THE REPUBLIC OF UGANDA
Ministry of Education and Sports

# ADVANCED SECONDARY CURRICULUM

# PHYSICS SYLLABUS

NCDC
NATIONAL CURRICULUM DEVELOPMENT CENTRE
2025

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CURRICULUM

# PHYSICS
# SYLLABUS

2025

NCDC
NATIONAL CURRICULUM
DEVELOPMENT CENTRE



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# Contents

# FOREWORD

The Ministry of Education and Sports, through the National Curriculum Development Centre (NCDC), aligned the Advanced Level Curriculum with the competency-based Lower Secondary Curriculum (LSC) to ensure a smooth learner transition from lower secondary to advanced level.

The two-year aligned Advanced Secondary Curriculum adopted learner-centered approaches, inquiry-based, and discovery methods. The learning outcomes give the learner hands-on experiences in real-life situations while being cognizant of different learner abilities and learning styles. The syllabus focuses on assessment for learning with emphasis on criterion-referenced assessment. It further provides learners with the opportunity to enhance the 21st-century skills and values that were acquired at the lower secondary level.

This Physics syllabus promotes the learner's application of scientific knowledge in relation to what happens in their communities in terms of energy resources, conservation of the environment, communication and other areas of application. It promotes acquisition of Higher-Order Thinking Skills (HOTS) such as inquiry, creativity and innovation, decision-making, critical thinking and problem-solving. It calls for the use of learner-centred pedagogies with hands-on experience by the learners in real-life situations, while acknowledging different learner abilities and learning styles.

As the Minister responsible for Education, I endorse this syllabus as the official document for teaching and learning Physics at the Advanced Level of secondary education in Uganda.

Hon. Janet Kataaha Museveni

**First Lady and Minister of Education & Sports**

# ACKNOWLEDGEMENTS

The National Curriculum Development Centre (NCDC) is indebted to the Government of Uganda for financing the alignment of the Advanced Level Curriculum to Lower Secondary Education in Uganda.

Our gratitude goes to the Ministry of Education and Sports for overseeing the adaptation of the curriculum, the Curriculum Task Force of the Ministry of Education and Sports for the oversight role and making timely decisions whenever necessary, and members of the public who made helpful contributions towards shaping this curriculum.

NCDC is also grateful to Members of Parliament, schools, universities, and other tertiary institutions, the writing panels, and professional bodies, for their input in the design and development of the Adapted A' level curriculum. To all those who worked behind the scenes to finalise the adaptation process of this teaching syllabus, your efforts are invaluable.

NCDC takes responsibility for any shortcomings that might be identified in this publication and welcomes suggestions for effectively addressing the inadequacies. Such comments and suggestions may be communicated to NCDC through P. O Box 7002, Kampala, or Email: admin@ncdc.go.ug or on the Website: www.ncdc.go.ug

Dr Grace K. Baguma
Director
**National Curriculum Development Centre**

# 1.0 INTRODUCTION

The Advanced Secondary Curriculum has been aligned with the Lower Secondary competency-based model for ease of progression of learners from the Lower to Advanced Secondary Level. The alignment is a result of the analysis of the Advanced Level Curriculum published in 2013, to determine whether the content is:

i) Appropriate;
ii) high pitched or an overload;
iii) covered at lower secondary;
iv) obsolete; and
v) repeated in different topics and redundant.

The results from the curriculum analysis revealed that there were overlaps of concepts with what was covered at the Lower Secondary, as well as concepts within different topics of the same subject. In addition, a number of syllabuses had content that is no longer necessary for today's contemporary society and the 21st century.

## 1.1 Changes in the Curriculum

The alignment of the A-Level Curriculum to that of the Lower Secondary led to changes in the pedagogies of learning from a knowledge- and objective-based, to an integrated and learner-centred competency-based approach. The adapted syllabus, therefore, is a result of rationalising, integrating and merging content with overlaps and similar skills, dropping topics that had been studied at Lower Secondary, or are no longer critical and relevant for the current learning needs, while upgrading those that were of low competencies to match with the advanced level. The programme planner details the learning progression derived from the learning outcomes. The detailed syllabus section unfolds the learning experiences with corresponding assessment strategies.

This Physics syllabus is part of the Advanced Secondary Curriculum. The teacher is encouraged to read the whole syllabus before planning your teaching programme, since many topics have been merged, upgraded, or removed. While aligning this syllabus, efforts were made to ensure a smooth progression of concepts from the Lower Secondary Level, adapting topics and content with familiar features that are of value to the learner and society. In addition, the process of developing this syllabus document removed what was considered obsolete, high pitched as well as content overlaps and overloads.

## 1.2 Classroom-Based Assessment

This syllabus requires classroom learning to be experiential, through the suggested learning activities for the acquisition of the learning outcomes. This is the gist of a learner-centred and activity-based approach to learning, which emphasises the acquisition of required competencies. Formative assessment in Physics will focus on the acquisition of knowledge and skills, through performance of the learning activities. The learning activities sprout from the learning outcomes, which are evidenced by acquiring and demonstsrating the application of the desired skills, to show that learning has taken place. The sample assessment strategies have been provided to guide the teacher on classroom-based assessment. The teacher can develop more assessment strategies based on the same principles of observation, conversation, and product, for the acquisition of the desired knowledge, skills, values, and attitudes. (See detailed syllabus)

## 1.3 Learners with Special Educational Needs

The Advanced Secondary Curriculum is designed to empower all learners, including those with Special Educational Needs (SEN), to reach their full potential and contribute meaningfully to the nation. By incorporating inclusive strategies, the curriculum ensures equitable access to high-quality learning opportunities while maintaining high academic standards. It emphasises creating an inclusive learning environment that supports the diverse needs of learners with SEN, enabling them to succeed alongside their peers.

## 1.4 Generic Skills

Generic skills are embedded within all subjects and are essential for learning and workforce readiness. These skills enable learners to engage with the entire curriculum effectively and prepare them for lifelong learning. These skills equip learners with the ability to adapt to change and navigate life's challenges in the 21st century.

**The key generic skills include:**

1

**Critical thinking and problem-solving**

i) Planning and carrying out investigations
ii) Sorting and analysing information
iii) Identifying problems and proposing solutions
iv) Predicting outcomes and making reasoned decisions
v) Evaluating different solutions

**Co-operation and Self-Directed Learning**

i) Working effectively in diverse teams
ii) Interacting effectively with others
iii) Taking responsibility for own learning
iv) Working independently with persistence
v) Managing goals and time

2

3

**Creativity and Innovation**

i) Using imaginations to explore possibilities
ii) Working with others to generate ideas
iii) Suggesting and developing new solutions
iv) Experimenting with innovative alternatives
v) Looking for patterns and making generalisation

**Communication**

i) Listening attentively and with comprehension
ii) Talking confidently and explaining ideas/opinions clearly
iii) Reading accurately and fluently
iv) Writing and presenting information coherently
v) Using a range of media to communicate ideas

4

5

**Mathematical Computation**

i) Using numbers and measurements accurately
ii) Interpreting and interrogating mathematical data
iii) Using mathematics to justify and support decisions

**Information and Communication Technology (ICT) Proficiency**

i) Using technology to create, manipulate and process information
ii) Using technology to collaborate, communicate and refine work

6

7

**Diversity and Multicultural Skills**

i) Appreciate cultural diversity
ii) Respectfully responding to people of all cultures
iii) Respecting positive cultural practices
iv) Appreciating ethnicity as a cradle for creativity and innovation

## 1.5 Cross-cutting issues

These are issues which young people need to learn about, and are not confined to a particular subject but are studied across subjects. They help learners to develop an understanding of the connections between the subjects and the complexities of life as a whole. They are:

i) Environmental awareness
ii) Health awareness
iii) Life skills
iv) Mixed abilities and involvement
v) Socio-economic challenges
vi) Citizenship and patriotism

These are a concern to all humankind irrespective of their areas of speciality. They are infused within the different learning outcomes of the different subjects.

## 1.6 Values

The Curriculum is based on a clear set of values. These values underpin the whole curriculum and the work of schools and communities. Learners need to base themselves on these values as citizens of Uganda. These values are derived from the Uganda National Ethics and Values Policy of 2013. They are:

i) Respect for humanity and environment
ii) Honesty, uphold and defend the truth at all times
iii) Justice and fairness in dealing with others
iv) Hard work for self-reliance
v) Integrity; moral uprightness and sound character
vi) Creativity and innovation
vii) Social responsibility
viii) Social harmony
ix) National unity
x) National consciousness and patriotism

These are not taught directly in lessons, nor are they assessed by pen and paper. However, they are incorporated in some learning outcomes and are developed as learners progress.

## 1.7 Information and Communication Technology (ICT) Integration

The use of ICT tools in teaching and learning while implementing this adapted curriculum is highly encouraged. Use of technology in teaching and learning is essential for the implementation of any competency-based curriculum because they encourage high levels of learner engagement, creativity, and lifelong learning through research. Teachers are encouraged to use ICT tools to generate interactive content, such as digital simulations and videos, that will bring abstract topics to life. Blended learning methodologies can be used with ICT platforms such as Google Classroom, Zoom, Microsoft Teams, or Google Docs to enhance collaboration and deliver customised feedback. Using ICT for teaching and learning will not only enhance the learning experience, but will also provide learners with critical digital skills for 21st century.

## 1.8 Projects and Project-based learning

Projects and project-based learning are part and parcel of learning in the 21st century. A number of projects have been integrated in the syllabus for different topics. These are but samples. Teachers are encouraged to guide learners during project engagements so that the projects can easily be linked to what is happening in their communities. While doing this, make effort to keep aligned to the learning outcomes of the Physics topics you are teaching.

## 1.9 The Aims of Secondary Education

The aims of secondary education in Uganda are to:

i) instill and promote national unity, an understanding of the social and civic responsibilities, strong love and care for others and respect for public property, as well as an appreciation of international relations and beneficial international co-operation;

ii) promote an appreciation and understanding of the cultural heritage of Uganda including its languages;

iii) impart and promote a sense of self discipline, ethical and spiritual values, personal and collective responsibility and initiative;

iv) enable individuals to acquire and develop knowledge and an understanding of emerging needs of society and the economy;

v) provide up-date and comprehensive knowledge in theoretical and practical aspects of innovative production, modern management methods in the field of commerce and industry and their application in the context of socio-economic development of Uganda;

vi) enable individuals to develop basic scientific, technological, technical, agricultural and commercial skills required for self-employment;

vii) enable individuals to develop personal skills of problem solving, information gathering and interpretation, independent reading and writing, self-improvement through learning and development of social, physical and leadership skills such as those obtained through games, sports, societies and clubs;

viii) lay the foundation for further education;

ix) enable the individual to apply acquired skills in solving problems of community, and to develop a strong sense of constructive and beneficial belonging to that community;

x) instill positive attitudes towards productive work and strong respect for the dignity of labour and those who engage in productive labour activities; and

xi) develop a positive attitude towards learning as a lifelong process.

## 1.10 Aims of the Advanced Secondary Curriculum

The Advanced Level curriculum aims to:

i) adopt a Competency-Based Learning approach;
ii) develop holistic education for personal and national development based on clear shared values;
iii) develop key skills which are essential to work and life and promote life-long learning;
iv) adopt an integrated approach to learning that develops the ability of learners to apply learning;
v) improve on assessments by incorporating school-based assessment into end of cycle assessment;
vi) emphasise learners' participation through engagement with the community; and
vii) prepare for further education.

## 1.11 Subject Overview

The areas of study have been re-organised within the syllabus to come up with the aligned version. The subject areas of study are comprehension, application and practical skills. Throughout the Advanced Level Physics Syllabus, learners are expected to acquire the following:

a) Comprehension or understanding:
   i) explaining different terminologies, conventions and phenomena;
   ii) explaining laws/principals and models, and describing experiments;
   iii) translating between various forms of information presentation; and
   iv) using a variety of methods to solve familiar and unfamiliar numerical problems.

b) Application and higher abilities:
   i) analysing presented information to make inferences;
   ii) synthesising ideas from various forms of presented data;
   iii) applying laws/principles and generalisations to everyday life and new situations;
   iv) devising experiments to test hypotheses and statements of models; and
   v) exercising evaluative judgment on suitability and results of scientific procedures.

c) Practical abilities:

Practical abilities are part and parcel of teaching and learning of Physics. Learners acquire the following competencies:

   i) planning to select techniques, apparatus and materials;
   ii) Identifying variables and controlling them;
   iii) making predictions based on prior knowledge and hypotheses;
   iv) manipulation of the apparatus and performing experiments to obtain readings/results;
   v) making and recording observations and measurements to the right accuracy of instruments and calculation;
   vi) presentation of data in an appropriate form, such as graphical and any other appropriate;

vii) manipulating graphical data by determining gradients, intercepts or any other required points and identifying patterns in outcomes;
viii) drawing conclusions from observations made;
ix) assessing the suitability of procedure by identifying errors, limitations of measurements and /or experimental procedures used and suggesting methods of minimising the errors for better results; and
x) devising projects in which the products/models employ Physics principles.

## 1.12 Rationale for teaching Physics at Advanced Level

The adaptation of the Advanced Level Curriculum was based on the Advanced Level Needs Assessment Study conducted in 2021/22 by the Ministry of Education and Sports through NCDC to:

i) identify the stakeholders' views; and
ii) map out the gaps affecting the achievement of the desired learning outcomes for the 21st Century needs and challenges.

The study recommends Physics to be part of the curriculum menu because of the following:

a) Enabling the learner to know:
   i) the basic principles and concepts of Physics;
   ii) how theories and models are used to explain concepts in Physics;
   iii) the resources available and how they are utilised using principles and concepts in Physics; and
   iv) the use of knowledge, principles and concepts of Physics in everyday life situations.
b) Making the learner aware of the effects of scientific discoveries and knowledge on everyday life through applications of Physics.
c) Enabling the learner to:
   i) develop an experimental attitude by performing experiments in school;
   ii) familiarise themselves with and practice scientific methods; and
   iii) develop the necessary skills to design and carry out practical investigations based on the knowledge of Physics.
d) Preparing the learner for further studies in Physics and the related fields.
e) Enabling the learner to appreciate the applicability of Physics in other disciplines.
f) Enabling the learner to develop:
   i) an initiative for inventiveness; and
   ii) capacity to design models and/or devices for use in problem-solving situations, basing on Physics principles.

## 1.13 Time Allocation

It is recommended that there will be 9 periods, each of 40 minutes per week for teaching and learning of Physics in Senior Five and Senior Six. It should be noted that no special time is set aside for practical work since the two should be taught together to reinforce each other.

## 1.14 Suggested Approaches to Teaching and Learning of Physics

The suggested approaches enhance learning and empower teachers to support learners so that they acquire the planned competencies. This necessitates teachers to work alongside learners, to guide, support and supervise them as they progress through the learning process. These approaches include:

a. Inquiry-based learning: Learners are encouraged to investigate and research using a variety of resources, including ICTs to solve problems through series of questions and scenarios enhancing critical thinking, communication and research skills.
b. Experiential learning: Learners actively participate in hands-on experiences during demonstrations and experiments which leads to construction of knowledge and innovation.
c. Problem and project-based learning: Learners find solutions to problems through their experience in research and projects. This leads to development of critical thinking, social and research skills.
d. Case-based learning: Learners refer to real world scenarios to discuss and analyse them which enable them to develop critical thinking, analytical and research skills.

