South Sudan

Secondary Physics 4

Secondary Physics has been written and developed by Ministry of General Education and Instruction, Government of South Sudan in conjunction with Subjects experts. This course book provides a fun and practical approach to the subject of Physics, and at the same time imparting life long skills to the students.

The book comprehensively covers the Secondary 4 syllabus as developed by **Ministry of General Education and Instruction.**

Each year comprises of a Student's Book and teacher's Guide.

The Teacher's Guides provide:

- Full coverage of the national syllabus.
- A strong grounding in the basics of Physics.
- Clear presentation and explanation of learning points.
- A wide variety of practice exercises, often showing how Physics can be applied to real-life situations.
- It provides opportunities for collaboration through group work activities.
- Stimulating illustrations.

All the courses in this secondary series were developed by the Ministry of General Education and Instruction, Republic of South Sudan. The books have been designed to meet the secondary school syllabus, and at the same time equiping the students with skills to fit in the modern day global society.

Funded by:

GLOBAL PARTNERSHIP for EDUCATION
quality education for all children

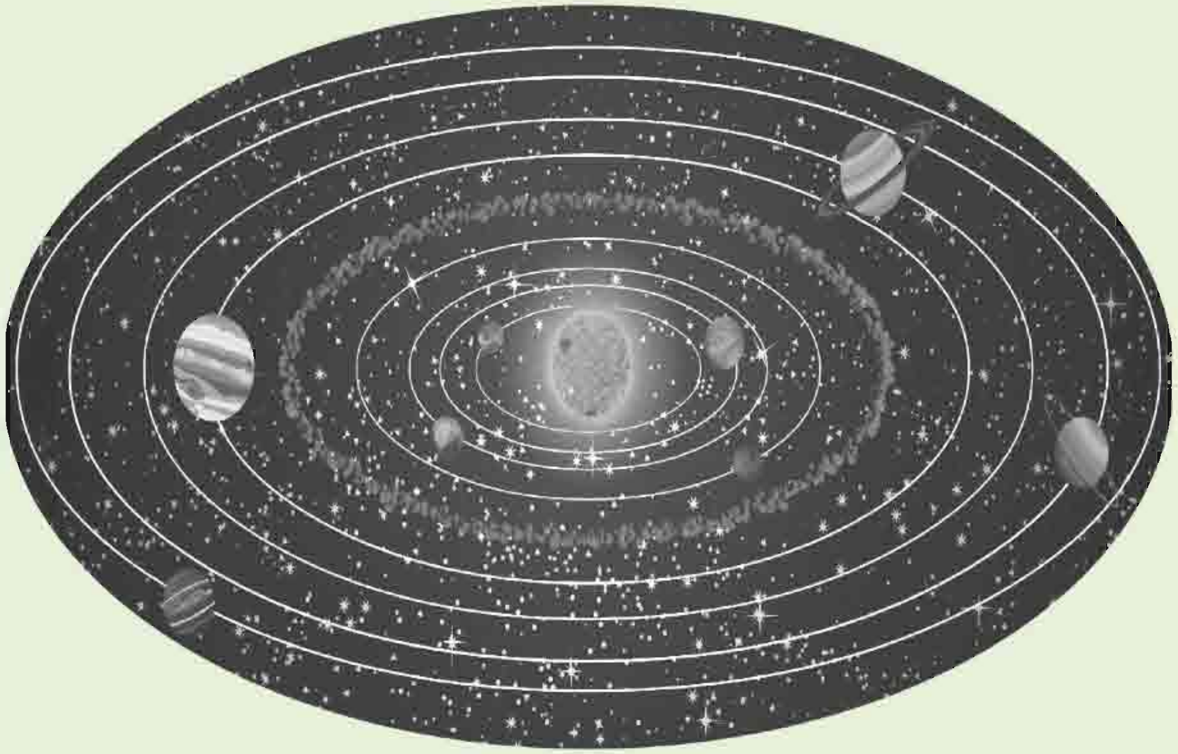
Secondary Physics Teacher's Guide 4

South Sudan

THE REPUBLIC OF SOUTH SUDAN
MINISTRY OF GENERAL EDUCATION AND INSTRUCTION

Secondary Physics 4

Teacher's Guide



Funded by:

GLOBAL PARTNERSHIP for EDUCATION
quality education for all children

How to take care of your books.

Do's

1. **Please cover with plastic or paper. (old newspaper or magazines)**
2. **Please make sure you have clean hands before you use your book.**
3. **Always use a book marker do not fold the pages.**
4. **If the book is damaged please repair it as quickly as possible.**
5. **Be careful who you lend your schoolbook to.**
6. **Please keep the book in a dry place.**
7. **When you lose your book please report it immediately to your teacher.**

Don'ts

1. **Do not write on the book cover or inside pages.**
2. **Do not cut pictures out of the book.**
3. **Do not tear pages out of the book.**
4. **Do not leave the book open and face down.**
5. **Do not use pens, pencils or something thick as a book mark.**
6. **Do not force your book into your schoolbag when it is full.**
7. **Do not use your book as an umbrella for the sun or rain.**
8. **Do not use your book as a seat.**

South Sudan

SECONDARY
4

Physics

Teacher's Guide 4

This book is the property of the Ministry of General Education and Instruction.

THIS BOOK IS NOT FOR SALE

Funded by:
GLOBAL PARTNERSHIP for EDUCATION
quality education for all children

FOREWORD

I am delighted to present to you this Teacher's Guide, which is developed by the Ministry of General Education and Instruction based on the new South Sudan National Curriculum. The National Curriculum is a learner-centered curriculum that aims to meet the needs and aspirations of the new nation. In particular, it aims to develop (a) Good citizens; (b) successful lifelong learners; (c) creative, active and productive individuals; and (d) Environmentally responsible members of our society. This textbook, like many others, has been designed to contribute to achievement of these noble aims. It has been revised thoroughly by our Subject Panels, is deemed to be fit for the purpose and has been recommended to me for approval. Therefore, I hereby grant my approval. This Teacher's Guide shall be used to facilitate learning for learners in all schools of the Republic of South Sudan, except international schools, with effect from 4th February, 2019.

I am deeply grateful to the staff of the Ministry of General Education and Instruction, especially Mr Michael Lopuke Lotyam Longolio, the Undersecretary of the Ministry, the staff of the Curriculum Development Centre, under the supervision of Mr Omot Okony Olok, the Director General for Quality Assurance and Standards, the Subject Panelists, the Curriculum Foundation (UK), under the able leadership of Dr Brian Male, for providing professional guidance throughout the process of the development of National Curriculum, school textbooks and Teachers' Guides for the Republic of South Sudan since 2013. I wish to thank UNICEF South Sudan for managing the project funded by the Global Partnership in Education so well and funding the development of the National Curriculum, the new textbooks and Teachers' Guides. I am equally grateful for the support provided by Mr Tony Calderbank, the former Country Director of the British Council, South Sudan; Sir Richard Arden, Senior Education Advisor of DfID, South Sudan. I thank Longhorn and Mountain Top publishers in Kenya for working closely with the Ministry, the Subject Panels, UNICEF and the Curriculum Foundation UK to write the new textbooks. Finally, I thank the former Ministers of Education, Hon. Joseph Ukel Abango and Hon. Dr John Gai Nyuot Yoh, for supporting me, in my role as the Undersecretary, to lead the Technical Committee to develop and complete the consultations on the new National Curriculum Framework by 29 November 2013.

The Ministry of General Education and Instruction, Republic of South Sudan, is most grateful to all these key stakeholders for their overwhelming support to the design and development of this historic South Sudan National Curriculum. This historic reform in South Sudan's education system is intended to benefit the people of South Sudan, especially the children and youth and the future generations. It shall enhance the quality of education in the country to promote peace, justice, liberty and prosperity for all. I urge all Teachers to put this textbook to good use.

May God bless South Sudan. May He help our Teachers to inspire, educate and transform the lives of all the children and youth of South Sudan.

Deng Deng Hoc Yai, (Hon.)
Minister of General Education and Instruction, Republic of South Sudan

Table of Content

Part 1 Introduction

1.1 Organisation of the book

This teacher's guide is organised into two main sections.

Part 1 is the general **introduction** section detailing information on competence based curriculum and pedagogical issues.

The main elements of Part 1 are:

- **1.2: Background information to the new curriculum** - It gives a brief overview of the general requirements of the new South Sudan competence-based including the guiding principles, the competences the students are expected to acquire, crosscutting issues to be addressed during learning and special needs education.
- **1.3: Basic requirements for an effective Physics lesson-** It highlights the teacher's and learner's roles for effective teaching/learning of Physics, teaching/learning resources, grouping learners for learning and teaching methods

Part 2 provides a **topic-to-topic guide** to the teacher on how to facilitate learners to acquire the knowledge, skills and attitudes envisaged in each unit. This part is therefore structured into units

The main elements of each unit guide are:

- **Unit heading** – This gives the unit title as stated in the syllabus.
- **Topic heading** – The units have been subdivided (by the authors) into manageable topics.
- **Learning outcomes** – This section outlines ***Knowledge and understanding***, ***Skills, Attitudes and values*** the learner is expected to achieve through his/her interaction with the concepts and activities planned for the unit.
- **Contribution to student's competences*:*** The section explains how the unit/topic will facilitate the student to acquire to the specified competences. These competences will be discussed in detail later in the next section.
- **Links to other subjects*:*** The section explains how the concepts in unit/topic link to other subject areas. This helps the teacher to understand how the unit will help the learner as he interact with facts or concepts in those subject areas, or how the students can transfer knowledge from those areas to help them understand concepts in this unit.

