R_3 (Ω)	Equivalent resistance of R_2 and R_3	**Theoretical equivalent external resistance of the circuit**	Trial No.	Voltmeter reading (V)	Ammeter reading (I)	**Calculated equivalent external resistance of the circuit**
					1			
					2			
					3			
Average								
			(1 marks)	(1 marks)		(1 mark)	(1 mark)	(1marks)
								(5 marks)

5. From the data collected **do the analysis and interpretation of the results** **(2)**
6. **Write down conclusions about the difference between the theoretical and calculated result if any in Part 2** of the experiment. **(2)**

Total marks part 2 (12 marks)

9. Write a ***report*** for **each part** of the experiment which must include the following headings:
   1. **Title**
   2. **Aim**
   3. **Theory/Background**
   4. **Apparatus**
   5. **Safety precautions.**
   6. **Variables**
   7. **Method (only the following aspects are required)**
   8. **Observation & Recording of results (tables and calculations)**
   9. **Analysis & Interpretation (graphs, relationships, laws, etc.)**
   10. **Conclusions**

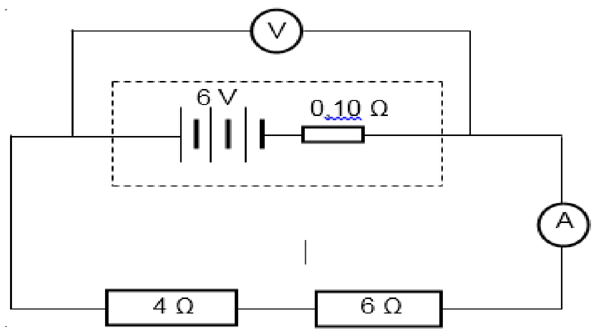
The following rubric will be used to measure the manipulative skills necessary for the full experiment.

Criteria	High **(3)**	Medium **(2)**	Low **(1)**	None **(0)**
Manipulative skills include correct handling of apparatus and materials.	Able to set up the circuit correctly and connect both the ammeter and voltmeter correctly.	Able to set up the circuit correctly but connect only the voltmeter/ammeter correctly.	Able to set up the circuit correctly but unable to connect the voltmeter and the ammeter correctly .	Unable to set up the circuit and connect the voltmeter and the ammeter correctly.
				3 marks

CONTROL QUESTIONS

QUESTION 1

In the circuit diagram below the emf of the battery is 6 V and its internal resistance is 0,10 Ω. The resistance of the resistors are 4 Ω and 6 Ω respectively.



1.1 Explain the term *internal resistance.* (2)

1.2 Write down an equation for the terminal potential difference using the values given. (3)

1.3 Draw a sketch graph of terminal potential difference versus current. Indicate the following in the graph:

- The value of the emf
- Current at which terminal potential difference is zero.

(3)

1.4. Calculate the total resistance in the circuit. (3)

1.5 A 7 Ω resistor is now connected in parallel to the 4 Ω resistor. How will this action affect the reading of the voltmeter? Write down only INCREASES, DECREASES or REMAINS THE SAME. Briefly explain the answer.

(4)

[15]

GRAND TOTAL –50 marks

11.2.2 Memorandum/ Marking Tool Experiment 3

EXPERIMENT 3

<u>Internal resistance and Series-Parallel networks</u>

Memorandum and rubric

Part 1

<u>Variables (3 marks)</u>

Independent: current✓

Dependent: Potential deference (terminal potential difference)✓

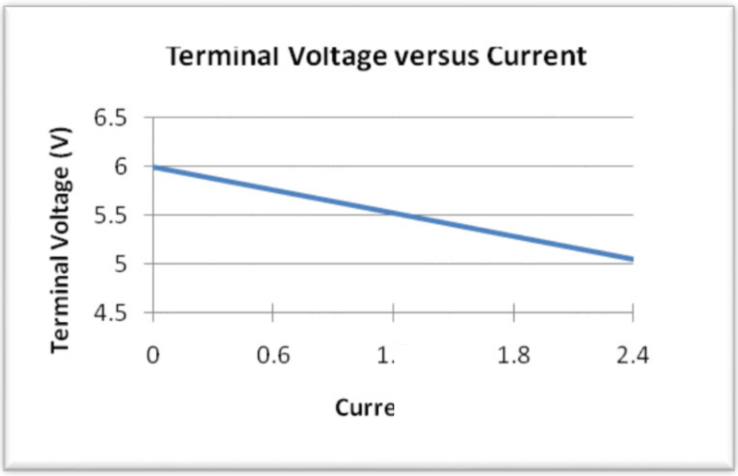
Controlled: Temperature.✓

<u>Observations and recording (10 marks)</u>

Trial No.	Ammeter reading (A)	Voltmeter reading [Terminal voltage] (V)	Marks One for each order pair)
1	0	6	✓
2	0,6	5,76	✓
3	1,2	5,52	✓
4	1,8	5,28	✓
5	2,4	5,04	✓
			(5 marks)