## 1.15 Programme Planner

| Class/Term | Topic | Sub-topic | Periods |
|---|---|---|---|
| **Senior Five Term 1** | 1. Measurement and Dimensions of Physical Quantities | 1.1 Measurement of Physical Quantities | 10 |
| | | 1.2 Dimensional Analysis | |
| | 2. Statics | 2.1 Resultant Force | 16 |
| | | 2.2 Moments and Couples | |
| | 3. Linear Motion | 3.1 Equations of Linear Motion | 38 |
| | | 3.2 Relative Motion | |
| | | 3.3 Momentum | |
| | | 3.4 Newton's Laws of Motion | |
| | 4. Motion Under Gravity | 4.1 Free Fall | 14 |
| | | 4.2 Projectiles | |
| | 5. Work, Energy and Power | 5.1 Work | 16 |
| | | 5.2 Energy | |
| | | 5.3 Power | |
| | 6. Solid Friction | 6.1 Static Friction | 14 |

| | | | |
|---|---|---|---|
| | | 6.2 Dynamic Friction | |
| | **Total Time** | | **108** |
| **Senior Five Term 2** | 7. Fluid Mechanics | 7.1 Molecular Forces in Fluids | 20 |
| | | 7.2 Pressure and Density of Liquids | |
| | | 7.3 Fluid Flow | |
| | 8. Mechanical Properties of Matter | 8.1 Loading Wires; Hooke's Law | 12 |
| | | 8.2 Modulus of Elasticity | |
| | 9. Thermometry | 9.1 Temperature Scales | 14 |
| | | 9.2 Types of Thermometers | |
| | 10. Heat Quantities | 10.1 Heat Capacity | 16 |
| | | 10.2 Change of State; Latent Heat | |
| | 11. Transfer of Heat | 11.1 Conduction | 18 |
| | | 11.2 Convection | |
| | | 11.3 Radiation | |
| | 12. Behaviour of Gases | 12.1 The Behaviour of Ideal Gases | 16 |
| | | 12.2 The Kinetic Theory of Gases | |
| | | 12.3 The Behaviour of Real Gases | |
| | | 12.4 Vapour Pressure | |
| | 13. Thermodynamics | 13.1 Internal Energy of Gas Systems | 12 |
| | | 13.2 The First Law of Thermodynamics | |
| | **Total Time** | | **108** |
| **Senior Five Term 3** | 14. Reflection of Light | 14.1 Reflection at Plane Surfaces | 14 |
| | | 14.2 Reflection at Curved Surfaces | |
| | 15. Refraction of Light | 15.1 Refraction at Plane Surfaces | 24 |
| | | 15.2 Critical Angle and Total Internal Reflection | |
| | | 15.3 Refraction Through Lenses | |
| | 16. Optical Instruments | 16.1 Microscopes | 10 |
| | | 16.2 Telescopes | |
| | 17. Electrostatics | 17.1 Production of Charge | 24 |
| | | 17.2 Electrostatic Force | |
| | | 17.3 Electric Field | |
| | 18. Capacitors | 18.1 Parallel Plate Capacitors | 22 |
| | | 18.2 Charging and Discharging Capacitors | |
| | | 18.3 Energy Storage in Capacitors | |
| | 19. Digital Electronics | 19.1 Junction Diodes | 14 |
| | | 19.2 Transistors | |
| | **Total Time** | | **108** |
| **Senior Six Term 1** | 20. Circular Motion | 20.1 Centripetal Force | 12 |
| | | 20.2 Conical Pendulum | |
| | | 20.3 Motion on Circular Tracks | |
| | 21. Simple Harmonic Motion | 21.1 Displacement, Velocity, Acceleration and Energy for SHM | 18 |

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|---|---|---|---|
| | | 21.2 Oscillations | |
| | 22. Gravitation | 22.1 Laws of Gravitation | 20 |
| | | 22.2 Motion in Orbits | |
| | | 22.3 Satellites | |
| | 23. Progressive Waves | 23.1 Basic Properties of Waves | 24 |
| | | 23.2 Interference of Waves | |
| | | 23.3 Diffraction of Waves | |
| | | 23.4 Polarisation of Waves | |
| | 24. Stationary Waves | 24.1 Formation of Stationary Waves | 16 |
| | | 24.2 Stationary Waves in Pipes and Strings | |
| | | 24.3 Resonance | |
| | 25. Sound Waves | 25.1 Production and Transmission of Sound | 18 |
| | | 25.2 Notes, Beats and Octaves | |
| | | 25.3 Doppler Effect | |
| | **Total Time** | | **108** |
| **Senior Six Term 2** | 26. Current Electricity | 26.1 Current, Resistance and Ohm's Law | 20 |
| | | 26.2 Slide Wire Meters | |
| | 27. Magnetism in Matter | 27.1 Magnetic Fields | 20 |
| | | 27.2 Magnetisation and Demagnetisation | |
| | 28. 28. Magnetic Effect of An Electric Current | 28.1 Force an A Current-Carrying Conductor | 26 |
| | | 28.2 Bio-Savart Law and Magnetic Flux Density | |
| | | 28.3 Torque on A Coil in A Magnetic Field | |
| | 29. Electromagnetic Induction | 29.1 Laws of Electromagnetic Induction | 18 |
| | | 29.2 Self and Mutual Induction | |
| | 30. A.C Circuits | 30.1 Measurement of A.C | 24 |
| | | 30.2 Inductance, Impedance and Reactance | |
| | | 30.3 Power in A.C Circuits | |
| | **Total Time** | | **108** |
| **Senior Six Term 3** | 31. Atomic Particles | 31.1 Rutherford's Atomic Model | 24 |
| | | 31.2 Cathode Rays and Positive Rays | |
| | | 31.3 Specific Charge; Thomson's and Milkan's Experiment | |
| | 32. Quantum Theory | 32.1 Photo Electric Effect | 24 |
| | | 32.2 Bohr Model | |
| | | 32.3 X-Rays | |
| | 33. Nuclear Processes | 33.1 Nuclear Stability | 24 |
| | | 33.2 Radioactivity | |
| | **Total Time** | | **72** |

## 1.16 Note to Users

Each topic has a competency, which is a broad statement that brings out what the learner is expected to do at the end of the topic. The competency is further broken down into learning outcomes, for which suggested learning activities and sample assessment strategies are developed as seen in the table below.

| Learning Outcome | Suggested Learning Activities | Sample Assessment Strategies |
|---|---|---|
| A statement of the knowledge, understanding, skills, generic skills, values, and attitudes expected to be learned by the end of the topic. Hence each learning outcome is coded with some of these as **k, u, s, gs and v/a** for emphasis to the teacher on what to consider during the lesson. | The sort of hands on and minds on engagements, which enable the learner to achieve the learning outcome including the generic skills and values. They are designed to enable learners to Discover, Explain, Apply and Analyse (**DEAA**) as they participate in knowledge construction. | Opportunities for assessment within the learning process ( during and after the lesson). |

The learning activities and assessment strategies in the syllabus are "suggested" and "samples" respectively and not exhaustive. As teachers you are encouraged to develop more learning activities and assessment strategies that are based on the learning outcomes. In addition, teachers are free to customise the suggested learning activities to make them suitable for their respective learning environments and for learners with special educational needs.

# 2.0 DETAILED SYLLABUS

## SENIOR FIVE TERM 1

### TOPIC 1: MEASUREMENT AND DIMENSIONS OF PHYSICAL QUANTITIES

**DURATION:** 10 Periods

**Competency:** The learner uses a variety of instruments to accurately measure physical quantities and applies the concept of dimensions to establish the relation between these quantities.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) measure a variety of physical quantities in the environment with minimal errors. (v/a, s, gs) | a. Learners brainstorm the fundamental and derived physical quantities met in their previous studies and make presentations.<br>b. Learners review the concepts of scientific notation and significant figures (s.f) and make presentations.<br>c. Individually or collaboratively, learners measure a variety of physical quantities using appropriate instruments and state their accuracies (digital measuring instruments, vernier callipers and micrometre screw gauges should be emphasised), then they make presentations.<br>d. In groups, learners identify the sources of errors for a variety of measurements and devise means to minimise them during discussions.<br>e. Learners collaboratively establish the accuracy of calculated values in a variety of situations and make presentations. | a. Observe learners as they brainstorm physical quantities, scientific notation and significant figures as you assess their interaction, how confidently they express their ideas and the correctness of the concepts<br>b. Probe learners on how to:<br>i) determine and minimise errors in measurements; and<br>ii) record measurements to a correct number of decimal places (d.p) and significant figures for different instruments.<br>c. Evaluate learners' written work focussing on:<br>i) the units and accuracies of measurements;<br>ii) interconversion of units;<br>iii) a written explanation of how errors are minimised; and<br>iv) the accuracy of calculated values in line with d.p and s.f. |

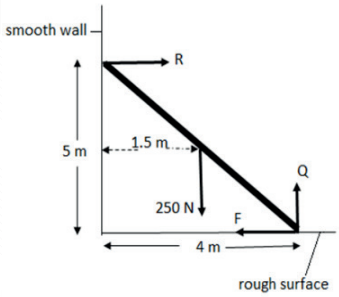
| | | |
|---|---|---|
| b) analyse the dimensions of a variety of derived physical quantities and use them to check the consistency of equations. (v/a, u, s, gs) | a) Learners explain the meaning of the dimensions of a physical quantity in a class discussion.<br>b) Learners state the dimensions of the fundamental physical quantities and use them to determine the dimensions of different derived quantities like power, force, velocity, acceleration, momentum and others.<br>c) In groups, learners check the consistency of equations using dimensions and make presentations.<br>d) In groups, learners discuss the merits and demerits of dimensional analysis and report in plenary. | a) Observe learners in their discussion on dimensions of fundamental and derived physical quantities while assessing:<br>i) confidence during the discussions;<br>ii) use of ICTs in presentations where possible; and<br>iii) respect for others' views.<br>b) Converse with learners about how the different quantities are related using dimensional analysis. Ask probing questions to clear misconceptions.<br>c) Assess learners' written work while looking for:<br>i) their ability to check the consistency of equations using dimensions; and<br>ii) the correctness of the statements for the merits and demerits of using dimensions. |

## TOPIC 2: STATICS

**DURATION:** 16 Periods

**Competency:** The learner investigates the effect of a number of forces on a system and how the centre of gravity relates to the stability of mechanical structures.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) determine the resultant of vectors in different situations. (v/a, u, s) | a) In groups or as individuals, learners review the meaning of scalar and vector quantities, and identify examples of each.<br>b) As individuals or groups, learners determine the resultant vector in different situations during class discussions. | a) Observe learners' presentations on determining the resultant of vectors while focusing on:<br>i) individual learner's skills to resolve vectors;<br>ii) ability of learners to apply different methods to obtain resultant vectors; and<br>iii) team building among learners.<br>b) Converse with learners about the different methods of obtaining the resultant vector while assessing whether they can compare the different methods.<br>c) Evaluate learners' products in the form of write-ups about the resultant vector. Check for the use of equations, sketch diagrams and accuracy of responses. |
| b) appreciate the concepts of moments and torque in the construction of different structures. (u, s, gs, v/a) | a) Learners collaboratively review the terms; moment of a force, centre of gravity, couple, equilibrium, torque, and make presentations.<br>b) Learners carry out investigations to determine the moment of a couple, centre of gravity of different shapes and analyse the data.<br>c) Individually or in groups, learners describe how centre of gravity affects stability of structures and make presentations. | a) Observe learners as they carry out investigations to determine the moment of a couple while assessing their ability to:<br>i) plan;<br>ii) use a variety of media/techniques to present findings; and<br>iii) effectively express themselves during presentations.<br>b) Converse with learners while assessing how they organise |

| | | |
|---|---|---|
| | d) Learners perform tasks such as; determining the resultant force at the point where the ladder is in contact with the ground as shown in the figure below.<br>  <br><br>e) Learners carry out group project work for modelling structures (bridges, roofing systems etc) and make recommendations on safety precautions in plenary. | investigations, record and analyse observations, and make conclusions.<br>c) Assess the written work by considering:<br>i) accuracy of the meaning of the terms couple, torque and how they are related;<br>ii) coherence in procedures for carrying out investigations and drawing conclusions;<br>iii) relevancy in the application of the principle of moments on different force systems;<br>iv) workability of the models in relation to the structures under investigation; and<br>v) the ability of learners to solve related numerical problems by interpreting data and applying the correct equations. |

## TOPIC 3: LINEAR MOTION

**DURATION:** 38 Period

**Competency:** The learner investigates the effect of force on the motion of bodies on land, water and air, and devises safety precautions for users of automobiles.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) derive the equations describing the linear motion of uniformly accelerated objects and apply them in a variety of situations. (u, s, gs) | a) In groups, learners review and discuss the meanings of the terms; distance, displacement, speed, velocity, and acceleration as applied to uniform motion and represent them graphically.<br>b) Learners individually or in groups search and derive the equations of uniformly accelerated motion (for linear motion) and apply them to solve a variety of numerical problems. | a) Observe learners during the discussion session while assessing whether they correctly explain the terminologies used under motion and their relationships. Also assess how learners:<br>i) confidently express themselves;<br>ii) respect others' opinions; and<br>iii) willingly and actively participate.<br>b) Converse with learners to probe their understanding of the interpretation of the graphs of motion in different situations.<br>c) Assess learners' written products while looking for the logical flow of the methods of deriving the equations and their applications in solving numerical problems. |
| b) determine the relative velocity and the distance of closest approach for moving bodies in real life. (u, s, gs) | a) In groups, learners investigate the concepts of relative velocity and closest distance of approach, and their application in real-life situations (such as crossing roads, rivers and aeroplane motion) and make presentations.<br>b) Learners individually or in groups apply concepts of relative motion to solve numerical problems. | a) Observe learners while assessing their ability to:<br>i) amicably build and work in teams;<br>ii) confidently express themselves; and<br>iii) respect others' opinions during the presentations.<br>b) Discuss with learners while probing them on the correct use of direction, sketches and formulae for obtaining relative motion.<br>c) Assess learners' written products while looking for accuracy in solving numerical problems related to relative motion. |

| | | |
|---|---|---|
| c) verify the principle of conservation of linear momentum and apply it in a variety of situations. (u, s, gs) | Basing on prior knowledge, in groups learners brainstorm the meaning of linear momentum and its units.<br>a) In groups or individually, learners derive and state the principle of conservation of linear momentum and apply it to solve numerical problems in different scenarios of collisions. | a) Observe learners while assessing their ability to:<br>i) amicably build and work in teams;<br>ii) confidently express themselves; and<br>iii) respect others' opinions.<br>b) Evaluate learners' ability to derive and apply expressions for linear momentum and energy under different collisions.<br>c) Converse with learners while assessing their ability to relate different types of collision to real-life experiences.<br>d) Assess the written products of learners while looking for accuracy of statements about momentum and in solving numerical problems. |
| d) apply Newton's laws of motion in different situations. (u, s, gs) | a) In groups, learners use their prior knowledge to state Newton's laws of motion and discuss their implications in real life.<br>b) In groups, learners derive the expression $F = ma$, and use it to determine the resultant force on objects.<br>c) Learners individually or in groups apply Newton's laws to explain motion in lifts, connected particles and other real-life situations. | a) Observe learners during the discussion session while assessing how they:<br>i) effectively express themselves;<br>ii) ask evaluative questions to further their understanding; and<br>iii) accurately state Newton's laws of motion.<br>b) Converse with learners about the implications of Newton's laws while assessing their confidence and the correctness of the information.<br>c) Assess written products while looking for:<br>i) how learners correctly apply Newton's laws in calculations in different situations; and<br>ii) the relevancy and coherency of the implications of Newton's laws in everyday life. |
| **Note:** Rigid bodies should be left out. Emphasis should be put on linear motion only**.** | | |