- **Crosscutting issues to be addressed in the unit***:* The section outlines the specific crosscutting issues that will be addresses through infusion as the learners do the activities and interacts with concepts planed for the unit This is meant to make the teacher conscious on and be on the look out for suitable opportunities through out the teaching/learning process in the entire unit to address the cited crosscutting issues. These issues will be discussed in detail later in this section. Note that a unit/topic may not necessarily address all the crosscutting issues outlined in the curriculum
- **Teaching methodologies***:* The section lists down the main teaching/learning methods that the teacher can employ in the unit/topic.
- **Attention to special needs***:* The section guides the teacher on how to handle learners with special needs as they do the learning activities organised in the unit
- **Background information***:* This section outlines key knowledge, skills attitudes and values that learners need to have acquired earlier that will facilitate easier acquisition of the new knowledge, skills attitudes and values envisaged in this unit. It also guides the teacher on how to find out that the learners posses them before they start learning the concepts in this unit, and how to help learners in case they do not posses them.
- **Subtopics:** This is a list in tabular form of the structuring of the topic into subtopics
- **Suggested teaching/learning activities***:* This section provides guidance to the teacher on how to facilitate students to learn by doing the activities outlined in the student's book. It also guides the teacher on how to assess the learning.

  The guidance for each subtopic is structured as follows:

  Subtopic title

  Specific learning outcome

  Teaching guidelines for the activity

  Assessment

1.2 Background Information on the new curriculum

The aim of the South Sudan Competence-based Curriculum is to develop in the learners competences that will enable them interact with the environment in more practical ways.

It clearly defines the **knowledge, skills** and **attitudes** that the learner should acquire by doing the specified learning activities.

Student's competences

Competencies are statements of the characteristics that students should demonstrate, which indicate they have the ability to do something to the required level of performance.

The following are the four competencies envisaged in this curriculum:

(i) Critical and creative thinking

Physics lessons and activities facilitate learners to acquire these competences by giving them opportunities to:

- Plan and carry out investigations, using a range of sources to find information
- Sort and analyse information and come to conclusions
- Suggest and develop solutions to problems, using their imaginations to create new approaches
- Evaluate different suggested solutions

(ii) Communication

Physics lessons and activities facilitate learners to acquire these competences by giving them opportunities to:

- Read and comprehend critically a variety of types and forms of texts during research activities.
- Write reports on scientific investigations and activities.
- Speak clearly and communicate ideas and science related information coherently.
- Listen and comprehend scientific facts presented by fellow classmates, group members, and teachers and resources persons.
- Use a range of media, technologies and languages to communicate messages, ideas and opinions

(iii) Cooperation

Physics lessons and activities facilitate learners to acquire these competences by giving them opportunities to:

- Work collaboratively towards common objectives when doing activities.
- Be tolerant of others and respectful of differing views, when working together
- Adapt behavior to suit different situations
- Negotiate, respect others' rights and responsibilities, and use strategies to resolve disputes and conflicts
- Contribute to environmental sustainability

(iv) Culture and identity

Physics lessons and activities facilitate learners to acquire these competences by allowing them to

- Take pride in South Sudanese identity and the diverse nature of South Sudanese society.

- Build understanding of South Sudanese heritage in relation to the wider world
- Appreciate and contribute to the development of South Sudanese culture
- Value diversity and respect people of different races, faiths, communities, cultures, and those with disabilities.

(b) Cross-cutting issues to be addressed during learning

These are issues that are of high national priority and hence have been incorporated in the learning process. The three cross-cutting issues that should be addressed through the teaching/learning process are:

(i) Environment and sustainability

A well-conserved environment is obviously key to our health and survival. It is therefore important for the Physics teacher to make use of the opportunities that arise in the process of teaching and learning Physics through activities to sensitise learners on the importance of conserving the environment. One way is by ensuring that the learners always dispose off the waste materials at the end of an activity in ways that do not pollute the environment.

(ii) Peace education

Peace is critical for a society to flourish and for every individual to focus on personal and national development.

The teacher of Physics needs to be in the fore front in educating his/her students on the need for peace, for example by encouraging group work in the learners activities and showing them ways of solving peacefully interpersonal problems that occasionally arise during interactions and discussions.

(iii) Life Skills

Learners need to progressively acquire some skills, abilities and behaviours that will help them effectively deal with the events and challenges of everyday life. Such skills include first aid, communication skills, conflict resolution, basic ICT skills etc. The physics teacher should as much as possible facilitate the learners to acquire these skills whenever an opportunity arises in the lesson execution

(c) Special needs education and inclusivity

All South Sudanese children have the right to access education regardless of their physical and physiological challenges. The physics teacher therefore is required to consider each learner's needs during the teaching and learning process. Assessment strategies and conditions should also be tailored to accommodate the needs of all learners.

The following are the most common categories of special needs in learners:

- Physical challenges
- Visual challenges
- Hearing challenges
- Mental challenges

The teacher should identify such cases and help facilitate the affected learners in learning. For example, learners with visual and hearing difficulties should sit near the teacher's table for easy supervision and assistance. The following are some suggestions on how to support special needs children in your class.

(i) Learners with Physical challenges

These are learners, who have some of their body parts not able to function normally due to Physical problems. For example, some learners have partial or total incapacitation in the use of limbs or hands. In such cases, the learners will need assistance during activities that involve movement. This could be during field excursions and other activities that learners have to stand for some reason. The teacher should organize for the learner's ease of movement. The learner should also be given time to catch up with the others. In case the hands are affected, the learners should be given more time to finish their work. In both cases, the learners should not be pressurized to do things that can cause injury or ridicule.

(ii) Learners with visual challenges

These learners have problems with their eyesight. The may be longsighted, short sighted or have some eye sicknesses. They should sit at a position where they are able to see the chalkboard without straining

The material to be observed should be brought to appropriate location where these learners can be able to see. Magnifying glasses can be used where necessary. The teacher should use large diagrams, charts and labels. In some cases, the learners can be allowed to touch and feel whatever they are looking at.

The teacher should read aloud most of the things he/she writes on the chalkboard. Other learners can also assist by reading aloud. The lighting system in the classroom should also be improved.

(iii) Learners with hearing challenges

The affected part in this case is the ear. The learner can have hearing aids. The teacher should use as many visual aids as possible. They should also project their voice and always talk while facing the learners. The teacher should also use gestures and signs while talking to such leaners figure out what he/she is saying.

(iv) Learners with speech challenges

One of the most common speech challenges is stammering. Such learners speak with many difficulties. The teacher should be patient with them and encourage them to express themselves in their own way. Such learners should be given more written exercises.

(v) Learners with mental challenges

The teacher should identify the nature and level of the mental difficulty with such learners. Such learners should then be given special assistance and attention at individual levels. They can be given special tests or assessments.

In general, all the learners with difficulties should be well facilitated. This encourages and motivates them. The teacher and the rest of the class should never ridicule learners with any of the difficulties. Note that generally, the people with any kind of disability can be very sensitive to any kind of negative comments or criticism.

*Remind them that '**Disability is not inability**'.*

Treat them fairly but not with undue favours.

1.3: Basic requirements for an effective Physics lesson

1.3.1 Teacher's role and basic skills for effective Physics lesson

The teacher is the most important resource for an effective Physics lesson.

(a) Some of the key roles of the Physics teacher include:

- Organising the classroom to create a suitable learning environment.
- Preparing appropriate materials for learning activities.
- Engaging students in variety of learning activities.
- Encouraging and accepting student autonomy and initiative.
- Allowing student responses to drive lessons, shift instructional strategies.
- Familiarizing themselves with students' understandings of concepts before sharing their own understandings of those concepts.
- Encouraging students to engage in dialogue, both with the teacher and one another.
- Engaging students in experiences that pose contradictions to their initial hypotheses and then encouraging discussion.
- Providing time for students to construct relationships and create metaphors.
- Using a variety of teaching and assessment methods.
- Adjusting instructions to the level of the learner.

- Nurturing students’ natural curiosity.
- Motivating learners to make them ready for learning.
- Coordinate learners’ activities so that the desired objectives can be achieved.
- Assessing learners’ activities and suggest solutions to their problems.
- Assist learners to consolidate their activities by summarising the key points learnt.

(b) Some of the key skills that the S4 Physics teacher should have include:

- Creativity and innovation.
- Makes connections/relations with other subjects.
- A high level of knowledge of the content.
- Effective disciplining skills manage adequately the classroom
- Good communicator.
- Guidance and counselling.

1.3.2 Learner’s role in learning Physics

Learning takes place only when the learner acquires the intended knowledge, skills and attitudes. As such, learning is a highly personal and individual process. Thus, a learner must be actively engaged in the learning exercise.

For active participation in learning, the learner should:

- Raise questions about what is observed.
- Suggest solutions to the problems observed.
- Take part in planning investigations with appropriate controls to answer specific questions.
- Carry out investigations to search for answers with the help of materials in search of patterns and relationships while looking for solutions to problems.
- Working collaboratively with others, communicating their own ideas and considering others’ ideas.
- Expressing themselves using appropriate Physics terms and representations in writing and talk.
- Engaging in lively public discussions in defence of their work and explanations.
- Applying their learning in real-life contexts.
- Reflecting critically about the processes and outcomes of their inquiries.

1.3.3: Teaching/learning resources

These refer to things that the teacher requires during the teaching process. They include:

- The classroom
- Textbooks
- Wall charts and wall maps
- Materials and apparatus
- Various tools and equipment
- Physics models
- Resource persons
- Firms such as hydroelectric power stations, engineering firms among others

(a) Classroom as a learning environment

A Classroom generally refers to the place where learning takes place. Learners learn from everything that happens around them, such as the things that they hear, see, touch, taste, smell and play with.