Analysis and interpretation of the results (6 marks)

Graph



<u>Graph</u>

1. Labelled axes with units✓

4. Plotting of points✓

5. Shape of the graph✓

(3 marks)

The graph is a streight line which is a representation of a linear function✓ with the following equation **Y= mx + C.**✓

y= V

m =-r

x= I

C= ε

Potential difference across the external circuit is equal to V = - rI + ε.

The absolute value of the gradient of the graph is the internal resistance $r = \frac{\Delta V}{\Delta I}$.✓

(3 marks)

Calculation of internal resistance

The absolute value of the gradient is the internal resistance and therefore:

$$r_T = \frac{V_2 - V_1}{I_2 - I_1}$$

$$r_T = \frac{5-6}{2{,}4-0} \checkmark$$

= -0,42 Ω

r= 0,42 Ω (absolute value)

∴ Internal resistance of one cell, $r = \frac{0{,}42}{4}$ ✓

= 0,11Ω ✓ **(3 marks)**

Conclusion

The *emf* of the battery is constant✓ then when current increases terminal potential decreases✓ due to the internal resistance remains constant.✓ **(3 marks)**

Part 2

Variables (3 marks)

Dependent: Potential difference✓

Independent: Current✓

Controlled: emf of the battery, resistance of the resistors, and temperature of resistors.✓

<u>Observations and recording</u>

R_1 (Ω)	R_2 (Ω)	R_3 (Ω)	Equivalent resistance of R_2 and R_3	**Theoretical equivalent external resistance of the circuit**		Voltmeter reading (V)	Ammeter reading (I)	**Calculated equivalent external resistance of the circuit**
10	20	10	$R_P = \frac{R_2R_3}{R_2+R_3}$ $= \frac{20\times10}{20+10}$ ✓ = 6,67 Ω	$R_T = R_P + R_1$ = 6,67 +10 = 16,67 Ω✓	1	5,5	0,35	$R_T = \frac{V}{I}$ $= \frac{5.5}{0,35}$ = 15,71 Ω
					2	5	0,3	$= \frac{5}{0,3}$ = 16,67 Ω
					3	4.5	0,28	$= \frac{4,5}{0,28}$ = 16,07 Ω
average						5✓	0,31✓	=16,13 Ω OR 16,15 Ω✓
			(1 marks)	(1 marks)		(1 mark)	(1 mark)	(1 mark)
								5 marks

Analysis and interpretation of the results (1 marks)

- The data collected shows that the internal resistance calculated experimentally is not equal to the theoretical internal resistance of the battery, the calculated equivalent external resistance is less than the theoretical equivalent resistance ✓✓ (2)

<u>Conclusions</u> (2 marks) ANY TWO (one mark each)

Possible answers are)

- There is no considerable difference between the theoretical and measured values. ✓
- The resistance of the wires cannot be neglected.✓
- The voltmeter and ammeter could have some errors/there were some errors in the measurements/the values of the resistances are not correct. ✓
- The heating effect of resistors played a role. ✓

(2)

Control questions (15 marks)

1.1 When current flows through a voltage source (battery/generator) a resistance to current flow arises✓ due to the resistance of the materials (chemicals/conductors) from which the source is made.✓

OR/*OF*

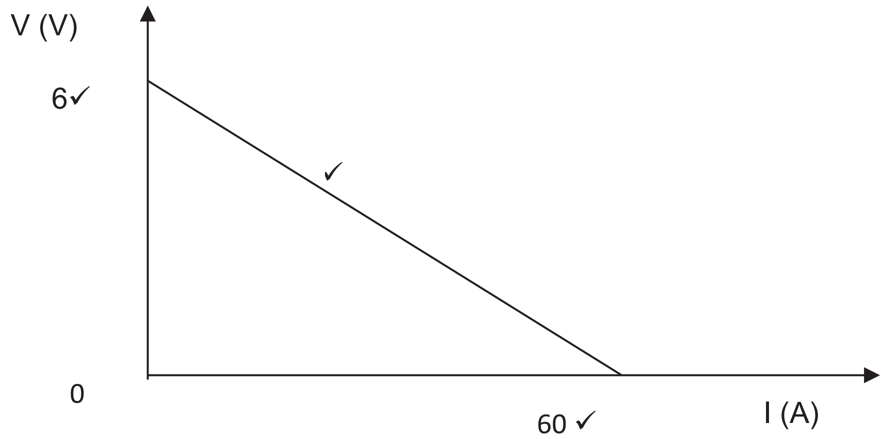
Internal resistance is the resistance offered to the electron flow✓ by the electrolyte/medium of the cell/generator.✓ (2)