## TOPIC 4: MOTION UNDER GRAVITY

**DURATION:** 14 Periods

**Competency:** The learner investigates the effect of force on bodies moving under gravity and the applications of this phenomenon in different situations.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) analyse the behaviour of bodies moving under gravity. (u, s, gs) | a) In groups, learners use prior knowledge to review the meaning of acceleration due to gravity and discuss its effect on moving objects.<br>b) In groups or as individuals, learners determine the value of acceleration due to gravity using different methods. | a) Observe learners during the discussion session while assessing how they:<br>i) effectively express themselves;<br>ii) ask evaluative questions to further their understanding; and<br>iii) accurately define and explain the effect of acceleration due to gravity on bodies.<br>b) Assess learners' ability to:<br>i) design experiments for the determination of acceleration due to gravity; and<br>ii) interpret, manipulate and analyse experimental data to make valid conclusions. |
| b) derive the equations of projectile motion and apply them in different real-life situations. (v/a, u, s, gs) | a) In groups, learners review the terminologies used in relation to projectile motion.<br>b) Learners investigate the motion of a projectile and determine the velocity, height, time of flight and range on a horizontal surface.<br>c) In groups, learners model systems that employ projectile motion (bouncing castles, bouncing balls and any other) and make demonstrations. | a) Observe learners during the discussion session about terms used under projectile motion and their applications while assessing the:<br>i) Use of ICTs in communicating ideas where possible;<br>ii) learners' confidence; and<br>iii) active participation during the discussion.<br>b) Converse with learners while looking for the appropriateness of the video/pictures based on applications of projectile motion.<br>c) Assess the product while looking for:<br>i) the correct meaning of terminologies used;<br>ii) the logical flow of derivations of equations under projectile motion;<br>iii) correct substitutions when solving numerical problems; and<br>iv) workability of the designed models. |
| **Note:** Projectiles on inclined planes should be left out. | | |

## TOPIC 5: WORK, ENERGY AND POWER

**DURATION:** 16 Periods

**Competency:** The learner investigates the resources and transformations of energy in the environment in order to ensure sustainable and improved efficiency of energy utilisation.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) derive expressions for work, power and energy, and apply them to solve real-life problems. (u, s, gs) | a) Learners review and brainstorm the meaning of the terms—work, energy and power. Then they discuss the importance of energy conservation and make presentations.<br>b) In groups, learners derive the expressions;<br>$k.e = \frac{1}{2}mv^2$<br>$p.e = mgh$<br>$P = Fv$<br>and apply them to solve numerical problems. | a) Observe learners in the brainstorming session about the concepts of work, energy and power, and in the derivation of the expressions while assessing learners:<br>i) active participation;<br>ii) confidence in presentations; and<br>iii) correctness of the information about the meaning of work, energy and power, and the importance of energy conservation.<br>b) Assess the written products by looking for:<br>i) correct procedure of derivation; and<br>ii) correct use of the equations in solving numerical problems. |
| b)explain the work-energy theorem, conservative and non-conservative force fields and how they relate to different bodies. (u, s, gs) | a) Learners in groups, research, discuss and present the work-energy theorem and its practical applications.<br>b) Learners research and make presentations on conservative and non-conservative force fields and their applications in real life.<br>c) Learners collaboratively develop a model for the car crash experiment using trolleys, inclined planes, marbles and different masses.<br>d) Learners discuss how different speeds/velocities of automobiles relate to energy consumption/emission of greenhouse gases and environmental conservation. | a) Probe learners during the discussion to ascertain the:<br>i) correctness of the statement of the work-energy theorem;<br>ii) relevant applications of the theorem to solve problems; and<br>iii) correct meaning of conservative and non-conservative force fields and how they help to explain natural phenomena like gravitational field, magnetic field, etc.<br>e) During the project, probe learners to ascertain how they:<br>i) demonstrate understanding of the work-energy theorem;<br>ii) identify the energy changes at each step of motion;<br>iii) explain the effects of green-house gases on the environment; and<br>iv) demonstrate an appreciation for energy conservation for the future. |

| | | |
|---|---|---|
| c) describe the structure and the energy production process of the Sun and its implication to life on Earth. (u, v/a, gs) | a) In groups, learners search for and make presentations on:<br>i) the composition and structure of the sun;<br>ii) the process of energy production by the sun; and<br>iii) harnessing solar energy.<br>b) Learners debate the merits and demerits of solar energy for the sustenance of life on Earth. | a) Observe learners' presentations and debate while assessing:<br>i) the correctness of the information about the composition and structure of the Sun;<br>ii) the accuracy of the information about how energy is produced by the Sun;<br>iii) the correctness of how solar energy is harnessed by the community;<br>iv) self-expression, confidence and respect for others' opinions during the debate; and<br>v) the learners' products in terms of write-ups on the concepts of work, energy and power. |
| d) apply the concepts of renewable and non-renewable energy resources in the conservation of energy. (u, s, gs, v/a) | a) In groups, learners review and discuss how the sun is the primary source of the following renewable energies:<br>i) hydro energy;<br>ii) wind energy;<br>iii) biomass energy;<br>iv) geothermal energy; and<br>v) tidal energy.<br>b) In groups, learners explore the operation of the following and make presentations:<br>i) solar thermal technologies;<br>ii) solar photovoltaic (PV) systems; and<br>iii) thermal storage systems.<br>c) In class projects, learners model devices that harness solar energy such as solar collectors, cookers, dryers, heaters, storage systems and discuss their importance to the community. | a) In a conversation, assess learners' understanding of:<br>i) different sources of energy;<br>ii) the merits and demerits of different sources of energy; and<br>iii) the solar thermal systems and photovoltaics.<br>b) Assess learners' write-ups while looking for the correct meaning of sun intensity, operating temperatures, cell output current, shadow effect, climate effect and electrical load matching.<br>c) Assess the learners' products while looking for:<br>i) selection of materials for the models;<br>ii) coherence and correctness of procedures in making models;<br>iii) innovativeness and collaboration in the project work; and<br>iv) workability and usefulness of the developed model to the community. |
| **Note:** Safety precautions and environmental conservation should be taken into consideration. | | |

## TOPIC 6: SOLID FRICTION

**DURATION:** 14 Periods

**Competency:** The learner investigates factors that determine solid friction and its effect on static and dynamic systems, and uses this concept to model efficient systems with minimised friction.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) investigate the nature of friction between static bodies and its implications. (u, s, gs, v/a) | a) Learners individually or as groups investigate the nature of friction between static bodies and make models to demonstrate the molecular theory of solid friction.<br>b) Learners in groups carry out experiments to determine the coefficient of static friction.<br>c) In class discussions, learners solve numerical problems involving the coefficient of static friction. | a) Observe learners as they make the models demonstrating molecular theory while assessing their:<br>i) active participation, creativity, collaboration and leadership; and<br>ii) ability to explain their models in relation to the molecular theory of solid friction and the laws that govern it.<br>b) Assess the modelled products of learners while looking for creativity, innovation and workability.<br>c) Assess learners' write-ups on (a) and (b) above while looking for coherence and correctness of procedures in experiments, making models and proper application of expressions in solving numerical problems. |
| b) investigate the effects of friction on dynamic bodies in order to improve the operation of systems. (u, s, gs) | a) Learners in groups or as individuals, determine experimentally the coefficients of dynamic friction for moving systems.<br>b) In class discussions, learners use the coefficient of dynamic friction in solving numerical problems.<br>c) Learners make models of braking systems of bicycles, motorcycle, cars, trucks and explain their operation in presentations. | a) Evaluate the experiments in terms of:<br>i) correct selection and use of apparatus;<br>ii) proper recording of results;<br>iii) correct analysis of data;<br>iv) identifying sources of errors;<br>v) making appropriate conclusions; and<br>vi) consideration of safety precautions.<br>b) Assess the correctness and coherence of the learners' written work on experiments and the accuracy of the solutions to numerical problems.<br>c) Assess models in terms of learners' creativity, innovation, effective communication and workability. |

# SENIOR FIVE TERM 2

## TOPIC 7: FLUID MECHANICS

**DURATION:** 20 Periods

**Competency:** The learner investigates the effect of molecular forces in fluids, fluid pressure and their applications in fluid systems.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) examine molecular forces in liquids and their implications. (u, s, gs) | a) Using think-pair-share, learners review, discuss and make presentations on the occurrence of surface tension, capillarity and factors which affect them.<br>b) In groups, learners carry out activities to:<br>i) determine coefficient of surface tension and measure angle of contact for liquids and their implications on liquids;<br>ii) derive expressions describing surface tension, capillarity, excess pressure in bubbles, and surface energy; and<br>iii) use derived expressions to solve numerical problems.<br>c) In pairs, learners research and make presentation on the effect of viscosity on the motion of bodies in fluids. | a) Observe learners' group discussions while looking for the correctness of the meaning of surface tension, capillarity and angle of contact with focus on learners' confidence in expressing ideas, team building and respect for others' views.<br>b) Converse with learners while assessing their ability to determine the coefficient of surface tension, measure the angle of contact, determine excess pressure in bubbles, surface energy, and the effect of viscosity on the motion of bodies in fluids.<br>c) Assess learners' written work while looking for:<br>i) coherence and accuracy in the procedures;<br>ii) appropriateness of explanations; and<br>iii) accuracy in solutions to solved numerical problems. |

| | | |
|---|---|---|
| b)assess the application of pressure in fluids in different situations. (s, u) | a) Learners review, brainstorm and present on the density of fluids, fluid pressure, Pascal's principle, Archimedes' principle, law of floatation, experiments to verify Archimedes' principle, law of floatation and their implications and applications.<br>b) Learners in groups research and present the derivation of expressions for Archimedes' principle, law of floatation and apply them to solve numerical problems.<br>c) Learners in groups model devices which apply Pascal's principle. | a) Observe learners' participation in discussions and look out for the correctness of the terms, principles and laws, implications, and correct any misconceptions.<br>b) Dialogue with learners while assessing their ability to correctly:<br>i) derive the expressions for Archimedes' principle and law of floatation; and<br>ii) use the expressions to solve numerical problems.<br>c) Assess learners' products to check on:<br>i) the appropriateness and correct use of the materials selected; and<br>ii) creativity, critical thinking, and workability of the model designed. |
| c) explain pressure variations in flowing fluids and its applications in variety of situations. (u, s, v/a) | a) Learners research, discuss and present on:<br>i) the meaning of streamline and turbulent flow of fluids;<br>ii) the derivation of the expression for the equation of continuity;<br>iii) the statement of Bernoulli's principle and derive its equation;<br>iv) the applications of Bernoulli's principle in a variety of situations;<br>v) the derivation of Stokes's and Poiseuille's formulae and use them to solve numerical problems;<br>vi) the measurement of the coefficient of viscosity;<br>vii) the measurement of terminal velocity using different liquids; and<br>viii) the explanation of the effect of temperature on viscosity of fluids using molecular theory.<br>b) Learners in groups model devices that apply Bernoulli's principle in their operations. | a) Dialogue with learners while assessing the correctness of the:<br>i) meaning of streamline and turbulent flow of fluids;<br>ii) statement of Bernoulli's principle;<br>iii) derivation of the expressions for the equation of continuity and Bernoulli's principle;<br>iv) derivation of Stokes' and Poiseuille's formulae;<br>v) use of expressions to solve numerical problems related to fluid flow;<br>vi) procedures in the measurement of the coefficient of viscosity; and<br>vii) explanation of the effect of temperature on viscosity of fluids using molecular theory.<br>b) Evaluate learners' products while checking on the:<br>i) appropriateness and the correct use of the materials selected; and<br>ii) creativity, critical thinking, and workability of the model designed. |

## TOPIC 8: MECHANICAL PROPERTIES OF MATTER

**DURATION:** 12 Periods

**Competency:** The learner explores the effects of force on the strength of different materials in order to guide on the selection of appropriate materials for construction work.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) investigate the elastic and plastic behaviour of stretched materials and their implications. (s, gs) | a) In a brainstorming session, learners review prior knowledge on terminologies related to mechanical properties of materials, sketch stress-strain curves and make presentations.<br>b) Learners review Hooke's law, features of a stress- strain curve for ductile materials in series and parallel arrangement, and make presentation.<br>c) Learners demonstrate ductility, brittleness, stiffness and strength, stress, strain and work out numerical problems related to them. | a) Observe the learners' participation during the brainstorming session while looking for:<br>i) precise explanations of terms and laws;<br>ii) ability of learners to categorise materials according to their mechanical properties; and<br>iii) accuracy in sketching stress-strain curves.<br>b) Assess the accuracy of the learner's written products about the investigation and the solutions to numerical problems. |
| b) investigate Young's Modulus and the work done during elastic extension and compression process of elastic materials. (u, s, gs, v/a) | a) In groups or individually, learners derive the expression for Young's Modulus and measure Young's Modulus for different materials.<br>b) Learners research and make presentations on the work done during the extension or compression process for different materials.<br>c) In groups, learners model structures and explain their choice of materials based on the mechanical properties and exhibit their work.<br>d) In groups or individually, learners use derived expressions for Young's Modulus to solve numerical problems. | a) Dialogue with learners to assess their understanding of the:<br>i) physical quantities used in deriving the expression for Young's Modulus; and<br>ii) explanations of the shapes of stress-strain or load-extension graphs for different materials such as glass, rubber, copper and others.<br>b) Check how learners establish the relationship between elastic potential energy and stretching force, and apply it to solve numerical problems.<br>c) Assess the workability, innovation and originality of the model. |
| **Note:** Bulk modulus and shear rigidity should be left out. | | |

## TOPIC 9: THERMOMETRY

**DURATION:** 14 Periods

**Competency:** The learner investigates the mode of operation of different types of thermometers and their applications in the real world.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) relate the expressions of temperature scales in order to solve real-life problems. (k, s, gs, v/a) | a) In a brainstorming session, learners review terms and concepts such as thermometric properties, fixed points, absolute zero, temperature scales, and make presentations.<br>b) In groups or individually, learners derive expressions for different temperature scales, their interrelations and use them to solve numerical problems. | a) Assess learners' responses during the brainstorming session with respect to:<br>i) correctness of concepts; and<br>ii) effective self-expression.<br>b) Assess learners' products in line with the:<br>i) accuracy and coherence in the derivation of the expressions of different temperature scales and their interrelations; and<br>ii) ability to solve numerical problems related to temperature scales. |
| b) compare different types of thermometers and how they are used in real life. (u, s, gs, v/a) | a) Learners research, discuss and report about the operations of different thermometers (constant volume gas thermometers, electrical resistance thermometers, digital infra-red thermometers, thermoelectric thermometer, optical pyrometer.<br>b) In groups, learners model different types of thermometers from locally available materials and use them to measure temperature. | a) Assess learners' written reports while looking for:<br>i) correctness of the explanation on the operation of different thermometers; and<br>ii) correct use and accuracy in measurement of temperature.<br>b) Assess:<br>i) learners' ability to collaborate and apply creativity in development of the model thermometers; and<br>ii) the workability and creativity of the model thermometer. |
| **Note:** Total radiation Pyrometer should not be considered. | | |

## TOPIC 10: HEAT QUANTITIES

**DURATION:** 16 Periods

**Competency:** The learner explores the behaviour of substances when heat is applied to them in order to sustainably apply them in heat systems.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) deduce that different objects require different amounts of heat to change their temperatures. (u, gs, s, v/a) | a) Learners in groups review, brainstorm and report about the:<br>i) meaning of heat capacity and specific heat capacity (SHC); and<br>ii) measurement of SHC by the method of mixtures.<br>b) In groups, learners:<br>i) determine the SHC of solids and liquids using the electrical method;<br>ii) determine the SHC of liquids using continuous flow method and suggest how errors are minimised; and<br>iii) solve numerical problems related to SHC and make presentations.<br>c) Learners work in groups to research and make presentations on Newton's law of cooling and the factors that affect the rate of cooling. | a) Observe learners' contributions during the brainstorming while looking for the correctness of the definitions, formulae, units and coherence of the procedures for the method of mixtures.<br>b) Dialogue with learners while assessing the:<br>i) coherence of the experimental procedures for electrical and the continuous flow methods; and<br>ii) ability to compare the two methods used above.<br>c) Assess learners' written products while looking for:<br>i) coherence and correctness of experimental procedures; and<br>ii) correct use of equations in solving numerical problems related to SHC. |
| b) evaluate the concept of change of state and its implication in real life. (u, s, gs) | a) In groups, learners review in class discussions and report on the:<br>i) the meaning of latent heat;<br>ii) experimental determination of latent heat by method of mixtures; and<br>iii) explanation of latent heat in terms of the molecular theory.<br>b) In groups, learners:<br>i) determine the latent heat of Vaporisation and Fusion of water by electrical method;<br>ii) discuss in a plenary, the sources of errors in a plenary; and<br>iii) solve related numerical problems. | a. Observe learners' presentations while looking for correctness of the meanings, formulae, units and coherence of the procedures for the method of mixtures.<br>b. Dialogue with learners while assessing the:<br>i) coherence of the experimental procedures for the electrical method; and<br>ii) possible sources of errors and how they can be reduced. |

| | | |
|---|---|---|
| | c) Learners work in groups to model systems that use the concepts of heat capacity and latent heat to improve energy conservation such as building materials, automobiles, cooking stoves, electric devices and any other suitable. | c. Assess learner's written product while looking for:<br>i) coherence and correctness of experimental procedures;<br>ii) use of equations in solving numerical problems related to latent heat;<br>iii) appropriateness and assembling of the materials used for modelling; and<br>iv) workability and applicability of the models. |
| **Note:** Verification of Newton's law of cooling and cooling correction should not be considered | | |