Classroom organization

It is important for the teacher to make the classroom an attractive and stimulating environment. This can be done by:

- Carefully arranging the furniture in the classroom in an organised way to allow free movement of learners and the teacher.
- Putting up learning and teaching aids on the walls. Examples are wall charts, pictures and photographs.
- Displaying teaching models.
- Providing objects for play for example toys.
- Having a display corner in the classroom where learners display their work.
- Setting a corner for storing materials so as not to obstruct learners or distract them.
- Spreading out the learners evenly so that they do not interfere with one another's activities.
- Setting up the materials for the series of lessons or activities going on for a number of days or weeks in a location where they do not interfere with other daily activities
- Organizing the sitting arrangement such that learners face the lighted areas of the room.
- Choosing the most appropriate location for the teacher and the chalkboard such that they are visible to all learners and the teacher has a good view of all learners in the class.

(b) Apparatus and materials

For learners to study Physics through the activity method, a number of materials and apparatus are required. The important role played by materials in learning has been felt for centuries. This is noted for instance in the old Chinese proverb that says:

- *When I hear I forget*
- *When I see I remember*
- *When I do I understand*

Since Physics is highly practical subject, materials help the teacher to convey his/ her points, information or develop skills simply and clearly, and to achieve desired results much faster.

Some of the materials that a teacher requires for Physics activities and calculations can be collected from the local environment.

Many others can be improvised while some have to be purchased. Whether collected, improvised or purchased, there are certain materials that are valuable to have around almost all the time.

These include:

(i) Science Kit

A science kit is a special box containing materials, apparatus and equipment necessary to conduct an array of experiments. The content of the physics kit depends on the curriculum requirements per level. Most science kits are commercially available and target particular levels of learners. However, the teacher is encouraged to come up with a kit based on the syllabus requirement

(ii) Models

A model refers to a three-dimensional representation of an object and is *usually much smaller than the object.* Several models are available commercially in shops. Examples of Physics models include models of electric motors, hydraulic systems among others. Schools for use can purchase these models during Physics activities.

(iii) Resource persons

A resource person refers to anybody with better knowledge on a given topic area. Examples include health practitioners such as doctors, nurses and laboratory technologists, agricultural extension officers, environmental specialists among others. Depending on the topic under discussion, the teacher can organize to invite a resource person in that area to talk to learners about the topic. The learners should be encouraged to ask as many questions as possible to help clarify areas where they have problems.

(iv) Improvisation

If each learner is to have a chance of experimenting, cheap resources must be made available. Complicated apparatus may not always be available in most schools. Such sophisticated equipment made by commercial manufacturers are usually expensive and majority of schools cannot afford them. The teacher is therefore advised to improvise using locally available materials as much as possible.

(vi) Scheduling learning activities and venues

Some of the activities suggested in the student's good planning and scheduling in order to get accurate results. The teacher should therefore think ahead while making the scheme of work so that the prevailing weather pattern and the most appropriate timing are considered..

1.3.4 Grouping learners for learning activities

Most of the Physics activities suggested in the student's book are carried out in groups and therefore the teacher should place 2 or 3 desks against each other and then have a group of learners sitting around those desks.

In certain activities, the teacher may wish to carry out a demonstration. In this case, the learners should be sitting or standing in a semicircle, or arranged around an empty shape of letter "U" such that each learner can see what the teacher is doing clearly and without obstruction or pushing. If the learners are involved in individual work, each learner can work on the floor or on the desk or a portion of the desk if they are sharing. In this case, they need not face each other.

Grouping learners for learning has increasingly become popular in recent years. In fact, the shift from knowledge-based to competence curriculum will make grouping the norm in the teaching process.

Learning grouping can be formed based one or a number of the following considerations:

- Similar ability grouping
- Mixed ability grouping
- Similar interests grouping
- Common needs grouping.
- Friendship grouping.
- Sex-based grouping.

Grouping learners in a Physics class has several advantages that include:

- The individual learner's progress and needs can easily be observed.
- The teacher-learner relationship is enhanced.
- A teacher can easily attend to the needs and problems of a small group.
- Materials that were inadequate for individual work can now be easily shared.
- Learners can learn from one another.
- Cooperation among learners can easily be developed.
- Many learners accept correction from the teacher more readily and without feeling humiliated when they are in a small group rather than the whole class.
- Learners' creativity, responsibility and leadership skills can easily be developed.
- Learners can work at their own pace.

The type of "grouping" that a teacher may choose may be dictated by:

- The topic or task to be tackled.
- The materials available.
- Ability of learners in the class (fast, average, slow).
- Class size

There is no one method or approach to teaching that is appropriate to all lessons. A teacher should, therefore, choose wisely the method to use or a combination of methods depending on the nature of the topic or subtopic at hand.

1.3.5: Teaching methods

There are a variety of possible methods in which a teacher can help the learners to learn. These include:

(a) Direct exposition

(b) Discovery or practical activity

(c) Group, class or pair discussion

(d) Project method

(e) Educational visit/ field trips

(f) Teacher demonstration

(g) Experimentation/Research

The particular technique that a teacher may choose to use is influenced by several factors such as the:

- Particular group of learners in the class.
- Skills, attitudes and knowledge to be learned.
- Learning and teaching aids available.
- Local environment.
- Teacher's personal preference
- Prevailing weather condition.
- Requirements of Physics syllabus

(a) Direct exposition

This is the traditional way of teaching whereby the teacher explains something while the learners listen. After the teacher has finished, the learners may ask questions. However, in a competence-based curriculum, this technique should be used very minimally.

(b) Guided Discovery

In this technique, the teacher encourages learners to find out answers to problems by themselves. The teacher does this by:

- Giving learners specific tasks to do.
- Giving learners materials to work with.
- Asking structured or guided questions that lead learners to the desired outcome.

Sometimes learners are given a problem to solve and then left to work in an open-ended manner until they find out for themselves.

This is the most preferred method of teaching in the implementation of competency-based curriculum.

(c) Group/class discussion or pair work

In this technique, the teacher and learners interact through question and answer sessions most of the time. The teacher carefully selects his/her questions so that learners are prompted to think and express their ideas freely, but along a desired line of thought. The method leads learners from the known to unknown in a logical sequence; and works well with small groups. The method boosts confidence in learners and improve interpersonal and communication skills.

The main disadvantage of this method is that some learners maybe shy or afraid to air their opinions freely in front of the teacher or their peers. It may give them more confident learners a chance to dominate the others.

(d) Project method

In this approach, the teacher organizes and guides a group of learners or the whole class to undertake a comprehensive study of something in real life over a period of time such as a week or several weeks.

Learners using the project method of studying encounter real life problems, which cannot be realistically brought into a normal classroom situation. A project captures learners' enthusiasm, stimulates their initiative and encourages independent enquiry. The teacher, using the project method, must ensure that the learners understand the problem to be solved and then provides them with the necessary materials and guidance to enable them carry out the study.

The main disadvantage of this method is that if a project is not closely supervised, learners easily get distracted and therefore lose track of the main objective of their study. Studying by the project method does not work well with learners who have little or no initiative.

(e) Educational visits and trips/nature walks

This is a lesson conducted outside the school compound during which a teacher and the learners visit a place relevant to their topic of study. An educational visit/nature walk enables learners to view their surroundings with a broader outlook that cannot be acquired in a classroom setting. It also allows them to learn practically through first-hand experience. In all "educational visit/nature walk lessons", learners are likely to be highly motivated and the teacher should exploit this in ensuring effective learning. However, educational visits are time consuming and require a lot of prior preparation for them to succeed. They can also be expensive to undertake especially when learners have to travel far from the school.

(f) Demonstration lessons

In a demonstration, the teacher shows the learners an experiment, an activity or a procedure to be followed when investigating or explaining a particular problem. The learners gather around the teacher where each learner can observe what the teacher is doing. It is necessary to involve the learners in a demonstration, for example by:

- Asking a few learners to assist you in setting up the activity.
- Requesting them to make observations.
- Asking them questions as you progress with the demonstration.

This will help to prevent the demonstration from becoming too teacher-centred.

When is a demonstration necessary?

A teacher may have to use a demonstration, for example when:

- The experiment/procedure is too advanced for learners to perform.
- The experiment/ procedure is dangerous.
- The apparatus and materials involved are delicate for learners to handle.
- Apparatus and equipment are too few.

1.4 Assessment

What is assessment?

"Assessment is the process of gathering and discussing information from multiple and diverse sources in order to develop a deep understanding of what students know, understand, and can do with their knowledge as a result of their educational experiences; the process culminates when assessment results are used to improve subsequent learning.

Categories of assessment

There are two categories of assessment:

- Formative assessment
- Summative assessment

Formative assessment

Formative assessment refers to the range of formal and informal assessment procedures undertaken by teachers in the classroom as an integral part of the normal teaching and learning process in order to conduct in-process evaluations of student comprehension, learning needs, and academic progress during a lesson, unit, or course. Therefore, formative assessment is diagnostic as opposed to evaluative.

The feedback obtained through formative assessment helps the teacher to:

- Gauge learners' progress, achievement and learning needs; and make immediate intervention to intervene to improve student attainment.