1. 2 $\varepsilon = V_{ext} + Ir$✓

$V_{ext} = 6$✓ $- (0{,}10)I$✓

(3)

1.3



$0 = 6 - (0{,}10)I$

$I = \frac{6}{0{,}1} = 60\ A$

(3)

1.4 $R_T = R_{ext} + r$ OR $R_T = R_{4\Omega} + R_6 + r$✓

$R_T = 4 + 6 + 0{,}10$✓

$R_T = 10{,}10\Omega$✓ (3)

1.5 DECREASE✓

Total resistance of the circuit decreases ✓

Current increases✓

$V_{internal\ resistance}$ increases✓

V_{ext} (voltmeter reading) decreases ($V_{ext} = \varepsilon - V_{int}$)

(4)

[15]

GRAND TOTAL – 50 marks

12. Guidelines for Developing a Project

As part of School-Based Assessment (SBA) you must develop a project on a topic of interest, which will represent 20% of your SBA year mark. To develop your project, you must apply the scientific method.

PROJECT

A science project is an investigation that is designed to solve a problem or answer a question. It is a "science" project because learners use a procedure called the **scientific method** to answer the question.

A project will entail one of the following:

(1) **Construction of a device,** e.g. electric motor

(2) **Building a physical model** in order to solve a challenge you have identified using concepts in the FET Physical Sciences: Physics curriculum

(3) **Practical investigation**

To do your project you must follow the following steps:

(i) Identify an area of interest.

- Decide what area of Physics is of interest

e.g. Snell's Law, energy, etc.

(ii) Narrow the area of interest so that it is more specific. E.g. ***calculate the power of a walking and a running learner.***

(iii) Gather information

- Search in the library for information on the area of interest in an organised manner by using reference material such as the *Reader's Guide* or the card catalogue.
- Keep in mind that most scientific journals publish information pertaining to a single field of Science, e.g. the *American Journal* relates to specific topics. On the other hand, some periodicals, such as *Scientific American* and *Science,* cover a range of scientific issues.
- Make sure to record the author(s), titles of the article and the journal, title page numbers, and pertinent publishing information for every reference used. (Recording this information on notecards is helpful).

(iv) Select a specific problem within the area of interest

- Identify a specific problem.

(v) Gather more information

- It may be necessary to return to the library and look for information that deals **directly** with the specific topic.

(vi) Plan the project

Keep these things in mind when designing the project:

- Are the variables appropriate?
- Are the variables measurable?
- What kind of controls will be included?
- What data will be collected?
- Is the project designed appropriately if the results are to be analysed statistically?
- Are the materials and equipment available?
- Are there some special safety or environmental concerns?

When the approach to the project is clear, it's time to write a proposal. The proposal should describe the project in detail, including required materials and equipment, any safety concerns, and expected results. Show your proposal to your teacher to evaluate the suitability of the project.

Include the following in the proposal:

- Background information: A review of the literature summarising information related to the project. Be sure to cite all references.
- Purpose and hypothesis: A brief description of the purpose of the project and a statement of the hypothesis.
- Experimental design: A detailed explanation of the research plan and the materials needed are included in this section. The methods and materials should be described in such a way that anyone can understand the experiment(s).
- Literature cited and references: Include a list of all authors cited and a list of supplementary references.

(vii) Obtain approval of the proposal from the teacher.

Ask the teacher about the approval of the proposal and if you can continue with your research project.

(viii) Conduct the experiment(s) and collect data

- Record the data immediately, completely, and accurately.
- Record other observations about the experiment, e.g. describe progress, take pictures, make sketches. Are some things not going according to plan? Are there any surprises? These observations may be important later.

(ix) Organise and report the results

Most data involve numbers and can be quantified. Therefore, using statistics, graphs, tables, and charts is appropriate. Remember, this is the portion of the research on which conclusions are based. The better this portion is presented, the easier it is to formulate conclusions. Data should be presented:

- in writing with graphs, tables, and charts;
- without conclusions or value judgements.

(x) Analyse and discuss the results

Think about the results. What do they mean? How should they be interpreted? Discussing various aspects of the experiment and observations, the data could provide additional viewpoints concerning the results. Look for patterns, relationships and correlations.