## TOPIC 11: TRANSFER OF HEAT

**DURATION:** 18 Periods

**Competency:** The learner investigates modes of heat transfer in nature and their application in industry and society.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) explain the mechanism of heat conduction in solids and how it applies to materials in heat systems. (u, gs, v/a) | a) Learners brainstorm the meaning of the concepts of heat conduction, the mechanism of heat conduction, the factors which affect the rate of heat conduction in a material and make presentations.<br>b) In groups, learners investigate and make presentations on the thermal conductivity of different materials and their applications in real life.<br>c) In class discussions, learners work out numerical problems related to thermal conductivity. | a) Observe learners' presentations while looking for:<br>i) the correctness of the definitions, factors that affect heat transfer and the mechanism of heat transfer; and<br>ii) participation and respect for others' opinions.<br>b) Converse with learners while assessing the:<br>i) coherence of the experimental procedures for the determination of the thermal conductivity of different materials; and<br>ii) ability to explain applications of materials in relation to their thermal conductivities.<br>c) Assess learners' written products while considering their ability to solve numerical problems related to thermal conductivity. |

| | | |
|---|---|---|
| b) examine the significance of convection in explaining weather and climate. (u, gs, v/a) | a) In a brainstorming session, learners review the meaning of convection and how it can be demonstrated in liquids and gases and its application.<br>b) Learners debate the implications of natural convection in relation to ocean currents, weather patterns and seasons. | a) Observe learners' during the brainstorming session while looking for:<br>i) correctness of the meanings and explanations on the occurrence of convection in liquids and gases and applications; and<br>ii) involvement and respect for others' opinions.<br>b) Converse with learners while assessing the coherence and accuracy of the implications of convection in daily life. |
| c) deduce that heat can be transferred in form of electromagnetic radiations and this has many real-life applications. (s, gs, v, a) | a) Individually, learners review and discuss various ways of detecting thermal radiation and state properties of good and bad radiators /absorbers in plenary.<br>b) Learners in groups research on the meaning of black body radiation, its laws and use them to estimate the temperature of the Sun and other black bodies and make presentations.<br>c) In small groups, learners discuss the applications of black body radiation.<br>d) In class projects, learners model devices that employ heat transfer mechanisms. | a) Observe learners during the review while looking for:<br>i) participation; and<br>ii) respect for other peoples' opinions.<br>b) Converse with learners while assessing the:<br>i) correct illustration of the devices used for detection of thermal radiation and their mode of operation;<br>ii) correct responses on the properties of good and bad radiators;<br>iii) appropriate explanation of the concept of black body radiation with respect to heat absorption and radiation; and<br>iv) correct statement and application of laws governing black body radiation.<br>c) Assess written products while looking for:<br>i) correct explanation of black body radiation;<br>ii) correct statements of the laws and their applications;<br>iii) materials used in the models;<br>iv) learners' ability to collaborate and apply creativity in the development of the models;<br>v) workability of the models; and<br>vi) correct description of the applications of black body radiation. |
| **Note:** Exclude Provost's theory of exchanges. | | |

## TOPIC 12: BEHAVIOUR OF GASES

**DURATION:** 16 Periods

**Competency:** The learner investigates the effect of heat on the properties of gases and their applications in the operation of different systems in the oil and gas industry.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) analyse the behaviour of ideal gasses under different conditions. (u, s, gs) | a) Learners in groups investigate the effect of changing temperature, pressure and volume of ideal gases, deduce and verify the ideal gas laws and make presentations.<br>b) In class discussions, learners derive the ideal gas equation and other related expressions and apply them to solve a variety of numerical problems.<br>c) Learners use the concept of ideal gases to model systems that employ gas behaviour under different conditions. | a) Observe learners as they Investigate the effect of increasing and decreasing temperature, pressure and volume on an enclosed gas system while looking for their collaboration and active participation.<br>b) Converse with learners as they verify the gas laws focusing on correctness and coherence.<br>c) Assess learners' written products in terms of:<br>i) correct statement of ideal gas laws and their applications;<br>ii) appropriateness of material selection and use in the models;<br>iii) their ability to collaborate and apply creativity in the development of the models; and<br>iv) workability of the model. |
| b) evaluate the kinetic theory of gases and use it to derive the expression for the pressure exerted by the gas. (s, u, gs) | a) Learners research about the kinetic theory of gases and discuss why a gas exerts pressure. Then they present in plenary.<br>b) Learners in a class discussion derive the expression $$p = \frac{1}{3}\rho\overline{c^2}$$ and state the assumptions made.<br>c) In groups, learners analyse the expression $p = \frac{1}{3}\rho\overline{c^2}$ and apply it to:<br>i) deduce how the kinetic energy of the gases is dependent on their temperature of the gas;<br>ii) deduce ideal gas laws; | a) Observe learners as they discuss looking for the accuracy of the:<br>i) procedure of the derivation;<br>ii) application of the equation in estimating the pressure of an enclosed system; and<br>iii) cooperation and respect for others' opinions.<br>b) Converse with learners to check the:<br>i) correctness of the assumptions made in ideal gas laws; and<br>ii) coherence in the derivation of expressions for ideal gases. |

| | | |
|---|---|---|
| | iii) verify Avogadro's law, Dalton's law of partial pressure and Grahams law of diffusion; and<br>iv) solve related numerical problems related to them. | c) Assess learners written products while looking for:<br>i) the correctness of statement of assumptions and derivation of expressions; and<br>ii) correct use of expressions to solve related numerical problems. |
| c) modify the ideal gas equation to suit the behaviour of real gases. (u) | a) In groups, learners:<br>i) discuss conditions under which real gases approximate ideal gas behaviour;<br>ii) deduce the modifications required in the ideal gas equation to suit the behaviour of real gases; and<br>iii) describe the key features of the P-V curves for real gases and discuss the significance of critical temperature to distinguish gases from vapours. | a) Assess learners' derivations while looking for correct procedure of derivation, the assumptions made and modification.<br>b) Discuss with learners while looking for:<br>i) correct properties of real gases;<br>ii) modifications required to approximate ideal gases to real gases;<br>iii) significance of Van der Waal's equation; and<br>iv) P-V graph for real gases and its features.<br>c) Assess learners written products on (b) above while looking for correctness of statements and expressions. |
| d) infer that vapours exert pressure and that this has many real-life application s. (u, s, gs, v/a) | a) In groups, learners brainstorm and review the terminologies related to vapours; saturated vapour (SV), unsaturated vapour (USV) and saturated vapour pressure (SVP), and their applications to real life.<br>b) Learners in groups:<br>i) investigate the variation of SVP of water with temperature and the implication of the results to water systems;<br>ii) sketch the P-V graphs showing the variation of SVP, USVP with temperature and volume; and<br>iii) distinguish between SV and USV and use the concept in solving related numerical problems. | a) Observe learners as they brainstorm and carry out investigations while looking for teamwork, involvement and respect for others' opinions.<br>b) Discuss with learners while checking for correctness of the terms, p-v graphs, implications and investigation procedures.<br>c) Assess learners' written products on the correctness of:<br>i) terminologies;<br>ii) P-V graphs;<br>iii) coherence of experimental procedures; and<br>iv) use of expressions to solve numerical problems on vapours. |

## TOPIC 13: THERMODYNAMICS

**DURATION:** 12 Periods

**Competency:** The learner appreciates the behaviour of compressed gas systems in relation to their domestic and industrial applications.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) deduce that every system has internal energy which is a function of its temperature. (u, s) | a) In groups or as individuals, learners:<br>i) explain the terminologies related to thermodynamic processes and how they apply to real-life situations;<br>ii) research about the concepts of external heat, internal energy and work done by an ideal gas; and<br>iii) derive the expression for work done by a gas: $\boldsymbol{W = \int PdV}$ and relate it to the compression of gas systems. | a) Converse with learners while looking for the correctness of the concepts of:<br>i) external heat, internal energy and work done by an ideal gas; and<br>ii) isothermal, isovolumetric and isobaric and adiabatic changes/processes.<br>b) Assess learners' written product on the coherence of the procedures in the derivation of the expression for work done by an ideal gas and use it to solve numerical problem. |
| b) analyse the first law of thermodynamics and its implications in real-life situations. (u, s, gs) | a) Learners in groups research, discuss and make presentations about:<br>i) the molar heat capacities ($\boldsymbol{C_p}$ **and** $\boldsymbol{C_v}$), molar ratio ($\boldsymbol{\gamma}$) of an ideal gas and<br>ii) the first law of thermodynamics to deduce the expression $\boldsymbol{\Delta Q = \Delta U + P\Delta V}$.<br>b) In groups or as individuals, learners derive and make presentations on the relationship $\boldsymbol{C_p - C_v = R}$ and other expressions for isothermal and adiabatic processes and use them to solve a variety of numerical problems. | a) Observe learners' presentations on derivations while looking for:<br>i) correct procedure of derivation and the assumptions made;<br>ii) correct use of the equations in solving numerical problems about thermodynamic processes; and<br>iii) the correctness of the implications of the thermodynamic expressions and processes in real life.<br>b) Evaluate learners' written products while looking for the coherence of the procedures in the derivation of thermodynamic expressions and their use in solving related numerical problems.<br>c) Assess learners' modelled products in terms of: |

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| | c) Learners discuss the concept of work done by an ideal gas at constant volume and constant pressure in relation to gas filling processes (gas cooker, compressors for refrigerators and air conditioners, washing machines, welding gas cylinders etc.).<br>d) Learners model the devices mentioned in (c) above where possible, and make exhibitions. | i) appropriateness of material selection and their use in the models;<br>ii) their ability to collaborate and apply creativity in the development of the models; and<br>iii) workability of the models. |

# SENIOR FIVE TERM 3

## TOPIC 14: REFLECTION OF LIGHT

**DURATION:** 14 Periods

**Competency:** The learner investigates the light reflecting properties of different surfaces and their applications in real life.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) employ the laws of reflection of light at plane surfaces to resolve different life scenarios. (u, v/a) | a) In groups, learners review, brainstorm and make presentations about the rectilinear propagation of light, the reversibility of light, statements and verification of the laws of reflection of light.<br>b) In groups or as individuals, learners research, discuss and derive the relationship between:<br>i) angle of deviation and glancing angle for two plane mirrors inclined at an angle to each other; and<br>ii) angle of rotation of a plane mirror and angle of rotation of the reflected ray and its real-life applications.<br>c) In groups, learners model optical systems that apply the laws of reflection of light at plane surfaces. | a) Observe learners' participation in the group work while looking for:<br>i) accuracy of information; and<br>ii) any misconceptions that need to be corrected.<br>b) Converse with learners about correctness and accuracy in the expressions derived.<br>c) Assess learners':<br>i) written products on the coherence of the procedures in the derivation of the expressions;<br>ii) material selection for models and workability; and<br>iii) ability to solve numerical problems about reflection on plane surfaces. |

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| b) apply curved reflecting surfaces in real-life situations. (u, gs, v/a) | a) In groups, learners review, brainstorm and make presentations about terms used under curved mirrors and ray diagrams.<br>b) In groups, learners research, discuss and make presentations about mirror equations, magnification formula, and the relationship **r = 2f** for spherical mirrors.<br>c) In pairs, learners design experiments to measure the focal length of curved mirrors. They discuss and report on the sources of errors and how they can be minimised.<br>d) In groups, learners model simple devices that use curved mirrors including those used to harness solar energy for domestic use and in telecommunication systems. | a) Listen to the group discussions while assessing the correctness of the:<br>i) meaning of terms used in relation to curved mirrors;<br>ii) procedures of derivations; and<br>iii) use of ray diagrams.<br>b) Assess the experimental design based on the:<br>i) correct use and choice of the mirrors;<br>ii) accuracy and analysis of data collected;<br>iii) conclusions drawn;<br>iv) sources of errors and how they can be minimised; and<br>v) participation and cooperation among the learners.<br>c) Assess learners' products based on the correctness of their write-ups:<br>i) in (b) above; and<br>ii) on applications of curved reflecting surfaces. |

## TOPIC 15: REFRACTION OF LIGHT

**DURATION:** 24 Periods

**Competency:** The learner explores the refractive properties of different materials for application in industries and medicine.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) apply the concept of refraction on plane surfaces to various situations in real life. (u, gs, v/a) | a) Learners review, brainstorm and present on the concept of refraction on plane surfaces (liquids, glass blocks, semi-circular glass and prisms), its effects and the laws of refraction of light.<br>b) In groups, learners research, discuss and make presentations about:<br>i) application of Snell's law to derive the expression $nsini = constant$ | a) Observe learners' participation while looking for the accuracy of the information and correct any misconceptions.<br>b) Dialogue with learners while assessing:<br>i) the correctness in the statement of laws of refraction and application of the concept in real life;<br>ii) coherence in the derivation of the expressions $d = (i_1 - r_1) + (i_2 - r_2)$, $d = (n - 1)A$; |

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| | for different media and use it to solve numerical problems; and<br>ii) expressions that describe refraction of light by glass blocks and glass prisms.<br>c) Learners investigate the:<br>i) refracting angle A, and minimum deviation $D_{min}$ for prisms;<br>ii) refractive indices of different materials using various methods such as (small quantity of a transparent liquid on a concave mirror, real and apparent depth); and<br>iii) sources of errors in determining the refractive indices and how they can be minimised. | iii) their ability to design investigations to determine the refracting angle A, the angle of minimum deviation, $D_{min}$ of a glass prism and refractive indices of different materials using various methods; and<br>iv) their ability to solve numerical problems under refraction.<br>c) Assess learners' products based on their write-ups in (b) above and the accuracy in the numerical problems solved. |
| b) analyse the concepts of critical angle and total internal reflection and their implications. (u, v/a, s, gs) | a) Learners in groups review and present on the concepts of critical angle and total internal reflection, and their applications.<br>b) In groups or as individuals, learners:<br>i) derive expressions relating critical angle and refractive index;<br>ii) carry out an investigation to determine the refractive index of a liquid using air- cell method; and<br>iii) solve numerical problems on critical angle and total internal reflection. | a) Observe learners' discussion while assessing the correctness of the concepts of critical angle, total internal reflection and their applications.<br>b) Dialogue with learners while assessing:<br>i) coherence in the derivation of the expressions relating critical angle and refractive index;<br>ii) their ability to perform the experiment to determine the refractive index of a liquid by air-cell method; and<br>iii) their ability to solve numerical problems on critical angle and total internal reflection.<br>c) Assess learners' written products to check whether they can write coherent derivations, experimental procedures and solve numerical problems related to critical angle and total internal reflection. |