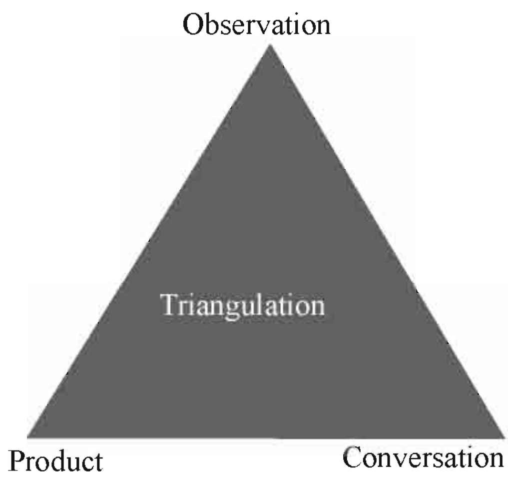
- Modify the teaching activities and instruction in order to enhance learners' achievement of learning objectives.

Opportunities for formative assessment occur in three forms.

Dr Anne Davies (Making Classroom Assessment Work 2011) called these three forms:

- **Observation** – watching students working (good for assessing skills)
- **Conversation** – asking questions and talking to students (good for assessing knowledge and understanding)
- **Product** – appraising the student's work (writing, science report, math 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, not something that the student says.

When all three are used, the information can be checked against the other two forms of assessment opportunity. This is often referred to as "triangulation".



Triangulation of assesment opportunities

These opportunities can be found in the "Learn About' sections of each syllabus unit. The section describes the learning that is expected and in doing so, it sets out a range of opportunities for the three forms of opportunity.

Summative assessment

This type of assessment is carried out at the end a defined instructional period like a project, unit, course, semester, program, or school year to evaluate the student's acquisition of knowledge and skills, academic achievement; and evaluate the effectiveness of educational programs, measure progress toward improvement goals, or make course-placement decisions, among other possible applications.

The students achievement is compared some standard or benchmark.

- Examples of formative assessment include:
- End-of-unit or chapter tests.
- End-of-term or semester tests.
- Standardized tests
- Final projects

Summative-assessment results are usually recorded as scores or grades into a student's permanent academic record e.g. a report card or test scores used in the college-admissions process.

Part 2 Topic to Topic Guide

UNIT 1

Periodic Motion

Topics in the unit

Topic 1: Circular motion

Topic 2: Simple harmonic motion

Learn about	Key inquiry Questions
Learners should carry out practical investigations on uniform circular motion to identify components such as radian, frequency and angular frequency, angular acceleration, angular displacement and velocity, investigate types of forces, such as centripetal and centrifugal associated with whirling a tied object. Learners should investigate simple harmonic motion, mass-spring systems, kinetic and potential energies of simple harmonic motion, and damped and forced oscillations. They should describe and derive mathematical expressions that relate period, frequency, angular frequency, velocity, acceleration and total mechanical energy of a simple harmonic motion. Learners should compare simple harmonic motion with uniform circular motion and derive the simple harmonic equation from the variables involved in the motion. They should develop their understanding about the compound pendulum and investigate the free oscillation of a simple pendulum, damped and forced oscillations and describe the types of damped oscillations (critical damped, under-damped and over-damped). Learners should design practical investigations to derive a relationship between momentum, circular and harmonic motion.	How do we apply simple harmonic in our daily activities? Why does the acceleration of simple harmonics tend towards the centre? Why does water in a bucket being whirled in a vertical circle doesn't get poured down? Why does a person running in a circular path tend to fall towards the center of the circle? Why a stone being whirled in a circular motion flies along the tangent when released?

Learning Outcomes		
Knowledge and Understanding	**Skills**	**Attitudes**
Understand momentum, circular and harmonic motion.	• Carry out practical investigations on uniform circular motion. • Investigate types of forces, such as centripetal and centrifugal associated with whirling a tied object. • Compare simple harmonic motion with uniform circular motion • Investigate the free oscillation of a simple pendulum. • Derive mathematical expressions that relate period, frequency and angular frequency. • Investigate simple harmonic motion. • Compare simple harmonic motion with.	Appreciate the impact of momentum.

Contribution to student competencies

- **Creativity and Critical thinking:** This unit enhances the acquisition of these competences in learners as they carry out a variety of activities and solve problems that demand critical thinking. Examples of such activities include analyzing the energy changes that take place during simple harmonic motion and derivation of mathematical expressions for different quantities e.g. centripetal force and total mechanical energy of simple harmonic oscillators.
- **Communication and Co-operation:** Most of the activities in this unit will be done by learners working collaboratively and harmoniously with others. An example of such activities is determination of the periodic time of a simple pendulum where learners will perform different roles to achieve the common objective. This promotes cooperation among them.

  Through group discussion in the activities, learner will improve their listening and speaking skills as they find out solutions to problems. These skills will be enhanced further as learners make presentations to the rest of the class.

Links to other subjects

- **Mathematics:** Learners will use arithmetic and trigonometric operations and problem-solving strategies learnt in mathematics to solve numerical problems on linear and angular displacements, velocities, acceleration and time.
- **Geography:** The knowledge gained in this unit will help the learners understand the motion of planets and satellites.
- **Chemistry:** The Knowledge gained in this unit will help the learners understand the working of centrifuges that are used to separate mixtures in chemistry laboratories.

Cross cutting issues addressed in this unit

- **Life skills:** This unit helps the learner to deal with day-to-day challenges and situations. For, example, it helps them to understand why a driver has to slow the car down when negotiating a bend to avoid skidding off the road. The unit also sensitizes the learners on the need to embrace people living HIV and AIDs.
- **Peace and value education:** This unit will enhance unity among the learners through group activities. During the discussions, learners will learn to respect each other's opinions.

Attention to special needs

- Plan remedial teaching for slow learners and give the gifted learners more tasks that require more critical thinking.
- Accommodate those learners with various special needs during teaching and learning process. See the introductory section of this teachers guide on how to handle learners with various physical disabilities.

Topic 1 Uniform Circular Motion

(Student's book pages 2-26)

Background information and /or prior knowledge

- Learners in their day-to-day life encounter or are involved in circular motion and its applications. For example, they see vehicles and motorcycles negotiating sharp bends at high speeds without skidding off the roads. This experience will help them understand and analyse the motion of objects in a circular path.
- In Secondary 3, the learners were introduced to concepts of linear motion including distance, displacement, speed, velocity and acceleration. Let the learners know that they will apply this knowledge to analyse circular motion of objects in this topic. Ask them probing questions to review their understanding of these concepts and guide them where necessary.

Subtopics

No.	Subtopic
1.1	Illustrating circular motion
1.2	Circular motion and centripetal force
1.3	Angular displacement and angular velocity
1.4	Applications of uniform circular motion

Suggested teaching and learning activities

1.1 Illustrating circular motion

Specific learning outcome

By the end of this section, the learner should be able to define, explain and illustrate circular motion.

Teaching guidelines for activities 1.1, 1.2 and 1.3

Activity 1.1

- Let the leaners do this activity as a whole class activity. Let all the learners stand in a semicircle at the front in the classroom or outside the classroom. Call one of the learners to the middle and give him/her and an umbrella.

- Ask the learner to open the umbrella, wet its cloth and spin it about the handle. Ask the class to observe what happens to the drops of water on the cloth.
- Ask them to explain why the water drops flew off the cloth. Let them name and describe the force responsible for 'flying off' of the drops

Activity 1.2

- You can improvise the circular disc described in the activity using a cardboard or the lid of a 20-litre bucket that is in a state of disuse. Ensure that they fix the peg firmly through the disc so it does not come off during rotation.
- Ask the learners to record the reading of the spring balance before setting the disc in motion.
- Let them rotate the disc and check the reading on the spring balance. Ask them to explain why the reading of the spring balance has increased. Ask them to identify and describe the force acting on the stone, which is responsible for the increase in the reading of the spring balance.
- Prompt them to predict what would happen to the reading of the spring balance if the disc is rotated faster. Ask them to confirm or disprove their prediction about increasing the speed of the disc.

Activity 1.3

- Let the learners tie a small tennis ball or a stone with a string. Let them use a strong string and tie tightly to avoid the string breaking or the ball/stone 'flying off' during rotation. This may be dangerous to the other learners who may be very close.
- Ask them to go outside in an open ground away from the other group members and whirl the stone in a horizontal circle.
- Let them release the string and observe the direction in which it flies away. Ask them to describe the direction of the force that keeps the stone in circular motion and why the stone flew away in the direction of tangent to the circle at the point of release.
- Let them represent the rotation of the stone with a diagram and indicate the forces acting on the stone and the string.

Assessment

Observation

Observe learners as they do the activities to gauge their understanding. Are they observing safety measures as guided? Is each one in the group participating in the activities? In Activity 1.2, are they reading of the spring balance correctly and recording their observations?

Conversation

Ask the learners probing questions as they are doing the activities. If some group members are not participating, encourage them by directing questions at them. Can they describe the force that keeps objects in circular motion, as acting towards the center of the circle?

Product

Check the learner's diagrammatical representation of the stone moving in a circle. Can they represent centripetal force and tension in the string as the forces in play as the string rotates?

1.2 Terms used to describe circular motion

Specific learning outcome

By the end of this section, the learner should be able to define the terms linear and angular displacement and velocity, and solve related problems.

Teaching guidelines for activity 1.4

- First prompt the learners to suggest the meaning of the terms angular displacement, angular velocity and frequency from their understanding of the terms angle, displacement, and velocity. Give them an opportunity to confirm the meanings from reference sources including their textbooks. Through a quick class discussion, ensure that they master the definition, otherwise the rest of the activity will be challenging for them to do without this knowledge.
- Ensure that each learner has a pair of compasses, ruler, protractor and pencil or at least the items that can be shared by each pair of learners. Ask them to draw a circle with a center O and radius 7 cm, and mark the sector MNO with angle MON = 30° accurately. Ensure that each learner draws the diagram.
- Guide them to observe safety as they cut out the circle and fix optical pin through the circle centre.
- Observe them as they do step 6 of the activity and ask them leading questions to help them determine the linear velocity, angular velocity and frequency of rotation of point M described in the activity. Encourage them to do this as a group so that they correct each other's mistakes and misconceptions.
- Give each group an opportunity to present their work to the rest of the group.
- Through a class discussion, guide the groups to come up with the mathematical expressions for angular displacement, angular velocity and frequency, guided by the discussion in the Student's book on pages 5 to 8.