(xi) Formulate conclusions

Was the hypothesis supported? This is an important step and must emphasise what has been learned from doing the project. Conclusion statements must be supported by data collected and should relate directly to the purpose and hypothesis.

(xii) Assess the project

Did the project go as planned? If so, were there other interesting aspects that deserve follow-up research? If the experiment did not go as planned, why not? Was the hypothesis too broad? Was the experimental design inappropriate? If the hypothesis was not confirmed, what was learned? Answers to all these questions can help form recommendations for further research.

(xiii) Final report

The final report is done according to the type of project developed.

Be sure that your science report touches on all of the elements of your project, including but not limited to the points of the Scientific Method.

You must submit a written report with the following headings (criteria) in A4 format.

- **List of content**
- **Abstract/ Summary**
- **Background**
- **Objective/ Aim**
- **Problem statement/ Question**
- **Hypothesis**

- **Materials**
- **Method/ Procedure**
- **Results**
- **Discussion/ Analysis of the results**
- **Conclusions**
- **Limitations**
- **Bibliography**
- **Acknowledgment**

(xiv) Presentation of the research project

You must do an oral presentation of your research project. Be sure to practise, preferably in front of an audience. Practicing will give you the confidence you need to sound like an authority in your area of research, and that is something that the teacher (judges) like to hear.

You must show your ability to discuss the project clearly, explaining each stage of your research and every step of your experiment. The teacher (judges) will ask you questions; therefore, practising will really help.

To present your project you can use a poster.

RECOMMENDED PRACTICAL INVESTIGATION FOR INFORMAL ASSESSMENT

Topic: Calculate the power of a walking and a running learner.

1. **Introduction**

1.1 Background (2 marks)

Write down the background (theory) of your investigation.

1.2 Objective/Aim: (1 mark)
Write down the objective of the investigation.
To determine experimentally when more power is developed by a learner's walking or running over the same distance and at the same height.

1.3 Investigative question: (2 marks)

Write down an investigative question for the investigation.

1.4 Hypothesis (2 marks)

Write down a hypothesis for the investigation.

2. Materials and method

You can use the following material to develop the experiment to verify the hypothesis.

*2.1 **Apparatus (materials)***

You can use the following apparatus to develop your investigation

- A flight of stairs
- Bathroom scale
- 5 m measuring tape
- Meter stick / ruler
- Stopwatch

2.2 Variables **(4 marks)**

Write down the variables for the investigation.

2.3 Method (procedures)

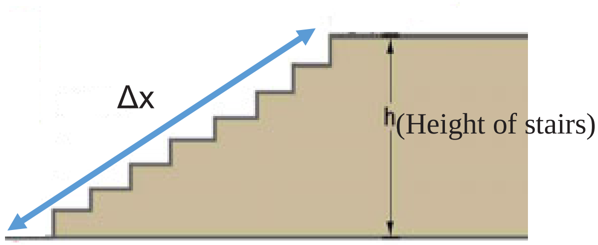
It is recommended that you follow the procedures below or design your own method.

2.3.1 Work in pairs or in groups of three.

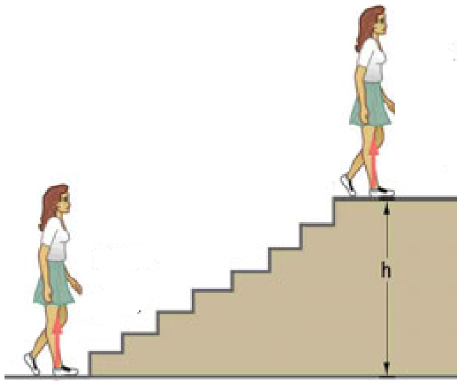
2.3.2 Use the bathroom scale to measure your mass. Record your mass.

2.3.3 Use the measuring tape and calculate the height of one step and multiply by the number of steps to determine the height of the stairs. Record it.

2.3.4 Use the measuring tape to measure the length of the stairs as shown in the figure below. Record it.

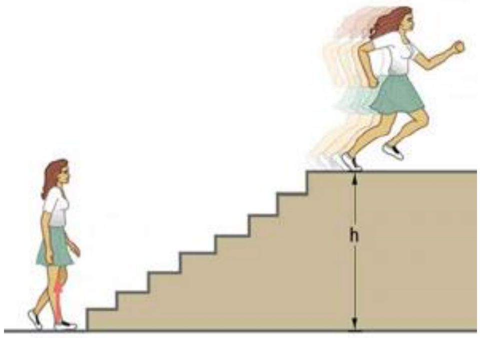


2.3.5 Each member of your group must walk up the stairs from rest, while another member of your group measures the time taken. Record it.