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| c) apply lenses in solving a variety of problems in the community. (u, gs, v/a) | a) In a brainstorming session, learners review the terminologies related to thin lenses and make presentations.<br>b) In pairs or as individuals, learners research and make presentations about the:<br>i) derivation of lens formula (convex and concave);<br>ii) determination of focal lengths of lenses using various methods and evaluate the effectiveness of the methods used;<br>iii) meaning of conjugate points, the lens maker's formula and derive the expressions<br>$l^2 - d^2 = 4df$, and<br>$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$; and<br>iv) meaning of spherical and chromatic aberrations, and how they can be minimised. | a) Listen to learners' views while asking probing questions to assess the correct use of terms under lenses, fluency in expressions, involvement in discussions and critical thinking abilities.<br>b) During discussions, ask learners probing questions to assess their ability to:<br>i) coherently follow the procedures to derive different expressions under thin lenses and in performing the experiment;<br>ii) apply derived expressions to solve related numerical problems; and<br>iii) explain the meaning of conjugate points and aberrations as applied to thin lenses.<br>c) Evaluate the quality of learning through assessment of learners' products, their presentations and write-ups in the derivation of the lens formula. |

## TOPIC 16: OPTICAL INSTRUMENTS

**DURATION:** 10 Periods

**Competency:** The learner explores the optical operation of different optical instruments that can be applied in a variety of fields such as medicine, military and navigation.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a. explain the principle of operation of a compound microscope and their real-life applications. (u, s) | a. Learners research, discuss and make presentations on the following concepts; near point, far point, accommodation, visual angle, exit pupil (eye ring) and magnifying power of an optical instrument.<br>b. In pairs, learners research and discuss the principle of operation of a compound microscope, derive expressions for its magnification in normal and abnormal adjustments and their real-life applications. | a. discuss with learners during their presentations while looking for:<br>i) the correct meaning of near point, far point, visual angle, eye ring and magnifying power; and<br>ii) their ability to describe the principle of operation of a compound microscope in normal and abnormal adjustment.<br>b. Assess products to ensure that learners have coherent and accurate write-ups on the operation of a compound microscope, derivations of magnifications and applications in solving numerical problems. |
| b. describe the principle of operation of refracting telescopes and their applications. (u, s) | a. Learners research, discuss and make presentations in groups on:<br>i) the mode of operation of refracting telescopes;<br>ii) derivations for the expressions of magnifications with the final image at near point, and at infinity; and<br>iii) real-life applications of refracting telescopes.<br>b. In groups, learners carry out a project to model optical devices such as telescopes. | a. Observe learners' discussions, while looking for:<br>i) accurate information on the mode of operation of refracting telescopes and correcting any misconceptions; and<br>ii) accurate use of ray diagrams to form final images.<br>b. Assess learners' product to check on:<br>i) appropriateness and the use of the materials selected;<br>ii) creativity and critical thinking; and<br>iii) workability of the models. |
| **NOTE:** Only compound microscopes and refracting telescopes should be considered. The operation of reflecting telescopes should be left out. | | |

## TOPIC 17: ELECTROSTATICS

**DURATION:** 24 Periods

**Competency:** The learner investigates the behaviour of charges at rest and their applications in printing and energy storage in batteries.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) apply the concept of Electrostatics in production of charge in real-life situations. (u, s, gs) | a) In pairs, learners review, discuss and make presentations on:<br>i) production and detection of charges by different methods;<br>ii) distribution of charge on conductors of different shapes; and<br>iii) corona discharge and its applications in real life.<br>b) In pairs, learners research and make presentations on the principle of Faraday's ice pail experiment and its applications.<br>c) In groups, learners model and explain the operation of devices which include among others car sprayer, ink-jet printers, electrostatic air cleaners and the Van der Graaf generator. | a) Observe and listen to the learners' participation in a discussion while looking for accuracy of information and correct any misconceptions.<br>b) Assess the:<br>i) choice of the materials used;<br>ii) procedure used in the description of ice pail experiment; and<br>iii) conclusions made based on charge distribution.<br>c) Assess learners' product to check on:<br>i) correctness of their write-ups on the experiments and models;<br>ii) appropriateness and the use of the materials selected for the model; and<br>iii) innovativeness and workability of the model designed. |
| b) appreciate the existence of a force between charges and its implications. (u, s, gs) | a) In groups or individually, learners demonstrate the existence of force between charged bodies.<br>b) In groups, learners search for and make presentations on the expression of Coulomb's law, and its applications in solving numerical problems. | a) Observe learners as they demonstrate the existence of force between two charged bodies while looking for:<br>i) their participation, creativity and correctness;<br>ii) appropriate choice of materials; and |

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| | | iii) critical thinking and respect for others' opinions.<br>b) Assess learners write-ups while looking for:<br>i) coherence and correctness in the statement and expression of Coulomb's law; and<br>ii) accuracy in solving numerical problems. |
| c) examine electric fields and their implications in various situations. (u, s) | a) Learners, in groups research, discuss and make presentations on:<br>i) the interaction of electric fields around different charges;<br>ii) the derivation of the expressions for resultant electric field intensity (E), electric field potential (V), work done and their applications in solving real-life problems; and<br>iii) variation of E and V with the distance r from a charged body. | a) Engage with learners in their discussions while looking for correct:<br>i) illustration of electric field patterns around charges; and<br>ii) procedures in the derivation of expressions for resultant electric field, electric potential, work done, and their applications in solving related numerical problems.<br>b) Assess learners write-ups on (a) above while looking for accuracy and relevancy of applications. |

## TOPIC 18: CAPACITORS

**DURATION:** 22 Periods

**Competency:** The learner models capacitors for use in electronic devices.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Suggested Assessment Strategies** |
|---|---|---|
| a) appreciate that capacitors store charge and have many applications. (s, u) | a) In groups or as individuals, learners research and make presentations about:<br>i) terminologies used in relation to capacitors;<br>ii) factors affecting the capacitance parallel plate capacitor;<br>iii) derivation of the expressions for the capacitance of a parallel plate capacitor;<br>iv) derivation of the expressions for effective capacitance in series and parallel networks; and<br>v) application of expressions to solve numerical problems.<br>b) In pairs, learners model simple capacitors using local materials and apply them in making electrical devices. | a) Converse with learners during their presentations while looking for the:<br>i) correct meaning of terms and description of factors affecting capacitance;<br>ii) coherence of procedures in the derivation of expressions; and<br>iii) accuracy of solving numerical problems.<br>b) Assess learners' products while looking for:<br>i) coherence in the description and correctness of numerical problems solved; and<br>ii) choice of materials used in making a capacitor, innovativeness and workability of the model. |
| b) apply the charging and discharging processes of a capacitor in electrical and electronic devices. (u, s, gs, a/v) | a) Learners in groups research, discuss and make presentations on:<br>i) charging and discharging processes of a capacitor;<br>ii) sketch graphs on variation of p.d versus time for the charging and discharging processes and their explanations; and<br>iii) description of the application of charging and discharging processes of capacitors.<br>b) Learners discuss the application of capacitors in; charge storage, tuning radio frequencies, smoothing of rectified a.c, loudspeakers, microphones, radios, sensors, power regulation, plastic films and others. | a) Discuss with learners in their discussions while looking for correctness:<br>i) in the explanation of charging and discharging processes of a capacitor;<br>ii) of sketch graphs on variation of p.d versus time for the charging and discharging processes and their explanations; and<br>iii) of different applications of capacitors.<br>b) Assess learners' products on the coherence and quality of write-ups in (a) above |

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|---|---|---|
| c) deduce that capacitors store energy which can be used in a variety of real-life situations. (u, s, gs) | a) Learners research and make presentations on:<br>i) source of energy stored on capacitors;<br>ii) derivation of expressions for the energy stored on a charged capacitor and their use in solving numerical problems; and<br>iii) the energy losses when isolated parallel plate capacitors are connected together. | a) Observe and listen to learners' participation in a discussion while looking for:<br>i) correctness of information and correct any misconceptions;<br>ii) logical flow in the derivation of the expressions for energy; and<br>iii) use of the derived expressions to solve related numerical problems.<br>b) Assess learners' products on the coherence and quality of write-ups in (a) above. |

## TOPIC 19: DIGITAL ELECTRONICS

**DURATION:** 14 Periods

**Competency:** The learner models electronic circuits using semiconductor materials and electronic devices for a variety of purposes.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) examine the performance of semiconductor diodes in different devices. (u, s, gs) | a) Learners review, brainstorm, discuss and make presentations on:<br>i) number base systems;<br>ii) logic gates and truth tables, and their applications;<br>iii) bistable switches; and<br>iv) potential dividers.<br>b) Learners research, discuss and make presentations on:<br>i) conductors, insulators and semi-conductors in terms of energy band gaps;<br>ii) doping process and formation of n-type, p-type semiconductors; and<br>iii) the operation of p-n junction diodes and characteristics of diodes. | a) Observe and listen to the learners' presentations in a discussion while looking for:<br>i) accuracy of information and correct any misconceptions;<br>ii) collaboration and teamwork; and<br>iii) creativity and innovation in the use of ICT on simulation videos.<br>b) Converse with learners during their presentations while looking for:<br>i) the correctness of the explanations and the meaning of conductors, insulators and semiconductors in terms of energy band gaps;<br>ii) ability to suggest materials for doping to create n-type or p-type semiconductors; and |

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| | c) Learners in pairs use ICT tools to obtain simulations/animations videos on the operations and applications of junction diodes. | iii) ability to explain the operation of a junction diode.<br>c) Evaluate learning by assessing the products focusing on the coherence of write-ups. |
| b) analyse the operation and application of transistors in various situations. (u, s, gs) | a) Learners are guided to research and make presentations about the:<br>i) operation of n-p-n and p-n-p type transistors;<br>ii) explanation of I-V characteristics for the transistors; and<br>iii) uses of transistors as switches, and amplifiers in electronic devices.<br>b) In groups, learners derive expressions on the operations of transistors and use them to solve numerical problems.<br>c) In groups, learners model devices that employ diodes and transistors and describe how they work. | a) Assess the presentations of learners based on their ability to:<br>i) distinguish between the operations of p-n-p and n-p-n transistors;<br>ii) explain the applications of transistors in electronic circuits;<br>iii) draw and interpret the I-V curves for transistors; and<br>iv) correctly derive expressions on the operations of transistors and use them in solving numerical problems.<br>b) Assess learners' products such as the workability of the devices modelled and innovations therein. |

# SENIOR SIX TERM 1

## TOPIC 20: CIRCULAR MOTION

**DURATION:** 12 Periods

**Competency:** The learner examines the motion of bodies on curved paths and ensures safety precautions for people using automobiles on such paths.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) investigate the forces acting on bodies moving in circular paths and how they relate to safety. (u, s, gs, v/a) | a) In a discussion and brainstorming session, learners identify daily life situations where motion in a circle exists and make presentations<br>b) In groups, learners explain the meaning of the terms; angular velocity, angular acceleration and centripetal force.<br>c) In groups, learners research and derive expressions for angular velocity, angular acceleration and centripetal force, and use them in solving related numerical problems. | a) Observe learners' presentations while looking for appropriateness in:<br>i) application of circular motion in daily life situations; and<br>ii) derivations of the expressions under circular motion and their use in solving numerical problems.<br>b) Assess learners' products on the coherence and quality of write-ups in (a) above. |
| b) derive the expressions for motion under conical pendulum and apply them in real life. (u, s, v/a) | a) In pairs, learners review, brainstorm, discuss and make presentations on the effect of gravity on the motion of bodies in a circular path.<br>b) Learners research, discuss and make presentations on expressions for the conical pendulum and apply them in solving numerical problems. | a) Observe learners' participation and listen to their discussion while looking for accuracy of information and correcting any misconceptions.<br>b) Dialogue with learners while assessing their ability to correctly:<br>i) derive the expressions for the motion on the conical pendulum; and<br>ii) use the expressions to solve numerical problems.<br>c) Assess leaners' product on the coherence and correctness of the write-ups in (b) above. |

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| c) investigate the conditions for non-skidding on banked and horizontal roads to ensure safety. (u, v/a) | a) In a discussion and brainstorming session, learners identify daily life situations where motion on banked roads exists and make presentations.<br>b) In groups, learners explain the meaning of angle of banking and derive expressions relating the angle of banking, velocity and acceleration of bodies moving in a circular path and apply these expressions in solving numerical problems. | a) Observe learners' presentations while looking for:<br>i) correct conditions for non-skidding motion on a circular path; and<br>ii) correct derivations of the expressions under banked motion and their use in solving numerical problems.<br>b) Assess learners' products on the coherence and quality of write-ups in (a) above. |
| **NOTE:** Motion in a vertical circle should not be included. | | |

## TOPIC 21: SIMPLE HARMONIC MOTION

**DURATION:** 18 Periods

**Competency:** The learner investigates the behaviour of oscillating systems in order to optimise the performance of devices that employ simple harmonic motion.

| Learning Outcomes<br>The learner should be able to: | Suggested Learning Activities | Sample Assessment Strategies |
|---|---|---|
| a) explain terminologies used in simple harmonic motion (SHM) and apply them to oscillating systems. (u, s) | a) In groups, learners research, discuss and make presentations on the derivations of expressions of displacement, velocity, acceleration, energy, period and frequency of a body executing SHM and apply the expressions to solve numerical problems.<br>b) Learners in groups discuss and make presentations on the oscillations of; simple pendulum, floating cylinder, liquid in a U-tube, mass at the end of a vertical spring or a horizontal spring on a smooth surface and derive expressions to show that these oscillations execute SHM. | a) Observe and assess the presentations of learners while looking for:<br>i) correctness of concepts, terminologies and graphical representation of SHM; and<br>ii) characteristics of SHM.<br>b) Dialogue with learners to find out the correctness and coherence in:<br>i) experimental determination of acceleration due to gravity;<br>ii) derivation of expressions for bodies executing SHM; and<br>iii) solving numerical problems.<br>c) Assess learners: |

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|---|---|---|
| | c) In groups or as individuals, learners use the expressions derived in (b) above to solve related numerical problems.<br>d) Learners in groups discuss the applications of SHM in the determination of acceleration due to gravity, g and other real-life situations such as shock absorbers, guitars, diving boards, earthquake proofs in buildings, to mention but a few. | i) on logical reasoning and acceptance of constructive criticism in their discussions about the applications of SHM in real-life situations; and<br>ii) on the correctness of their write-ups. |
| b) explore energy conservation in oscillating systems and its implications in various daily experiences. (u, s, gs) | a) In pairs, learners research, discuss and make presentations on:<br>i) interchange of energy in a SHM and relate it to the principle of conservation of energy; and<br>ii) different types of oscillations and their implications in real life.<br>b) Learners work in groups to model and design oscillating system devices. | a) Observe and assess the presentations of learners while looking for correctness of concepts of energy conversions in different oscillating systems and graphical representations.<br>b) Dialogue with learners while assessing:<br>i) the accuracy and relevance of the implications of the different types of oscillations in real life; and<br>ii) choice of materials suitable for the construction of the selected system.<br>c) Assess learners' products while looking for creativity, innovation, teamwork and workability of the model. |
| **Note:** Do not include connected springs. | | |

## TOPIC 22: GRAVITATION

**DURATION:** 20 Periods

**Competency:** The learner evaluates the effects of gravitation and its applications on objects both on earth and in space.