- Through a class discussion, guide the learners through examples 1.1 to 1.3. Ask two learners to guide the class through Examples 1.4 and 1.5. Ask the class to do Exercise 1.1.

Assessment

Observation

Observe the learners as they do the activity. Can they use the geometrical instruments well to draw the circle and angle accurately? Is each one in the group participating? Do they appear to understand what they are doing and why?

Conversation

Listen to the learners as they work and discuss the activity and as they present their findings. Can they define the terms angular displacement, angular velocity and frequency correctly? Do all group members understand?

Product

- Look at the circular diagrams drawn. Do they demonstrate mastery of some basic geometry skills to help them draw diagrams to determine quantities in circular motion?
- Look at the mathematical expressions they have derived for angular displacement angular velocity and frequency. Do they demonstrate understanding of the terms angular displacement angular velocity and frequency?

1.3 Centripetal force and acceleration

Specific learning outcome

By the end of this section, the learner should be able to explain and solve problems involving circular motion and centripetal force.

Teaching guidelines for activities 1.5, 1.6 and 1.7

Activity 1.5

- Ensure that each group has all the materials listed for the activity. In the absence of a glass or plastic pipe, let them use a biro pen casing and ensure the string used freely passes through it.

- Guide the learners in setting up the apparatus as shown in Fig. 1.11 on page 11 in the Student's book. Ensure that they tie mass *m* securely with the string to prevent it from flying off during rotation.
- Guide them to set the mass *m* at a fixed radius of 1 m from the tube using the clip. Emphasize that one should at all times strive to maintain this radius as they rotate the mass so that it does not affect the results of the investigation. Let them practice beforehand how to maintain the radius constant as they rotate the mass.
- Now let each learner rotate mass *m* keeping the radius constant and for a particular value of mass M, as other learners in the group count the number of revolutions made in a given time e.g. 10 s. Let one of the learners be the time keeper, signaling the starting and the stopping of the counting. Emphasise that the one rotating the mass must be at reasonable distance from the others and take great care not to accidentally release the string, to avoid hitting the others.
- Ensure that one-learner records for the group the value of mass M, number of revolutions made in t time (N), frequency ($f = \frac{N}{t}$) and period ($T = \frac{1}{f}$), and record all in Table 1.1. Let them calculate the linear speed (v) of the stone and record in the table.
- Let each leaner in the group repeat the activity but for a different value of masses M.
- Prompt them to identify the quantity that provides the centripetal force (F) to keep mass *m* in circle during the rotation.
- Let each of them draw a graph of mass *M* against the velocity v in their graph books. Let them analyse the graph as a group and deduce the relationship between *F* and *v*.

Activity 1.6

- This activity should be conducted as a learner designed/driven investigation with you, the teacher, as just a facilitator.
- Let the learners work in groups. Ask them to use the same set up they used in Activity 1.5 and observe the same safety measures, but this time investigate the relationship between centripetal force (*F*) and the radius (*r*) of the rotation.
- Prompt them to identify the variable to keep constant (in this case the frequency of rotation) and the one to vary (in this case the mass *M*) to obtain corresponding values of *r*. Ensure that each group has got the quantities right otherwise they will be doing the wrong investigation. Maintaining the frequency constant may not be very easy but they can achieve this to a reasonable degree though trial and error and practicing a number of times before taking the measurements.
- Let them write down the procedure and record their results in a table. The expected results are values of *M* and corresponding values of *r*.

- Ask them to analyse their values by drawing the relevant graph (in this case a graph of M against r. Let them use the graph to deduce the relationship F α $\frac{1}{r}$.
- Give each group an opportunity to present their findings to the rest of the class.

Activity 1.7

- In this activity, the learners will use the same set up they used in Activity 1.5 and observe the same safety measures, but this time investigate the relationship between centripetal force (F) and the mass m of the object.
- Prompt them to identify the variable to keep constant (in this case the frequency of rotation and radius r) and the one to vary (in this case mass m to obtain corresponding values of Mass M. Maintaining the frequency constant will be achieved by trial and error as in activity 1.6.
- Let the learners set a fixed radius (about 1 m) of the rotation using the clip. Let them begin with one mass for m, rotate it and record the value of M required to maintain the stone at the same frequency of rotation. Let them repeat this for different values of m (increasing the number of masses) and record their results in Table 1.3.
- Ask them to each draw a graph of mass M against m in their graph books. Let them analyse the graph as a group and deduce the relationship between F and m in circular motion.
- Having done activities 1.5, 1.6 and 1.7, ask the learners to combine the results and come up with one expression connecting F to m, r and v (in this case $F = \frac{mv^2}{r}$).
- Through a class discussion, guide the learners through the derivation of the expressions of centripetal force and acceleration in terms of linear velocity and angular velocity, as guided by the discussion in the Student's book on pages 14 to 15.
- Guide them through Examples 1.6 and 1.7 and ask them to do Exercise 1.2.
- Guide the learners through a discussion of the applications of circular motion in a horizontal circle, guided by the discussion in the Student's Book on pages 17 to 20.

Assessment

Observation

Observe the learners as they do the activities. Are they observing safety measures to avoid accidents? Are they following the right procedure? Are they taking and recording the measurements of masses M, m time t, and radius r as expected in the respective activities? Is every learner involved in the activities? Encourage any non-participants to engage. Are there learners facing some challenges who need to be guided.

Conversation

- Listen to the learners as they discuss the activities and also ask them guiding and probing questions. Do their conversations demonstrate understanding of the procedure and the quantities being measured? Can they explain why they are varying some quantities and keeping others constant?
- Listen to the group's presentations on the applications of circular motion in a horizontal circle. Can they clearly and accurately describe the effect and applications of circular motion?

Product

- Check each learner's data tables and graphs. Do the general trends of the values and graph reflect the correct relationships being investigated?
- Check the combined relationships between F and m, v and r as deduced by the learners. Is it factually correct, that $F = \frac{mv^2}{r}$?

1.5 Motion in a vertical circle

Specific learning outcome

By the end of this section, the learner should be able to describe and analyse the motion objects in a vertical circle.

Teaching guidelines for Activity 1.8

- Let the learners in groups tie a small stone securely with a weak string and whirl it slowly in a vertical circle. Again emphasize that the person doing it should observe all the safety measures by being far away from the rest of the group members.
- Let them predict the position of the stone at which the string is more likely to break if the speed of rotation of the stone is increased.
- Let the learner whirling the stone do so faster until the string breaks, taking care for himself/herself not to be hit by the stone. Let the group members confirm or disprove their earlier prediction.
- Ask the learners to describe all the forces acting on the stone at positions A, B and C (See Fig. 1.19 in the student's book) and derive the expressions for the tension in the string in terms of the other forces acting at those points. Let them compare the values of the tension at those points and determine the point at which tension is greatest. Guide them to understand that the string is more likely to break at point A than at the other points.

- Ask the learners to discuss the applications of motion in a vertical circle including the ability of motorbikes and airplanes to execute loops in vertical circles.
- Give each group an opportunity to present to the rest of the class.
- Cement the learning by briefly summarizing the analysis of motion of an object in vertical circles guided by the discussion in the Student's Book on page 21.
- Ask two learners to take the class through examples 1.8 and 1.9. Let the class do Exercise 1.3 in class and Unit Test 1 as take away assignment.

Assessment

Observation

Observe the learners as they do the activity. Can they whirl the stone in a perfect vertical circle? Are they observing safety measures?

Conversation

- Ask the learners some probing questions and listen to their responses and presentations. Can they identify and describe the forces acting on the object at different points in the vertical circle? Can they describe the applications of motion in a vertical circle in the terms of the forces acting on the objects?
- Listen to the learners as they describe the applications of motion in a vertical circle. Do they demonstrate an understanding of these applications?

Product

Check the learners' written expressions on the tension in the string at positions A and B of the stone in the vertical circle. Are the expressions factual?

Answers to numerical problems

Exercise 1.1

1. (b) (i) $\frac{2}{9}\pi$ (ii) $\frac{3\pi}{2}$ (iii) 3π

2 (a) 18.85 m (b) 6.28 m

3. 0.00178 rad/s

4. 10 πrad/s

5. (a) 4 πrad/s or 12.57 rad/s (c) 8 πm/s or 25.13 m/s

   (b) 25.13 m/s

Exercise 1.2

1 (a) 4.36×10^{-4} rad/s (b) 2.44 m/s^2 (c) 5585.05 m/s

2. (a) 10 πrad/s (b) 200 πrad/s (c) 19739.21 m/s^2

3. 8.67 m/s^2, F = 69317.39 N

4. (a) 25.13 m/s (b) 315.83 m/s^2 (c) 4 πrad/s or 12.57 m/s

Exercise 1.3

1. T = 75.3 N

2. (a)

F(N)	8	32	72	128
V (m/s)	4	8	12	16

(b) 0.1 kg

Topic Test 1

2. (a) 3.125×10^{-3} m/s^2

(b) 62.50 N

3. (a) 1.25 m/s^2 (b) 4.375 N

4. 1.927×10^{-3} m/s^2

5. (a) 450 m/s^2 (b) 292.5 N

6. 6 912 N

7 100 m/s

10. (a)

r(cm)	16	4
F(N)	12.5	50

(b) 2 m/s

11. (c) 8 640 N

13. 12 m/s

14. 1 000 N

Topic 2 Simple Harmonic Motion

(Student's book pages 27-60)

Background information and/or prior knowledge

- Learners have come across pendulums, seesaws and many other systems that execute simple harmonic motion. This topic will help them understand the forces that are responsible for this kind of motion and the energy changes that take place during the motion.
- Some prior knowledge and skills that the learners need to have acquired to facilitate learning in this topic include the terms used to describe oscillations i.e. amplitude, frequency, velocity and period, determination of KE and PE (learnt in Secondary 2 Physics), trigonometric ratios (learnt in Senior 3 Mathematics) and calculus (learnt in Senior 4 mathematics). Use question and answer method to quickly review these meaning of these terms and their mathematical expressions.