2.3.7 Calculate the power for each learner walking.

2.3.8 Measure the time it takes for each learner to run up the stairs from rest.



3. Results (24 marks)

3.1 With the values obtained, complete the following tables.

TABLE 2.1 WALKING LEARNERS

LEARNER	Mass (kg)	Time taken to walk (s)	Average speed walking ($m\cdot s^{-1}$) $v_{av} = \frac{\Delta x}{\Delta t}$	Change in kinetic energy (J) $\Delta E_K = \frac{1}{2}mv_{av}^2$	Change in gravitational potential energy (J) $\Delta E_P = mgh$	Work done (J) $W = \Delta E_K + \Delta E_P$
A						
B						

TABLE 2.2 RUNNING LEARNERS

LEARNER	Mass (kg)	Time taken to run (s)	Average speed running ($m\cdot s^{-1}$) $v_{av} = \frac{\Delta x}{\Delta t}$	Change in kinetic energy (J) $\Delta E_K = \frac{1}{2}mv_{av}^2$	Change in gravitational potential energy (J) $\Delta E_P = mgh$	Work done (J) $W = \Delta E_K + \Delta E_P$
A						
B						

4. Analysis of the results

4.1 Calculate the power for each learner. (3)

4.1.1 Draw a bar graph with the values of work and power for each learner walking and running. (8)

4.1.2 When did you do the most work? (Walking or running) (1)

4.1.3 When did you develop the greatest power? (Walking or running) (1)

5 Conclusion

5.1 Write down the conclusion for this practical investigation. (2)

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14. Suggested Marking Guideline for Grade 11 Project

RESULTS AND SUGGESTED ANSWERS

1.1 **Background** (3 marks)

If an external force is applied to an object (which we assume acts as a particle), and if the work done by this force in the time interval Δt is W, then the average power expended during this interval is defined as:

$$P = \frac{W}{\Delta t}$$

The work done on the object contributes to the increase in the energy of the object. Therefore, a more general definition of power is the **time rate of energy transferred.**

Or

Power as the rate at which work is done or energy is expended ✓✓

When non-conservatives forces are acting

$$W_{non-conservative} = \Delta E_K + \Delta E_p$$

$$W_{non-conservative} = (E_{Kf} - E_{Kf}) + (E_{Pf} - E_{Pi})✓$$

1.2 Objective/Aim (1 mark)

To determine experimentally when more power is developed by a learner's walking or running over the same distance and at the same height.✓ ✓ (2)

1.3 Investigative question

What is the influence of the change in speed of the learner on the power delivered by a learner?✓✓ (2)

1.4 Hypothesis

When a learner runs, the power delivered is greater that when the learner walks, provided that the distance and the height are constant.

OR

The greater the change in speed, the greater the power delivered, provided that the distance and the height are constant. (2)

2.2 Variables

- Independent variable: Power✓ (1)
- Dependent variable: Change in speed/change in kinetic energy ✓ (1)
- Controlled (constant) variables: Mass✓, same flight of stairs (distance covered and height).✓ (2)

3. Results

3.1 With the values obtained, complete the following tables.

TABLE 1 WALKING LEARNERS

LEARNER	Mass (kg)	Time taken to walk (s)	Average speed walking (m·s^{-1}) $v_{av} = \frac{\Delta x}{\Delta t}$	Change in kinetic energy (J) $\Delta E_K = \frac{1}{2} m v_{av}^2$	Change in gravitational potential energy (J) $\Delta E_P = mgh$	Work done (J) $W = \Delta E_K + \Delta E_P$
A	✓	✓	✓	✓	✓	✓
B	✓	✓	✓	✓	✓	✓

TABLE 2 RUNNING LEARNERS

LEARNER	Mass (kg)	Time taken to run (s)	Average speed running ($m\cdot s^{-1}$) $v_{av} = \frac{\Delta x}{\Delta t}$	Change in kinetic energy (J) $\Delta E_K = \frac{1}{2}mv_{av}^2$	Change in gravitational potential energy (J) $\Delta E_P = mgh$	Work done (J) $W = \Delta E_K + \Delta E_P$
A	✓	✓	✓	✓	✓	✓
B	✓	✓	✓	✓	✓	✓

(24)

4. Analysis of the results.

4.1 Calculate the power for each learner.

Formula $(P = \frac{W}{\Delta t})$✓

Substitution ✓

Answer ✓ (3)

Bar graphs (one mark for each correct bar graph) (8)

4.1.2 Running ✓ (1)

4.1.3 Running✓ (1)

5. Conclusion

The hypothesis was accepted✓. The most work was done when running, therefore the greatest power developed when change in speed was the greatest✓. (2)

[50]

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