| Learning Outcomes<br>The learner should be able to: | Suggested Learning Activities | Sample Assessment Strategies |
|---|---|---|
| a) apply the laws and principles of gravitation to real life. (u, v/a, gs) | a) Learners research, discuss and make presentations on:<br>i) the interaction of masses in space and the nature of force acting on them;<br>ii) Kepler's and Newton's laws of gravitation; and<br>iii) gravitational field intensity.<br>b) Learners use the information from activity (a) above to derive the dimensions and S.I units of the gravitational constant, G.<br>c) In groups learners use Newton's and Kepler's laws of gravitation to explain and derive the expressions for:<br>i) the variations of g with latitude;<br>ii) weightlessness in orbits; and<br>iii) distance of bodies from the centre of the earth and how it relates to ocean tides, seasons, cyclones among others, and make presentations.<br>d) As individuals or in groups, learners use the expressions derived in (c) above to solve related numerical problems. | a) Observe learners as they present about Kepler's and Newton's laws of gravitation while assessing their ability to:<br>i) effectively express themselves and respect others' opinions;<br>ii) use a range of presentation techniques; and<br>iii) explain the implications of the laws.<br>b) Assess the learners' written products about Kepler's and Newton's laws on gravitation while looking for:<br>i) accuracy in statements of the laws; and<br>ii) correct use of mathematical expressions to solve numerical problems and explain related phenomena. |
| b) investigate the effect of gravity on bodies orbiting in space such as communication satellites and related phenomena. (u, s, gs) | a) Learners use Kepler's and Newton's laws of gravitation to determine parking orbits, velocity of escape and energy of the satellite.<br>b) Learners review previous knowledge about satellites and their applications in; communication (telephone, television, radio broadcast), navigation, disaster management and security among others. | a) Observe and probe learners during the presentations while assessing their ability to:<br>i) determine parking orbits, velocity of escape and energy of the satellite in orbit; and<br>ii) confidently explain the applications of satellites in real life. |

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| | c) Learners use ICT tools such as simulations and videos to study orbiting satellites and planets, and make presentations. | b) Assess learners' written products while looking for:<br>i) logical flow in the derivation of expressions describing the motion of bodies in orbits around the earth;<br>ii) accuracy in the determination of parking orbits, velocity of escape and energy of satellites; and<br>iii) relevancy and coherence in applications of satellites. |
| **Note:** Experimental determination of G should be left out. | | |

## TOPIC 23: PROGRESSIVE WAVES

**DURATION:** 24 Periods

**Competency:** The learner investigates the propagation of progressive waves in matter and its application in different situations.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) deduce that waves are a means of transferring energy and that this has many applications. (u, s, gs) | a) Learners review, brainstorm, discuss and make presentations about:<br>i) terminologies used in waves;<br>ii) types and forms of waves;<br>iii) the general wave equation;<br>iv) reflection and refraction of waves.<br>b) In groups, learners research, explain and report on:<br>i) the characteristics of a progressive wave and state their examples; and<br>ii) different types of wave fronts, optical path, reflection and refraction of waves and phases of vibration.<br>c) In groups, learners research and derive the expression for displacement on a progressive wave; $y = a \sin 2\pi \left(\frac{t}{T} \pm \frac{x}{\lambda}\right)$ | a) Observe learners' presentations and look out for:<br>i) the correctness of the meanings of terminologies and correct any misconceptions; and<br>ii) individual learner's participation.<br>b) Converse with learners while asking probing questions to test their ability to:<br>i) identify the types of progressive waves;<br>ii) represent reflection and refraction of progressive waves using appropriate diagrams; and<br>iii) explain the significance of ± in the progressive wave equation.<br>c) Assess products while looking for: |

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| | and explain the significance of ± in the equation, and use it to solve numerical problems.<br>d) In pairs, learners research, discuss and make presentations on Huygen's principle and its application in a variety of situations.<br>e) Learners model and develop communication systems that use the concept of progressive wave transmission. | i) correctness of the meanings of terminologies related to progressive waves;<br>ii) coherence in the derivation of the progressive wave equation and its proper use in substitution; and<br>iii) innovations and creativity in the development of models. |
| b) deduce that when waves interfere, they generate properties that have various applications in real life. (u, s, gs, v/a) | a. Learners review, brainstorm, discuss and make presentations about:<br>i) the term interference of waves;<br>ii) the conditions for constructive and destructive interference to occur; and<br>iii) production of interference in a ripple tank.<br>b. In groups, learners research and report on:<br>i) coherent sources, path difference, energy of a wave, division of amplitude and wavefront;<br>ii) Young's double slit experiment and derive the expression $\boldsymbol{\Delta y = \frac{\lambda D}{a}}$ and how it is applied to solve numerical problems; and<br>iii) appearance of fringes and how Young's double slit experiment can be used for measuring wavelength, slit separation, and fringe separation. | a. Observe learners' presentations while assessing:<br>i) the correctness of the meanings of interference of waves and its applications; and<br>ii) individual learner's participation.<br>b. Probe learners' ability to:<br>i) relate amplitude, frequency, velocity and phase during the superposition of different waves; and<br>ii) identify the conditions for constructive and destructive interference and correct any misconceptions.<br>c. Asses learners' written products basing on the ability to:<br>i) draw and explain fringe patterns in different situations; and<br>ii) describe the young's experiment coherently. |
| c) explain concepts related to diffraction of waves and apply them to everyday life situations. (s, gs, v/a) | a) Learners in groups research, discuss and make presentations on:<br>i) the concept of diffraction of waves;<br>ii) the dependence of diffraction on wavelength;<br>iii) derive the expression $\boldsymbol{dsin\theta = n\lambda}$ for diffraction of waves and use it to solve numerical problems; and<br>iv) the occurrence of diffraction in real life.<br>b) Learners describe the appearance of diffraction images in a single slit, double slit and discuss the effect of | a) Observe learners' discussions while assessing their ability to:<br>i) participate and relate; and<br>ii) correctness of the terms, concepts and sketch diagrams.<br>b) Assess written products while looking for ability to:<br>i) relate atomic spacing to optical;<br>ii) path length for diffraction in a material; and<br>iii) explain the applications of diffraction in different situations. |

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| | the number of slits per unit length on the appearance of fringes. | |
| d) examine the phenomenon of wave polarisation and how it applies to real life. (u, v/a) | a) In groups, learners research, discuss and report about:<br>i) concept of polarisation of light;<br>ii) distinction between plane polarised and non-plane polarised light;<br>iii) polaroid;<br>iv) production of polarised light using a variety of methods; and<br>v) applications of polarised light. | a) Observe learners' presentations and look out for the correctness and accuracy of the meanings of terms and concepts related to polarisation (polariser, transmission axis, **s** and **p** polarised waves) and correct any misconceptions.<br>b) Converse with learners paying particular attention to their ability to explain the concept of polarisation and distinguish between polarised and unpolarised light and correct any misconceptions.<br>c) Assess written products while looking for:<br>i) coherence in the process of production of polarised light by different methods; and<br>ii) applications of polarised light. |
| **Note**: Numerical concepts on polarisation of light should be left out. | | |

## TOPIC 24: STATIONARY WAVES

**DURATION:** 16 Periods

**Competency:** The learner investigates the behaviour of stationary waves and their applications in different situations.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
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| a) analyse the behaviour of stationary waves, and the expressions that describe them. (u, s) | a) In groups, learners research, discuss and present on:<br>i) the superposition of progressive waves;<br>ii) formation and characteristics of stationary waves stating examples; and<br>iii) derivation of the stationary wave equation and its use in solving numerical problems. | a) Observe the discussions and presentations while assessing the correctness of superposition and characteristics of stationary waves.<br>b) Probe learners while assessing their ability to explain the formation of stationary waves and their features.<br>c) Assess learners' written products while looking for:<br>i) coherency in the derivation of the stationary wave equation; and<br>ii) proper application of the equation to solve numerical problems. |
| b) deduce that stationary waves can be produced in pipes and strings for use in a variety of situations. | a) In groups, learners research, discuss and report on:<br>i) stationary waves on stretched strings;<br>ii) factors affecting the pitch of a note from a stretched string;<br>iii) derivation of the expression $v = \sqrt{\frac{T}{\mu}}$ and use it to solve numerical problems;<br>iv) stationary waves in pipes and determine end-error-correction; and<br>v) harmonics in strings and pipes and how they relate to the advantages and disadvantages of open and closed pipes.<br>b) In groups, learners investigate how frequency is determined in a stretched string.<br>c) In groups or as individuals, learners model systems that apply the concept of stationary waves in pipes and strings. | a) Probe learners while assessing their ability to:<br>i) identify points of maximum and minimum energy on a stationary wave;<br>ii) establish resonance positions and end corrections; and<br>iii) solve numerical problems relating to wavelengths, velocity and frequency in a stationary wave.<br>b) Assess written products while focussing on:<br>i) coherency in the derivation of velocity in a stationary wave;<br>ii) coherence in the steps used to investigate how frequency in stretched strings is determined; and<br>iii) workability and innovation in the models of learners. |

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| c) illustrate the concept of resonance of waves and its applications. (u, s, v/a) | a) In groups, learners research, discuss and present on:<br>i) resonance in strings and pipes (closed and open); and<br>ii) how resonance relates to the length of an air column in a pipe or length of string.<br>b) In groups, learners determine the speed of sound in air using a resonance tube.<br>c) Learners discuss and report on applications of stationary waves in electronics such as radio, TV receivers, amplifiers and filters. | a) Converse with learners to ascertain whether they can explain the application of stationary waves:<br>i) to control the quality and pitch of sound;<br>ii) in production of beats and reverberations in amplifiers; and<br>iii) in resonance to explain the tuning of radio, amplifiers and TV.<br>b) Assess written products to ascertain the:<br>i) appropriateness of the materials (strings, masses) and the procedures used in the investigation;<br>ii) appropriateness and use of the materials (tuning forks of different frequencies metre rule) in investigating resonance;<br>iii) proper use of wave equation in determining the speed of sound using resonance; and<br>iv) identification of possible sources of errors in the investigation and how they can be minimised. |

## TOPIC 25: SOUND WAVES

**DURATION:** 20 Periods

**Competency:** The learner investigates the behaviour of sound waves and their applications in different situations.

| Learning Outcomes<br>The learner should be able to: | Suggested Learning Activities | Sample Assessment Strategies |
|---|---|---|
| a) analyse beats, notes and octaves as applied in sound, and their implications in a variety of situations. (u, s) | a) Learners review in a think-pair-share session and discuss:<br>i) the production and propagation of sound in different media;<br>ii) factors that affect the speed of sound in different media;<br>iii) echoes and reverberations; and<br>iv) methods of determining the speed of sound.<br>b) Learners research, discuss and make presentations on:<br>i) the meaning of tone, fundamental note, overtones, harmonics, octaves, and beats; and<br>ii) the effect of overtones on the quality of sound.<br>c) In groups, learners research and discuss on:<br>i) formation of beats and their applications; and<br>ii) derivation of the expression for beat frequency $\Delta f = f_2 - f_1$ and apply it in solving numerical problems. | a) Observe learners' discussion and look out for the correctness and accuracy of the concepts relating to the:<br>i) production and propagation of sound in different media; and<br>ii) formation of overtones and harmonics and correct any misconceptions.<br>b) Dialogue with learners while looking for:<br>i) understanding of how beats are formed and correcting any misconceptions;<br>ii) applications of beats in real-life situations; and<br>iii) correct procedure used in the derivation.<br>c) Assess written products and ascertain the:<br>i) correctness in the terminologies related to sound waves;<br>ii) coherence in the derivation of beat frequency; and<br>iii) application of the beat frequency expression. |

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| b) investigate doppler effect and how it applies to various fields. (u, v/a) | a) Learners in groups research, discuss and make presentations about description of some applications of doppler effect such as sonar, weather forecasting, tracking systems, sirens, radar, medical imaging, blood flow and satellite communication.<br>b) In groups, learners research and make models of cell phones, radio broadcasting or sound scan imaging among others that use the concept of waves in their mode of operation. | a) Observe the presentations in order while assessing the learners':<br>i) understanding of the concept of doppler effect;<br>ii) ability to derive the equations of frequency in different relative motions and proper use of wave equations in the investigation of doppler effect;<br>iii) ability to explain the theory of different systems based on the doppler effect; and<br>iv) understanding of echoes, reverberations and interference of sound waves.<br>b) Assess learners' written products while looking for:<br>i) coherence in derivation of the apparent frequency in doppler effect and its use;<br>ii) proper statements for application of doppler effect; and<br>iii) innovations in the models made by learners. |

# SENIOR SIX TERM 2

## TOPIC 26: CURRENT ELECTRICITY

**DURATION:** 20 Periods

**Competency:** The learner investigates electric current, it's properties, transmission and uses in order to reduce power losses and improve personal and national safety.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) deduce the relationship between current, resistance and voltage, and how they relate to transmission of charges in materials. (u, s) | a) In a brainstorming session, learners make review, discuss and report on:<br>i) electric current, emf, resistance and potential difference, internal resistance, Ohm's law and its verification; and<br>ii) effective resistance for resistors in series and parallel arrangements and solve related numerical problems.<br>b) In groups, learners research, investigate and report on:<br>ii) heating effects of electric current; and<br>iii) resistivity and temperature coefficient of resistance of a material.<br>c) In groups, learners research, discuss and make presentations on:<br>i) expressions for electric energy and power; and<br>ii) derivation for the condition for maximum power output in an Ohmic resistor and sketch graphs for variation of efficiency, power output and terminal potential difference (p.d) with load resistance. | a) Observe learners' participation while looking for:<br>i) accurate information about electric current, emf, resistance and potential difference and their units; and<br>ii) correct statement of Ohm's law its mathematical expression, graphical interpretations while correcting any misconceptions.<br>b) Discuss with learners during their presentations while looking for:<br>i) correct meaning of resistivity and temperature coefficient of resistance;<br>ii) accurate explanations of the heating effect of electric current;<br>iii) how resistance, cross-section area and length of the wire affects the efficiency of power transmission; and<br>iv) why long-distance transmission requires low current.<br>c) Assess written products to ascertain the:<br>i) logical flow of procedures and deductions made during the investigation of internal resistance; |

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| | d) In pairs, learners research, discuss and present on Kirchhoff's laws and use them to solve electrical circuit problems.<br>e) In groups, learners explain the use of resistors in the modification of galvanometers into ammeters and voltmeters. | ii) appropriateness of the procedures used in the derivation of the maximum power;<br>iii) ability to sketch graphs of efficiency, power output and p.d with load;<br>iv) ability to resolve resistor networks using Kirchhoff's laws; and<br>v) correctness of explanations relating to the conversion of galvanometers into ammeters and voltmeters. |
| b) investigate the operation of slide wire meters and apply them in a variety of situations. (s, gs, v, a) | a) In groups, learners review the operation of a potential divider and make presentations during plenary.<br>b) In groups, learners search, discuss and make presentations on the mode of operation and solve numerical problems relating to the:<br>i) Wheatstone bridge.<br>ii) Meter bridge.<br>iii) Potentiometer.<br>c) In groups, learners investigate how the slide wire meters are used to measure:<br>i) resistance and internal resistance.<br>ii) emf and p.d across a resistor.<br>iii) electric current. | a) Observe learners' presentations to ascertain:<br>i) active participation;<br>ii) correct explanation about the operation of potential dividers; and<br>iii) appropriateness of the materials selected for investigation.<br>b) Assess learners' written products while emphasising the:<br>i) ability of the learners to describe the operation of a slide wire potentiometer and establishment of calibration constant; and<br>ii) learners' ability to manipulate data to determine resistance, emf of cell and emf of thermocouples, and current. |

## TOPIC 27: MAGNETISM IN MATTER

**DURATION:** 20 Periods

**Competency:** The learner appreciates the magnetic properties of matter and uses them to model different useful magneto-electric devices.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) deduce that the Earth has magnetic properties and this has many implications. (u, s, gs) | a) In a brainstorming session, learners review and report on the following:<br>i) magnetic fields and magnetic field lines, neutral point, magnetic shielding; and<br>ii) Earth's magnetic field.<br>b) In pairs, learners research, discuss and make presentations on:<br>i) geographic and magnetic meridian, magnetic and geographic axes, angle of dip, declination, horizontal and vertical components of the Earth's field; and<br>ii) magnetic flux and magnetic flux density B, deduce its expression and unit; and apply it to solve numerical problems. | a) Observe learners' presentations while looking for:<br>i) accuracy of information about the neutral point, magnetic shielding and the Earth's magnetic fields with clear drawings, and correct any misconceptions; and<br>ii) correct sketches of magnetic field patterns for different magnet arrangements.<br>b) Assess learners' written products while considering the:<br>i) correctness of the meanings of terminologies relating to Earth's magnetic field; and<br>ii) logical flow of the derivation of flux density and its use in solving related numerical problems. |