Subtopics

No.	Subtopic
2.1	Definition of simple harmonic motion
2.2	Terms used to describe simple harmonic motion
2.3	Equation of simple harmonic motion
2.4	Simple harmonic oscillating systems
2.5	Energy changes in simple harmonic motion
2.6	Damped oscillations

Suggested teaching/learning activities

2.1 Definition of simple harmonic motion

Specific learning outcome

By the end of this section, the learners should be able to define simple harmonic motion.

Teaching guidelines for activity 2.1

- Ensure each group has a complete set of apparatus for the activity. Ask the learners to setup a simple pendulum system as shown in Fig 2.1 in the student's book. Emphasise that the pendulum bob should be suspended at a reasonable distance off the bench so that it can oscillate freely without touching the bench.

- Let them displace the pendulum bob through a small but significant angle and then release it to oscillate. Ask them to describe the motion of the pendulum.
- Let them explain why the pendulum bob reaches maximum height on the other side and moves back instead of continuing to move up.
- Ask them to hold the pendulum bob and release it once again. Let them observe at least 30 oscillations. Ask them to explain why the amplitude and displacement of the consecutive oscillation keep on decreasing. Note that the pendulum must make a reasonable number of oscillations for one to observe a notable decrease in the amplitude.
- Prompt the learners to describe the force acting on the pendulum bob during oscillation in terms direction, how and why it varies with the displacement of the bob instead of being constant?
- Let one or two members of each group present the findings to the rest of the class in a class discussion. Ask the rest of the class to comment on or critique facts presented by each group.
- Guide the learners through the discussion on the Student's book on page 29 to 30 on the force law of simple harmonic motion.

Assessment

Observation

Observe as the learners are setting up the apparatus and doing the activity. Is every group member participating? Is the pendulum oscillating freely without hindrances from obstacles?

Conversation

Listen to the learners as they are discussing and answering questions. Can they describe simple harmonic motion and the restoring force using the appropriate scientific terminology?

2.2 Terms used to describe simple harmonic motion

Specific learning outcome

By the end of this section, the learners should be able to explain the terms used to describe simple harmonic motion.

Teaching guidelines for activity 2.2

- In case the learners don't have enough textbooks to be shared by each pair of learners, draw the graph shown in Fig 2.4 on a the chalkboard or manila paper and hang it at a convenient location for all the learners to see clearly.
- Let them work in pairs to define the terms displacement, amplitude period and frequency, and determine their values in the graph given.
- Give them an opportunity to compare their work with other classmates.
- Help the learners refine their definition of the terms by the guiding them through the discussion of the terms given in the Student's Book page 30 to 32.

Assessment

Conversation

Listen to the learners as they are discussing the terms. Are their definitions of the terms appropriate?

Product

Check the mathematical expressions and values of displacement, velocity, amplitude period and frequency written by the learners for the given oscillation. Do the values suggest an understanding of the terms?

2.3 Equation of simple harmonic motion

Specific learning outcome

By the end of this section, the learners should be able to derive the equation of simple harmonic motion.

Teaching guidelines for activity 2.3

- In order to understand the derivation of the equation of simple harmonic motion, the learners will need the knowledge on how to find the first and second derivatives of trigonometric functions. These skills may not be taught in their secondary mathematics course. It is important that they get some basic understanding of this before embarking on learning this section.
- Ask them to do a research from mathematics reference sources on how to find the first and second derivatives of trigonometric functions. If these resources are not available the teacher may have to guide the class through the processes.

- Give them an opportunity to briefly share their findings in a class presentation. You should give your input to help the whole class understand those concepts during the discussions.
- Extend the class discussion by guiding learners to apply the knowledge they have now acquired to derive the equation of simple harmonic motion as discussed in the student's book page 33.
- Guide them through Example 2.1. Ask two learners to take the class through Examples 2.2 and 2.3. Ask them to do Exercise 2.1 as a take away assignment.

Assessment

Observation

Observe the learners as they find the derivatives of the functions. Can they be able to follow the correct procedure to find the derivatives?

Conversation

Listen to the learners as they are discussing how to differentiate trigonometric functions in their groups and in the presentations. Does their talk demonstrate an understanding of the process of doing differentiation? Have they mastered how to derive the equation of simple harmonic motion?

Product

Look at the learners' written work in their books and chalkboard on finding the first and second derivatives of the functions $y = sin\theta$, $y = sina\theta$ and $y = bsina\theta$. Do their workings suggest an understanding of the principles of differentiation? Do they need some guidance?

2.4 Simple harmonic oscillating systems

Simple pendulum

Specific learning outcome

By the end of this section, the learners should be able to derive the expression of the periodic time for a simple pendulum.

Teaching guidelines for activity 2.4

- Ask the learners to set up a simple pendulum as they did Activity 2.1 guided by Fig. 2.1. Emphasize that the pendulum bob should be suspended at a reasonable distance off the bench so that it can oscillate freely without hitting the bench.

- Ask them to displace it through a small angle θ and then release it to oscillate. Note that the motion of the pendulum is harmonic only for small displacements i.e. angle less than 15°. Let them describe the motion of the pendulum.
- Let them identify all the forces acting on the bob when at the maximum displacement on one side (point B in Fig. 2.7) and indicate their directions on the diagram.
- Ask them to write down the mathematical expression relating the force restoring the pendulum bob and the other forces acting on it. Rewrite the equation to obtain an expression for periodic time of the pendulum. It is likely that not all learners will get this right. You need to organise a brief class discussion at this moment to ensure that each group has obtained the correct equation, otherwise some learners will not be able to move on with the next part of the activity.
- Now ask them to displace the bob again through angle θ, count and record the time it takes to make 20 oscillations. Ask them to use the data they correct to fill table 2.1.
- Give them graph papers and let them draw a graph of T^2 against length L. Emphasize to them the importance of choosing convenient scales on both axes and to draw the line of best fit.
- Let the learners use their graph to determine the value of acceleration due to gravity. Give them tips including the need to reorganize the equations of the graph in the form y = mx + c, then identify what *m* and *c* represents.
- Let them to compare their value of 'g' with the other groups and the known the theoretical value (9.81 ms^{-2}).
- Let them identify the possible sources of errors in the activity and how to minimize them. Such errors include in accurate timing and premature estimation of measurements.
- Take them through a quick overview of the derivation of the equation of the period of simple pendulum discussed in the Student's Book page 40 – 41 and help them discover how to handle the challenges they may have encountered in the activity.
- Guide the learners through Examples 2.4 and 2.5

Assessment

Observation

Observe the learners as they are taking measurements. Are they handling the stopwatch and meter rule as they should and taking measurements of time and length of accurately?

Conversation

Ask the learners some probing questions as they discussing the derivation of the expression of the period of a simple pendulum. Do their responses demonstrate understating of the forces at play during the motion of the pendulum and the relationship between them? Do they need your guidance?

Product

Look at the table of values prepared by the learners and the graphs they have drawn. Do the values show that the learners are following the procedure appropriately? Are the values accurately obtained? Are there wide discrepancies between groups? Is the graph well drawn? Can it give an acceptable value of 'g'?

Mass suspended on a spiral spring

Specific learning outcome

By the end of this section, the learners should be able to derive the expression of the periodic time of mass suspended on a spiral spring.

Teaching guidelines for activity 2.5

- Ask the learners to set up the apparatus as shown in Fig. 2.10. Ask them to ensure that the pointer of the spring is touching the scale of the meter rule, to minimize parallax errors when reading the values of extensions.
- Ask them to slightly displace the mass downward and release it to oscillate. Let them describe the motion of the mass.
- Let them derive the expression for periodic time of the oscillation given that the restoring force on the mass is equal to the stretching force on the spring ($ke = mg$). This may challenge some learners hence you need to guide them by giving them hints. Ensure that each group has obtained the correct equation; otherwise some learners will not be able to move on with the part 2 of the activity.
- Now ask them to determine the extension produced by a 200 g mass. Let them displace the mass downwards then release it and determine the time for 20 oscillations. Let other learners in the group repeat this to make a minimum of three trials, then determine the average time and record in table 2.2
- Ask them to calculate the periodic time (T) and the value of T^2 and record in the table. Let them use the values to calculate the value of acceleration due to gravity (g).
- Let them to compare their value of 'g' with the other groups and the known of value of $9.81 ms^{-2}$.

- Let them identify the possible sources of errors in the activity and suggest ways in which they can be minimised. Such errors include inaccurate timing and premature estimation of measurements.
- Guide them through a brief discussion of the derivation of the equation as discussed in the Student's Book page 44 – 45 and help them discover how to handle the challenges they may have encountered in the activity.
- Guide the learners through Examples 2.6. Ask one learner to guide the class through Example 2.7.
- Through a class discussion, guide them the derivation of the equation for the period of a simple pendulum and Example 2.8. Ask them to do Exercise 2.2 as homework.