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| b) explain how magnetisation and demagnetisation occur in matter. (u, s) | a) In a brainstorming session, learners review and give a report on the domain theory, magnetisation, magnetic saturation and demagnetisation, using molecular theory.<br>b) In groups, learners research, discuss and make presentations on:<br>i) the features of the graphs showing the variation of B with the magnetic field strength, H; and<br>ii) characteristics of hard and soft magnetic materials, ferromagnetic, paramagnetic and diamagnetic materials.<br>c) In groups, learners model devices that show the practical uses of magnetism in matter. | a) Discuss with learners during their presentations while looking for:<br>i) correct understanding of domain theory and magnetic saturation; and<br>ii) learners' ability to explain magnetisation and demagnetisation using molecular theory.<br>b) Evaluate learners' products while considering:<br>i) the correctness of the graphs of variation of B and H, its features;<br>ii) correct characteristics of hard and soft magnetic materials, ferromagnetic, paramagnetic and diamagnetic materials; and<br>iii) workability of the modelled devices and their relevance to society. |

## TOPIC 28: MAGNETIC EFFECT OF AN ELECTRIC CURRENT

**DURATION:** 26 periods

**Competency:** The learner appreciates that a current carrying conductor in a magnetic field experiences a force and uses this concept to design models of different devices to solve societal needs.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) investigate the existence of a force on a current-carrying conductor in a magnetic field. (u, s, gs,) | a) In a brainstorming session, learners review, discuss and make presentations on the following:<br>i) magnetic fields around current carrying conductors;<br>ii) direction of the force on current carrying conductor in a magnetic field; and<br>iii) factors affecting the magnitude of the force on current carrying conductor in a magnetic field.<br>b) In groups or as individuals, learners derive the expressions: $F = BIlsin\theta$ for the force on a current carrying conductor in a magnetic field $F = Bqvsin\theta$ for the force on a charge moving in a magnetic field.<br>c) Use the expressions for the forces above to solve related numerical problems. | a) Observe learners during the presentations while assessing:<br>i) participation and effective communication;<br>ii) proper sketches of magnetic fields on straight conductors, coils, magnets and solenoids;<br>iii) methods used to investigate the force existing on a current carrying conductor in a magnetic field; and<br>iv) the correctness of the factors affecting this force.<br>b) Probe learners while assessing their ability to:<br>i) explain how the force on a current carrying conductor in a magnetic field can be varied; and<br>ii) describe the applications of this force in devices like d.c motor, relay and others.<br>c) Assess written products while emphasising:<br>i) coherence in the derivations of forces on conductors and charges in a magnetic field and the use of the equations in solving numerical problems; and<br>ii) proper sketches of magnetic fields in different situations. |
| b) use Biot-Savart's law to write expressions for magnetic flux density in a variety of situations. (u, s, gs) | a) In a think-pair-share, learners research, discuss and make presentations about:<br>i) the expression for Biot-Savart's law and interpret it;<br>ii) the expressions for flux density at a perpendicular distance from a straight conductor, at the centre of a coil and in a solenoid;<br>iii) use of the expression; | a) Observe learners during the discussions while assessing:<br>i) how learners can interpret the expressions for Biot-savart's law and apply them;<br>ii) the correctness of the expressions for flux density at a perpendicular distance from a straight conductor, at the centre of a coil and in a solenoid and the use made of them; and |

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| | $F = BIlsin\theta$ to determine the expression for the magnetic force between two long parallel current carrying conductors;<br>iv) the Hall effect hence derive an expression for the Hall voltage $V_H = \frac{BI}{net}$<br>v) the use of expressions to solve related numerical problems. | iii) the logical flow in the derivation of the force between two long conductors carrying current.<br>b) Converse with learners to ascertain whether they can:<br>i) apply the expression for the force between two long conductors carrying current to define an ampere; and<br>ii) describe the Hall effect and its derivation. |
| c) explain how the force on a current-carrying conductor in a magnetic field is applied in the operation of various electrical devices. (u, s) | a) In a class discussion, learners derive the expression for the torque on a coil in a magnetic field $\tau = BANIsin\theta$ and use it to solve related numerical problems.<br>b) In group projects, learners fabricate devices such as an electric bell, a loudspeaker, a simple d.c motor and any others that use the concept of a force and torque around a current carrying conductor. | a) Discuss with learners while assessing how they explain the torque in electromagnetic devices and apply the expression for torque to solve numerical problems.<br>b) Assess learners' products while considering:<br>i) the workability of the devices that use the principle of force in a current carrying conductor in a magnetic field;<br>ii) the correctness of the write-ups describing the operation of the devices above; and<br>iii) the correctness of derivation of torque on a coil in a magnetic field and the proper substitutions used to solve numerical problems. |
| **Note**: Experiments to measure B along a straight conductor, centre of circular coil and solenoid are not required. | | |

## TOPIC 29: ELECTROMAGNETIC INDUCTION

**DURATION:** 18 Periods

**Competency:** The learner evaluates how magnetism and current are linked and how this principle is applied in the operation of transformers and generators.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) explain the concept of electromagnetic induction and how it is applied in a variety of situations. (u, s, gs) | a) In groups, learners review, brainstorm, discuss and make presentation on the use of a coil and a magnet to demonstrate the production of electricity; and use Fleming's right-hand rule to determine direction of the induced current.<br>b) In groups, learners research, discuss and make presentations on:<br>i) magnetic flux linkage;<br>ii) Induced emf;<br>iii) relationship between the change in flux linkage and induced current;<br>iv) statements for the laws of electromagnetic induction;<br>v) derivation for the expressions of Faraday's and Lenz's laws; and<br>vi) using the derived expressions to solve numerical problems. | a) Dialogue with learners while looking for their:<br>i) choice of materials used in demonstrating electromagnetic induction;<br>ii) understanding of how electricity is produced in a conductor by a changing magnetic flux; and<br>iii) ability to use Fleming's right-hand rule to determine the direction of the current.<br>b) Assess learners' written products while considering the:<br>i) correctness of the statements of the laws of electromagnetic induction and related concepts.<br>ii) correct application of Faraday's and Lenz's laws in solving numerical problems. |
| b) appreciate the concepts of self and mutual induction and their application in a | a) In groups, learners review, brainstorm, discuss and make presentations on the:<br>i) concepts of mutual and self-induction; | a) Observe group presentations while emphasising:<br>i) proper illustrations of the direction of current; and |

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| variety of devices. (u, s, gs) | ii) mode of operation of d.c and a.c generators; and<br>iii) mode of operation of a transformer and its efficiency.<br>b) In groups, learners research, discuss and make presentations on the:<br>i) derivations of the expressions for mutual and self-induction and apply them to solve numerical problems;<br>ii) explanation of the processes that lead to the production of a back e.m.f and eddy currents in a motor coil;<br>iii) derivation of the expressions for back e.m.f and eddy currents, and their applications; and<br>iv) structure and mode of operation of moving coil meters.<br>c) In groups, learners carry out project works to model devices that employ the principles of electromagnetic induction. | ii) correctness of concepts about electromagnetic induction.<br>b) Converse with learners during their presentations while looking for:<br>i) correct understanding of how a change in flux linkage induces current in a conductor;<br>ii) correctness of procedures of derivations based on the assumptions made; and<br>iii) correct understanding of how a.c and d.c generators operate, and how back e.m.f is produced.<br>c) Assess products while looking for the:<br>i) correct explanation of how eddy currents are produced in coils;<br>ii) correct statements for the concept of self and mutual induction, and the procedure used;<br>iii) coherence in the derivation of expression for eddy currents and back e.m.f.; and<br>iv) selection of materials for the models, their innovativeness, creativity and workability of the models. |

## TOPIC 30: A.C CIRCUITS

**DURATION:** 24 Periods

**Competency:** The learner measures a.c and investigates its behaviour in different devices.

| Learning Outcomes<br>The learner should be able to: | Suggested Learning Activities | Sample Assessment Strategies |
|---|---|---|
| a) explain the operation of a.c measuring devices and their various applications in real life. (u, s) | a) Learners review, brainstorm, discuss and make presentations on the:<br>i) meaning of a.c and d.c and how they can be interconverted; and<br>ii) advantage of using a.c in commercial supply compared to d.c.<br>b) In groups, learners research, discuss and make presentations on the:<br>i) structure and mode of operation of the hot wire meter and moving iron meter;<br>ii) the meaning of root-mean square value (rms) of current/voltage, and the peak value of a.c; and<br>iii) derivation of the expressions for rms of current and voltage and their use in solving numerical problems. | a) Observe and evaluate the learners' presentations based on:<br>i) the ability to distinguish between a.c and d.c and how they can be interconverted; and<br>ii) the understanding of the advantages of using a.c in commercial power supply compared to d.c.<br>b) Converse with learners and probe their understanding of the operation of a hot wire meter and moving iron meter.<br>c) Assess learners' written products while looking for:<br>i) correct description of the operation of hot wire meters and moving iron meters; and<br>ii) correct meaning of root mean square value, its derivation and application in solving numerical problems. |
| b) evaluate the inductance, reactance and impedance of a.c circuits and their applications in real life. (u, s, gs, v/a) | a) In groups, learners research, discuss and make presentations on:<br>i) effect of capacitors and inductors in a.c circuits;<br>ii) derivation of expressions for inductive and capacitive reactances; | a) Observe learners during the presentations while assessing their ability to:<br>i) communicate effectively; and<br>ii) logically present ideas during the derivation of reactances and impedances. |

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| | iii) derivation of expressions for impedance in a.c series circuits and solve related numerical problems;<br>iv) the average energy and power in a resistor, capacitor and inductor connected separately in an ac circuit;<br>v) the use of the derived expressions to solve numerical problems; and<br>vi) characteristic graphs for a.c flowing through a resistor (R), capacitor (C) and inductor (L) connected individually and in combinations.<br>b) In groups, learners research and model simple electronic devices using capacitors, inductors and resistors arranged in a circuit board and explain how they work. | b) Discuss with learners while assessing their ability to:<br>i) explain the steps in the derivations of combined resistance;<br>ii) correctly interpret the sketch graphs and phasor diagrams; and<br>iii) explain the effect of L, R and C on the flow of a.c current in a circuit.<br>c) Assess learners' products while looking for:<br>i) correct description of the effects of capacitors and inductors in circuits;<br>ii) logical flow of the derivations for energy and power in a.c circuits;<br>iii) coherent explanation of the a.c graphs; and<br>iv) workability and innovation in the modelled electronic devices. |
| **Note:** Do not include parallel circuits. | | |

# SENIOR SIX TERM 3

## TOPIC 31: ATOMIC PARTICLES

**DURATION:** 24 Periods

**Competency:** The learner appreciates the structure of the atom and how the components of the atom are applied in different devices.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
|---|---|---|
| a) apply the Rutherford's scattering experiment to explain atomic structure. (s, u) | a) Learners review, brainstorm and make presentations on Dalton's atomic theory, the particles constituting an atom and their properties.<br>b) As groups, learners research, discuss and make presentations on:<br>i) the procedure of Rutherford's scattering experiment and the observations therein; and<br>ii) the conclusions made from Rutherford's experiment in terms of the structure of atoms.<br>c) As groups, learners discuss Millikan's oil drop and Thomson's experiments to determine electronic charge, specific charge and explain charge quantisation.<br>d) In groups, learners search and discuss the mass spectrometer and how it can be used to determine the specific charge of positive ions. | a) Dialogue with learners while looking for their:<br>i) ability to recall the fundamental particles in atoms;<br>ii) ability to explain the Rutherford's scattering experiment; and<br>iii) understanding of the Rutherford's model of an atom.<br>b) Assess learners' written products while looking for:<br>i) correctness of explanation of the Millikan's oil drop experiment, and how it can be used to determine specific charge;<br>ii) coherent explanation about how the mass spectrometer can be used to determine the specific charge; and<br>iii) correct derivations of relevant expressions and their use in solving numerical problems. |
| b) examine the behaviour of charged particles and their applications in real life. (u, s, gs) | a) In class discussion, learners research and make presentations on:<br>i) production of cathode rays and positive rays in a cathode ray tube; | a) Observe learners' participation in the discussions while looking for:<br>i) accuracy of information about the production and |

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| | ii) characteristics that distinguish cathode and positive rays; and<br>iii) derive expressions for the motion of electrons in electric and magnetic fields and apply them in solving numerical problems.<br><br>b) In groups, learners explore qualitatively the deflection of electron and ion beams through electric and magnetic fields and discuss the observed pattern.<br>c) In plenary, learners discuss the applications of cathode rays in real life. | properties of cathode rays and positive rays; and<br>ii) proper use of sketches in explaining the production and deflection of cathode rays in electric and magnetic field.<br><br>b) In a conversation, probe learners to ascertain whether:<br>i) they can account for the observed path of particles in electric and magnetic fields; and<br>ii) distinguish cathode rays from positive rays.<br><br>c) Assess learners' written products while looking for:<br>i) correct write-ups for the procedure of producing cathode rays and positive rays;<br>ii) coherent derivation of the path taken by electrons in a magnetic and electric field; and<br>iii) proper substitutions while solving numerical problems. |

## TOPIC 32: QUANTUM THEORY

**DURATION:** 24 Periods

**Competency:** The learner examines how electromagnetic waves carry energy in packets and that this behaviour can be harnessed in a variety of fields.

| **Learning Outcomes** The learner should be able to: | **Suggested Learning Activities** | **Sample Assessment Strategies** |
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| a) explain the process of photoelectric effect and its applications in real life. (u, gs) | a) In groups, learners research, discuss and present on the:<br>i) meaning of photoelectric effect and its characteristics; and<br>ii) explanation of photoelectric emission using quantum theory.<br>b) Learners report on the results of their discussion on the:<br>i) description of the experiment to verify Einstein's photoelectric effect and determination of the Plank's constant;<br>ii) Einstein's photoelectric equation; and<br>iii) $\frac{1}{2}mV_{max}^2 = hf - \phi$, and its application in solving related numerical problems.<br>c) Learners use the theory of photoelectric effect to model burglar alarms, photocell, photo sensors, among others. | a) Observe learners' group presentations while assessing:<br>i) correct description of the quantum theory of electromagnetic radiations;<br>ii) correct explanation of the photoelectric effect based on quantum theory; and<br>iii) participation of individual learners.<br>b) Dialogue with learners about the:<br>i) significance of the photo electric equation; and<br>ii) procedures used to verify Einstein's equation and hence determination of Plank's constant.<br>c) Assess learners' products while emphasising:<br>i) correct meaning of photoelectric effect, work function and related terminologies;<br>ii) logical flow of derivation of photoelectric effect equation and its implications;<br>iii) logical flow of the determination of Plank's constant; and<br>iv) innovativeness, creativity and workability of the models that employ photoelectric effect principles. |