Assessment

Observation

Observe the learners as they take measurements. Are they handling the stopwatch and meter rule appropriately and taking measuring time and length of accurately?

Conversation

Ask the learners some probing questions as they are discussing the derivation of the expression of the period of the oscillating mass. Do their responses demonstrate some understating of the forces at play during the motion and the relationship between them? Do they need your guidance in some aspect?

Product

Look at the table of values prepared by the learners. Do the values show the learners are following the procedure? Are the values accurately obtained? Are there wide discrepancies between groups?

2.5 Energy Changes in Simple Harmonic Motion

Specific learning outcome

By the end of this section the learners should be able to describe the energy changes in simple harmonic motion and the expression for the total mechanical energy of such systems.

Teaching guidelines for activity 2.6

- This activity is meant to be a learner designed/ driven investigation with you as just a facilitator.

- Let the learners interpret the objective of the activity and set up a simple pendulum.
- Let them identify the variables they need to keep constant and those to vary.
- Ensure they write down their procedure. Move round asking them probing questions to help them improve their procedure or setup where necessary.
- Let them carry out the procedure and record any observation they make and the data they obtain.
- Make it clear to them that all their investigations must help them to:
  (a) Describe how PE and KE change in one oscillation
  (b) Identify the positions where KE is maximum and where it is minimum and do the same for P.E.
  (c) Describe how the total mechanical (PE + KE) vary during one oscillation.
- Let them discuss as a group and derive the expression of the total mechanical energy of the system at any point during the oscillation. Ask them to explain why the total mechanical energy of the system is the same at all points (neglecting air resistance).
- Give them through the discussion in the student's book page 50 to 53 to cement their understanding of the energy changes during simple harmonic motion.
- Guide them through Examples 2.9 and 2.10 and let them do Exercise 2.3.

Assessment

Conversation

As the learners are discussing listen to their arguments. Can they describe the energy changes taking place as the bob oscillates? Can they tell where KE or P.E is maximum and vice versa?

Product

Look at the expression for the total mechanical energy of the system as derived by the learners. Is it an expression of the sum of K.E and PE? Have they written the correct expressions for K.E and P.E?

2.6 Damped oscillations

Specific learning outcome

By the end of this section, the learners should be able to explain damped oscillations and represent then in a sketch graph.

Teaching guidelines for activity 2.7

- You can take the learners to a water pool near the school. In the absence of such a pool, use water in a large trough or washing basin.
- Ask the learners to wait until water in the pool or basin settles then generate water waves by dropping a small stone. Let them observe the waves decrease in amplitude as they spread out.
- Ask them to explain why the amplitude of the waves is decreasing with time.
- Let them describe applications of damping of oscillations.

Assessment

Conversation

Listen to the learners as they describe the behavior of the water waves. Can they tell that the amplitude of the waves is decreasing? Can they tell the cause of the damping of the waves i.e. friction between water and the container or pool floor? Can they describe some applications of damped oscillation?

Answers to numerical questions

Exercise 2.1

3. (b) 1.508 m/s, $x = 0$

   (c) 37.9 m/s^2, at $x = A$

4. (a) 2.5 s

   (b) 0.4 Hz

   (c) 2.513 rad/s

5. (a) 2 Hz, 0.5 s

   (b) 4 m

   (c) $\frac{\pi}{2}$ rad/s or 90°

   (d) 0.3723 m

   (e) 50.25 m/s

7. (a) $x = A\sin(\omega t + \theta)$, $V = \omega\sqrt{A^2 - x^2}$

   (b) $V_{max} = 0.98$ cm/s at mean position.

Exercise 2.2

1. (a) 1.26 s (b) 0.796 Hz
5. 8.886 s, 0.1125 Hz

Exercise 2.3

1. 1.0 J
2. (a) 36 N (b) 360 N/m (c) 45 N (d) 62.8 s
4. (a) 1.8 J (b) 1.8 J, 3 m/s (c) –0.45 J 1.35 J (d) 9 m/s^2
5. (b) 35.9 s (c) 0.49 J (d) 0.4 m/s (e) 0.08 J; 0.41 J
6. (a) 3.44 s (b) 0.33 J (c) 0.017 J, 0.313 J

Topic Test 2

1. (a) $x = 12 \sin (4.4ft + \theta)$ (b) 7.5×10^{-3} N/m
   (c) 2.9 m/s^2 at x = 4 (d) 22.4 m/s^2
   (c) 0.26 m/s, x = 0
2. 6.9551 s
3. (a) 500 J (b) 500 J (c) 10 m/s (d) 19.87 s
5. (a) 50 N (b) 500 N/m (c) 42.5 N (d) 15.5 cm
   (e) 0.628 s

UNIT 2

Newton's Law of Gravitation

Topics in the unit

Topic 3: Newton's law of gravitation

Learn about	**Key inquiry Questions**
Learners should revisit their prior learning about Newton's laws and through practical investigation develop their understanding about Newton's Law of Gravitation, the orbits of planets and satellites and estimate mass of the sun and planets, gravitation field, variation of acceleration with altitude from the Earth's surface, gravitational potential energy and field, and force between an extended body and particle Learners should know and apply Kepler's laws of gravitation and describe and derive mathematical formulae for the motion of planets, and satellites about their respective orbits and why the planets and satellites remain in orbit. They should describe and derive the mathematical formula for escape and first astronomical velocity, and geostationary orbit, and relate them. They should understand applications of geostationary orbits in communications and television signals, elliptical path of planets.	Why do planets remain in their orbits while orbiting the sun? What are the names of some of the planets? How would the speed of satellite be affected when moving in higher orbits? How you relate the orbiting of the planets around the sun to those of the electrons around the nucleus of an atom?

Learning Outcomes		
Knowledge and Understanding	**Skills**	**Attitudes**
Understand Newton's law of gravitation, the orbit of planet and satellites	• Design investigations on escape velocity, gravitational acceleration • Apply Kepler's laws of gravitation and describe and derive mathematical formulae for the motion of planets Graph variation of gravitational acceleration inside and outside the Earth surface	Appreciate we are living on a moving planet.

Contribution to student competencies

- **Creativity and critical thinking:** These competences are enhanced as the learners do activities and solve problems that require them to think critically. In addition, learners will require critical thinking to analyze planetary motion as described by Kepler's laws. They will enhance their creativity as they design and carry out investigations.
- **Communication and Cooperation:** The unit has numerous group activities. As learners discuss the activities, their listening and speaking skills will improve.

  Working collaboratively work in groups activities enhances unity among learners as they deal with issues they face in day-to-day life.

Links to other subjects

- **Mathematics:** The learners will be required to use the knowledge they have learned in mathematics especially on formula to solve problems on Newton's gravitational law.
- **Geography:** The knowledge gained in this unit will help learners to understand planetary motion, which they study in geography.

Cross cutting issues addressed in this unit

- **Peace and values education:** Group discussion and collaboration in the activities teaches learners to work in teams and respect other people's views. This leads to a harmonious co-existence among learners.
- **Environment and sustainability:** This unit deals with the solar system, planetary bodies like the sun and the moon obviously have an impact on the season and weather. For example, the rotation of the moon around earth is responsible for high and low tides. Therefore, studying this unit gives the learner a foundation required for further understanding of the influence of planetary motion in our environment.

Attention to special education needs

Facilitate learners with special diverse special needs as guided in the introductory section of this teacher's guide.

Topic 3 Newton's law of gravitation

(Student's book pages 62-78)

Background information and /or prior knowledge

- Learners in their day-to-day life experience rotation of the earth and moon around the sun. They also hear about satellites that orbit the earth and are used in communication. However, they usually don't understand how these objects orbit one another. This topic will help them understand the laws and principles that govern planetary motion.
- Some of the prior learning that will help the leaners in learning this topic includes concepts of circular motion (covered in Unit 1 of this book) and elliptical geometry. Use question and answer method to review basic terms used to describe circular motion including linear and angular velocity, and acceleration. Give the learners the task to research on the properties of an ellipse before starting to learn aboutKepler's laws.

Subtopics

No.	Subtopics
3.1	Newton's Universal law of gravitation
3.2	Kepler's laws of planetary motion
3.3	Applications of Newton's law of gravitation and Kepler's laws

Guidelines to learning and teaching activities

3.1 Newton's universal law of gravitation

Specific learning outcomes

By the end of this section, the learner should be able to state the Newton's universal law of gravitation, derive its mathematical expression and use it to solve problems.

Teaching guidelines for activity 3.1

- Let the learners throw a stone upwards and observe it as it falls. Ask them to explain why the stone falls to the ground instead of continuing to move up. Why does the force pull the stone to the earth instead of the other way round? Ask them to explain what the difference would be if the same stone is thrown upwards with the same force from the surface of the moon.

- Let them explain how the force between the stone and the earth varies with the masses of the stone and the earth, and the distance between them. Then, let them discuss in their group and derive the expression for the gravitational force of attraction between the stone of mass m_1 and the earth (mass m_2).
- Give them an opportunity to do a research from reference sources on the Newton's law of gravitation its mathematical expression. Let them compare the expression they derived with what they get from the references. Let them state the value of the universal gravitational constant from their research.
- Give them an opportunity to present to the to rest of the class.
- Through a class discussion, briefly take the learners through discussion on Newton's universal law of gravitation as discussed in the student's book page 62-63. Guide them through Example 3.1. Ask two learners to guide the class through examples 3.2 and 3.3.
- Briefly take the learners through discussion on the variation of gravitational field strength with distance as discussed in the student's book page 65-66. Guide them through Example 3.1. Ask two learners to guide the class through examples 3.4 and 3.5. Let them to do Exercise 3.2 as take away assignment.