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| b) analyse Bohr's model and how it is used to explain atomic spectra of different elements. (u, s, gs) | a) In groups, learners review, discuss and present on inadequacies of Rutherford's atomic model.<br>b) In groups, learners research, discuss and report on Bohr's model of the atom and use it to explain the:<br>i) origin of absorption and emission spectra;<br>ii) presence of energy levels in atoms; and<br>iii) ionisation in atoms and calculate ionisation energy. | a) Converse with learners during their presentations while looking for:<br>i) correct understanding of the inadequacies Rutherford's model;<br>ii) correct description of Bohr's model of the atom;<br>iii) correct procedure used in the derivation of energy of an electron; and<br>iv) correct illustration and interpretation of energy levels of an atom.<br>b) Assess learners' written products while looking for:<br>i) correct statements in the Bohr's model of the atom;<br>ii) coherence in the description of the origins of atomic spectra and their significance; and<br>iii) correct use of the expressions for calculating ionisation energies. |
| c) deduce that when fast moving electrons are stopped by matter, they produce energetic radiations which have many applications. (u, s, gs, v/a) | a) In groups, learners review, discuss and present on the production, characteristics, uses and health hazards of X-rays.<br>b) In groups, learners research, discuss and report on:<br>i) types of X-rays;<br>ii) continuous (background) radiation, line X-ray spectra and cut-off wavelength;<br>iii) derivation of the expression $\frac{hc}{\lambda_{min}} = eV$ and its application in solving numerical problems; and<br>iv) diffraction of X-rays, derivation of Bragg's law $2dsin\theta = n\lambda$ and application of the equation in different situations.<br>c) Learners watch videos or simulations showing motion of electrons to produce X-rays and interpret them. | a) Observe learners' participation while looking for:<br>i) accuracy of information about the structure and operation of the X-ray tube; and<br>ii) correct statements about the properties of X-rays, their uses and health hazards of X-rays to humans.<br>b) Discuss with learners while looking for:<br>i) understanding of the concept of diffraction by crystals, diffraction planes, atomic spacing, conditions for Bragg's law; and<br>ii) the understanding of the origin of the energy of the X-ray radiation.<br>c) Assess learners' written products while looking for:<br>i) coherence in the description of the production of X-rays;<br>ii) logical flow in the derivations of energy of X-rays and Bragg's law and their applications; and<br>iii) distinction between soft and hard X-rays. |

## TOPIC 33: NUCLEAR PROCESSES

**DURATION:** 24 Periods

**Competency:** The learner appreciates that nuclear reactions involve high amounts of energy which can be both constructive and destructive.

| Learning Outcomes<br>The learner should be able to: | Suggested Learning Activities | Sample Assessment Strategies |
|---|---|---|
| a) appreciate that nuclear reactions generate energy which can be harnessed for different purposes. (u, s, v/a) | a) As a class, learners review and brainstorm the:<br>i) meanings of nuclide, atomic number, mass number and isotopes and give examples; and<br>ii) meaning of nuclear fission and nuclear fusion and represent them using equations.<br>b) In groups, learners research, discuss and report on:<br>i) the meaning of unified atomic mass unit and its equivalent in electron volts;<br>ii) Einstein's mass-energy relation $\Delta E = \Delta mc^2$;<br>iii) binding energy, mass defect and binding energy per nucleon;<br>iv) factors which affect nuclear stability;<br>v) the graph to study the variation of binding energy per nucleon with mass number and its significance on nuclear fission and fusion processes;<br>vi) production of electrical energy using nuclear processes; and<br>vii) derivation of expressions under nuclear energy and use them to solve numerical problem.<br>c) Learners debate the merits and demerits of using nuclear energy in real life.<br>d) Learners watch a video showing nuclear fusion and fission and compare them. | a) Observe learners during the brainstorming session while assessing:<br>i) levels of participation, communication, creativity and innovation; and<br>ii) ability of learners to correctly explain the meaning of mass number, atomic number, isotopes, nuclear fission and fusion.<br>b) Dialogue with learners while checking for their understanding of the process of generation of electricity using nuclear reactions; the merits and demerits of this source of electricity.<br>c) Assess learners' written products while emphasising the:<br>i) correct statement for meaning of atomic mass unit (U), and its relation with electron volt, joules and kilogram;<br>ii) correct method of calculating the mass defect and energy released during a nuclear reaction;<br>iii) sketch of a graph of B.E per nucleon against mass number and its accurate description; and<br>iv) accurate description of the factors that affect nuclear stability. |

| | | |
|---|---|---|
| b) deduce that nuclides disintegrate emitting particles and energy which have a variety of applications. (u, s, gs, v/a) | a) In groups, learners review, discuss and present on:<br>i) the meaning of radioactivity, radiations emitted during radioactivity, their properties and balanced equations for nuclear equations;<br>ii) the meaning of Half-life and its determination using the graphical method; and<br>iii) uses, hazards and safety precautions of nuclear radiations.<br>b) In pairs, learners describe the structure and mode of operation of radiation detection devices (ionisation chamber, Geiger Müller tube and counter, cloud chamber) and make presentations.<br>c) In groups, learners discuss and present on:<br>i) the law of radioactivity, the decay constant;<br>ii) derivation of the expression $\boldsymbol{N = N_o e^{-\lambda t}}$ and use it to deduce the expression for half-life; then apply them in solving numerical problems; and<br>iii) use of decay equations to estimate the age of fossils and rocks.<br>d) In groups, learners research and discuss the production of artificial isotopes (induced radioactivity), their applications and make presentations. | a) Observe learners' participation while looking for accuracy of information about the types and properties of the radiations emitted during radioactivity and correct any misconceptions.<br>b) Discuss with learners to ascertain the:<br>i) correct meaning of radioactivity, types and properties of the radiations emitted during radioactivity;<br>ii) correct balancing of the decay equations; and<br>iii) understanding of the mode of operation of the different radiation detectors.<br>c) Assess learners' written products while looking for:<br>i) coherence in the derivation of expression $\boldsymbol{N = N_o e^{-\lambda t}}$ and its use to deduce an expression of half-life;<br>ii) correct substitution in the decay equations to calculate the age of fossils and rocks;<br>iii) ability to draw and explain the decay curve and use it to determine half-life of a radioactive material; and<br>iv) correct statements for the hazards of radioisotopes and associated safety measures. |

# 3.0 ASSESSMENT

## 3.1 Assessing Physics

This Advanced Secondary Curriculum sets new expectations for learning, with a shift from Objectives to Learning Outcomes that focus mainly on the application of knowledge and deeper learning that leads to the acquisition of skills. These Learning Outcomes require a different approach to assessment. The "Learning Outcomes" in the syllabi are set out in terms of Knowledge, Understanding, Skills, Values and Attitudes. This is what is referred to by the letters k, u, s v & a.

It is not possible to assess values and attitudes in the same way as knowledge, understanding, and skills because they are more personal and variable, and are long-term aspirations. This does not mean that values and attitudes are not important or cannot be assessed. They too can be assessed but not easily done through tests and examinations. Values and attitudes can be assessed over a period of time through observing and having interactions with the learner.

To assess knowledge and its application, understanding, and skills, we need to look for different things. Knowledge can be assessed to some extent through written tests, but the assessment of skills, application of what is learnt, and deeper understanding requires different approaches. Because of this, the role of the teacher in assessment becomes much more important. This section focuses on knowledge, understanding, and skills.

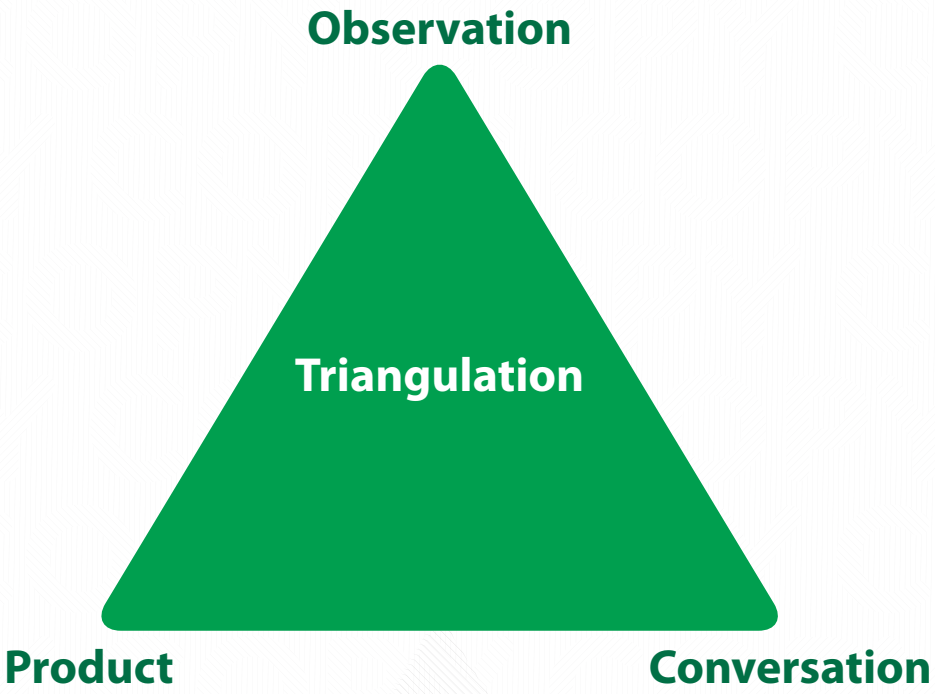
## 3.2 Formative Assessment

In this curriculum, the teacher's role in assessment is not only to write tests for the learner but also to make a professional judgment about the learner's learning during the teaching and learning process. The professional judgment is about how far the learner achieves the Learning Outcomes that are set out in this syllabus. To make these judgments the teacher needs to look at how well the learner is performing in terms of each Learning Outcome.

Formative assessment can be done through:

a) **Observation** — watching learners working (good for assessing skills, values and attitudes);
b) **Conversation** —asking questions and talking to learners (good for assessing knowledge and understanding);
c) **Product**—appraising learner's work (writing, report, translation, calculation, presentation, map, diagram, model, drawing, painting etc). In this context, a "product" is seen as something physical and permanent that the teacher can keep and look at.

When all three are used, the information from any one form can be checked against the other two forms of assessment (e.g., evidence from "observation" can be checked against evidence from "conversation" and "product"). This is often referred to as "triangulation"




### 3.3 Assessing Generic Skills

The generic skills have been built into the syllabuses and are part of the learning outcomes. It is therefore not necessary to assess them separately. It is the increasingly complex context of the subject content that provides progression in the generic skills, and so they are assessed as part of the subject learning outcomes. Assessing generic skills is done with the help of an observation checklist and scoring rubric.

### 3.4 Assessing Values/Attitudes

It is not possible to assess values and attitudes in the same way as knowledge, understanding and skills because they are more personal and variable and are long-term aspirations. This does not mean that attitudes are not important. It means that we must value things that we cannot easily assess through tests and examination. However, values and attitudes can be assessed over a long period of time through observing and interactions.

### 3.5 Assessment of Projects

Project-based learning is a teaching method in which learners or participants gain knowledge and skills by engaging for an extended period of time to investigate and respond to an authentic challenge. The task must have a driving question and it involves sustained inquiry. Project-based learning is assessed using a rubric and an observation checklist.

## 3.6 Examinations

There will be only one school based summative assessment at the end of the year. There will no longer be examinations or tests set at the beginning and end of every term. Instead, there will be a summing up of on-going teacher assessments made in the context of learning through end of topic scenario-based tasks (Activities of Integration). The learners will also be subjected to the end of cycle assessment for certification.

## 3.7 Record Keeping

In competency-based learning, accurate and comprehensive record keeping is crucial to track learners' progress and achievements. Therefore, the teacher and school must keep accurate records about learners' achievement.

Various assessment tools and strategies are employed to capture learners' demonstration of abilities and achievements, including observation checklists, rubrics, and scoring grids. These tools provide a holistic picture of learners' strengths, weaknesses, and areas for improvement.

The collected data and evidence from these assessments are correctly recorded and maintained in learners' files, portfolios and anecdotal notes.

# GLOSSARY OF KEY TERMS

| Term | Definition |
|---|---|
| competency curriculum | one in which learners develop the ability to apply their learning with confidence in a range of situations |
| differentiation | the design or adaptation of learning experiences to suit an individual learner's needs, strengths, preferences, and abilities |
| formative assessment | the process of judging a learner's performance, by interpreting the responses to tasks, in order to gauge progress and inform subsequent learning steps |
| generic skills | skills which are deployed in all subjects, and which enhance the learning of those subjects. These skills also equip young people for work and for life |
| inclusion | an approach to planning learning experiences which allows each student to feel confident, respected, safe and equipped to learn at his or her full potential |
| learning outcome | a statement which specifies what the learner should know, understand, or be able to do within a particular aspect of a subject |
| process skill | a capability acquired by following the programme of study in a particular learning area; enables a learner to apply the knowledge and understanding of the learning area |
| sample assessment activity | an activity which gives a learner the opportunity to show the extent to which s/he has achieved the Learning Outcomes. This is usually part of the normal teaching and learning process, and not something extra at the end of a topic |
| suggested learning activity | an aspect of the normal teaching and learning process that will enable a formative assessment to be made |

# APPENDIX: MATHEMATICAL REQUIREMENTS

The study of Physics involves mathematical manipulations. Learners use mathematical skills to make meaning and interpret Physical phenomena using some or all of the following concepts.

**Arithmetic**

**Learners should be able to:**

a) recognise and use expressions in decimal and standard form (scientific);

b) use appropriate calculating aids (electronic calculator or tables) for addition, subtraction, multiplication and division;

c) find arithmetic means, powers (including reciprocals and square roots), sines, cosines, tangents (and the inverse functions), exponentials and logarithms (*log* and *ln*);

d) take account of accuracy in experimental work and handle calculations so that significant figures are neither lost unnecessarily nor carried beyond what is justified;

e) make approximate evaluations of numerical expressions (e.g., $\pi^2 \approx 10$) and use such approximations to check the magnitude of machine calculations.

**Algebra**

**Learners should be able to:**

a) change the subject of an equation. Most relevant equations involve only the simpler operations but may include positive and negative indices and square roots;

b) solve simple algebraic equations. Most relevant equations are linear but some may involve inverse and inverse square relationships. Linear simultaneous equations and the use of the formula to obtain the solutions of quadratic equations are included;

c) substitute physical quantities into physical equations using consistent units and check the dimensional consistency of such equations;

d) formulate simple algebraic equations as mathematical models of physical situations, and identify inadequacies of such models;

e) recognise and use the logarithmic forms of expressions like $ab$, $\frac{a}{b}$, $x^n$, $e^{kx}$; understand the use of logarithms in relation to quantities with values that range over several orders of magnitude;

f) manipulate and solve equations involving logarithmic and exponential functions;

g) express small changes or errors as percentages and vice versa;

h) comprehend and use the symbols <, >, «, », ≈, /, ∝, <x> (= $\bar{x}$), Σ, Δx, δx, √.

**Geometry and trigonometry**

**Learners should be able to:**

a) calculate areas of right-angled and isosceles triangles, circumference and area of circles, areas and volumes of rectangular blocks, cylinders and spheres;

b) use Pythagoras' theorem, similarity of triangles, the angle sum of a triangle;

c) use sines, cosines and tangents (especially for 0°, 30°, 45°, 60°, 90°). Use the trigonometric relationships for triangles: $\frac{a}{sinA} = \frac{b}{sinB} = \frac{c}{sinC}$, $a^2 = b^2 + c^2 - 2bc\ cosA$;

d) use sin θ ≈ tan θ ≈ θ and cos θ ≈ 1 for small θ; $sin^2\theta + cos^2\theta = 1$; and

e) understand the relationship between degrees and radians (defined as arc/radius), translate from one to the other and use the appropriate system in context.

**Vectors**

**Learners should be able to:**

a) find the resultant of two coplanar vectors, recognising situations where vector addition is appropriate;

b) obtain expressions for components of a vector in perpendicular directions, recognising situations where vector resolution is appropriate.

**Graphs**

**Learners should be able to:**

a) translate information between graphical, numerical, algebraic and verbal forms;

b) select appropriate variables and scales for graph plotting;

c) for linear graphs, determine the slope, intercept and intersection;

d) choose, by inspection, a straight line which will serve as the line of best fit through a set of data points presented graphically;

e) recall the standard linear form $y = mx + c$ and rearrange relationships into linear form where appropriate;

f) sketch and recognise the forms of plots of common simple expressions like $\frac{1}{x}$, $x^2$, $\frac{1}{x^2}$, $sin\ x$, $cos\ x$, $e^{-x}$;

g) use logarithmic plots to test exponential and power law variations;

h) understand, draw and use the slope of a tangent to a curve as a means to obtain the gradient; and use notation in the form $\frac{dy}{dx}$ for a rate of change;

i) understand and use the area below a curve where the area has physical significance.

**Note: Calculators used must be non-programmable.**

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