Assessment

Observation

Observe the learners as they do the activity. Is every group member participating actively?

Conversation

Listen to the learners as they are discussing. Are their arguments in line with the Newton's universal law of gravitation? Could they be having some misconceptions?

Product

Look at their written derivation of the expression of the Newton's universal law of gravitation. Is it factual?

3.2 Kepler's laws of planetary motion

Specific learning outcomes

By the end of this section, the learner should be able to state Kepler's laws of planetary motion and apply them in solving problems.

Teaching guidelines for activity 3.2

- Steps 1 to 3 of the activity introduce the learner to the properties of an ellipse, as they may have no prior knowledge about it and it is key to understanding Kepler's first law and second laws of motion of planetary motion.
- Ensure that each group has all the listed materials. Ask them to follow steps 1 to 3 and draw the ellipse. Let them now describe an ellipse based on their experience as in drawing it. A simple description of an ellipse is a curved line forming a closed loop, where the sum of the distances from two points (foci) to every point on the line is constant.
- Now give the learners an opportunity to research from the reference sources and write down Keepler's three laws of planetary motion. Let them fill Table 3.1 to establish if the Earth and Mars obey Kepler's third law.
- Give all the groups an opportunity to present their findings to the rest of the class and accept discussion points from the others. Make clarifications to the class during the presentations.
- Guide the learners through Kepler's 1^{st} , 2^{nd} 3^{rd} law as discussed in the student's book page 68 to 72 to cement their understanding of the laws.

Assessment

Observation

Observe the learners as they are drawing the ellipse. Can each one of them follow the instructions and draw a perfect ellipse?

Conversation

Listen to the learners as they describe an ellipse, state and explain Kepler's laws. Can they tell what an ellipse is and describe elliptical motion? Can they state the Kepler's laws accurately?

Product

Look at the values in Table 3.1 as recorded by the learners. Do the values support their conclusions at to whether the earth and mars obey Kepler's third law?

3.3 Applications of Newton's law of gravitation and Kepler's laws

Specific learning outcomes

By the end of this section, the learner should be able to describe the applications of Newton's law of gravitation and Kepler's laws.

Teaching guidelines for activity 3.3

- As stated in the background information of this topic, learners have an idea that some planets orbit others e.g. the earth orbits the sun and so on. Prompt them to explain what keeps the planets on their orbits without falling off as they orbit other planets. Let them also try to explain how planets are launched into space. This will help you gauge their curiosity and understand the misconceptions they might have
- Give them an opportunity to research from reference sources to confirm or disprove their prior hypothetical knowledge.
- Organise a class debate where each group presents as the others support or challenge the facts. Intervene from time to help them get the facts right on various the applications of Kepler's and Newton's Gravitational law.
- Briefly take the learners through the applications of Kepler's laws guided by the discussion in the in the student's book page 72 to 77 to cement their understanding. Guide them through Examples 3.6 and 3.7. Let them do Exercise 3.2 and Unit Test 3 as take home assignment.

Assessment

Conversation

Listen to the learners as they discuss and answer the questions. Can they clearly describe the applications of Kepler's and Newton's Gravitational law?

Answers to numerical questions

Exercise 3.1

1. 14 606.91 N
2. 92.63 N
3. 3.7×10^8 N
4. 2.67 kg
5. 1.445 m

Exercise 3.2

3. 2.1437 m/s^2
4. 1.274 m/s

Topic Test 3

4. (a) 6.435×10^6 m

   (b) 2 884.36 N

5. 7869.45 m/s

6. 3.905×10^7 m

8. 8 634 m/s, 1.491×10^{11} J

UNIT 3

Wave Reflection, Refraction, Interaction, Interference and Diffraction

Topics in the unit

Topic 4: Wave reflection, refraction, interaction, interference and diffraction

Learn about	Key inquiry Questions
Learners should revisit prior learning about wave motion and sound and develop their understanding to explain the superposition of waves, wave interactions, wave-fronts, refraction of waves both in plane and curved boundaries, diffraction of waves through wide and narrow openings and diffraction gratings, and interference of waves to produce constructive and destructive interferences. They should describe and derive mathematical formulae for superposition of waves and standing waves in a string fixed at both ends, air columns, rods and plates, beats and wave polarization. Learners should design and carry out investigations to demonstrate interference produced by water waves, diffraction of waves through wide and narrow slits, the relation between angle of diffraction and wavelength, and the formation of spectrum by diffraction grating.	Why is it easier to see waves in a still water than in running water? Why are waves important? Why do floating objects on surface of water move up and down as the wave propagate through?

Learning Outcomes

Knowledge and Understanding	Skills	Attitudes
Use understanding of waves to explain wave interaction, interference and diffraction	• Design investigations on wave interference, diffraction, and standing waves • Predict what might happen • Identify and control variables • Extract information about wave parameters from graphs	Appreciate the importance of waves

Contribution to student competencies

- **Critical thinking:** This competence is enhanced in learners as they do activities on analyzing various properties of waves and solve problems in the given exercises.
- **Communication and Cooperation:** This unit enhances learner's communication skills though active participation in group discussions. This makes learners to improve their speaking and writing skills. It also enhances unity among learners as they collaboratively solve problems. This builds in them a foundation for working together even in national building.
- **Culture and identity:** The unit uses locally available materials like strings, pipes drums and stringed instruments. These items are part and parcel of South Sudan Culture hence by so doing; the unit makes the learners appreciate their culture.

Links to other subjects

- **Mathematics:** The learners will apply mathematical skills to work out some quantities of waves like frequency and the harmonics.
- **Geography:** The knowledge of waves acquired in this will help the learners understand the means of communication as studied in geography

Cross cutting issues addressed in this unit

- **Life skills:** This unit highlights some dangers associated with some wave phenomena e.g. the tendency of objects like bridges to break up if it vibrates in resonance with the rhythm of the steps of the pedestrians walking on it. This cautions the learner's as they use such bridges.
- **Environment and sustainability:** Different types of waves including light, water and sound waves are part and parcel of our environment. This unit sensitizes the leaners on to how some of these waves, as produced by man, can be a nuisance in our environment. For example, unnecessary noise pollutes the environment hence should be avoided.

Attention to special education needs

Accommodate those learners with varied special needs during teaching as guided in the introductory section of this teacher's guide.

Topic 4 Wave reflection, refraction, interaction, interference and diffraction

(Student's book page 80-122)

Background information and/or prior knowledge

In their daily lives, learner's observe or experience the properties of waves e.g. reflection, refraction and diffraction of light, water and sound waves. This unit will help them understand the science behind these behaviors of waves. Therefore, approach the teaching of the concepts in this unit from the known to the unknown.

The prior knowledge that will help the learners in studying this unit include the behavior of light on straight and curved surfaces (studied in Secondary 1 and 2) and the characteristics of waves as covered in secondary 2. Pose some probing questions to learners to help them remember the basic concept studied under those topics including basic terms e.g. incident ray, reflected ray, refracted ray, angle of incidence, angle of reflection, angle of refraction, laws of reflection and refraction.

Subtopics

No	Subtopic
4.1	The ripple tank and wave fronts
4.2	Reflection of waves
4.3	Refraction of waves
4.4	Diffracting of waves
4.5	Interference of waves
4.6	Principle of superposition
4.7	Resonance
4.8	Beats

Suggested teaching and learning activities

4.1 The ripple tank, pulses and wave fronts

Specific learning outcome

By the end of this section, the learners should be able to use a ripple tank to analyze waves.

Teaching guidelines for activity 4.1

- The purpose of this activity is to familiarize the learners with the ripple tank, as they will use it in a number of activities in this unit. Note that in the absence of a ripple tank, you can improvise one by digging a rectangular hole on the ground and filling it with water or using a large rectangular plastic basin.
- Let the learners perform this activity as whole class or taking turns in groups. Let them produce some waves on the water by switching on the point vibrator (for ripple tank) or dropping a small stone into the water in the basin. Let them observe and draw the wave fronts. Let them explain how the energy of the wave is propagated by the circular wave fronts produced. Let them label the crests, troughs and wavelength.
- Ask the learners to repeat the activity by producing straight wave front using a straight vibrator in the ripple tank or a piece of wood in the basin. Let them observe and draw the wavefronts. Let them explain how the energy of the wave is propagated by the straight wave fronts produced. Ask them to label the crests, troughs and wavelength.
- Give the learners a chance to discuss their experiences with the water waves in their day-to-day experiences.
- Cement their understanding of wavefronts by quickly taking them through the discussion in the student's book on pages 81 to 82.

Assessment

Observation

Observe the learners as they do the activity. Is every learner actively participating during the activity?

Conversation

Listen to the learners as they describe the wave fronts and energy propagation by the circular and straight wavefronts. Does their conversation depict an understanding of wave propagation?

Product

Observe the wavefronts drawn by the learners. Can they correctly identify crests, troughs and wavelength?

Properties of waves

Specific learning outcomes

By the end of this section, the learners should be able to:

(i) State and explain the properties of waves: reflection, refraction, interaction, interference and diffraction of waves.

(ii) Solve problems involving properties of waves.

4.2 Reflection of waves

Specific learning outcome

By the end of this section, the learners should be able to describe and explain reflection.

Teaching guidelines for activity 4.2

- Organise learners to design and carry out this activity as a whole class or taking turns in groups, using ripple tank or large basin of water or an small pool of water. Your role in this activity is just facilitation.
- Clearly communicate the objective of the activity to the learners i.e. to investigate the reflection of water waves on a straight barrier.
- Let them also know the deliverables from the investigation as mentioned in the activity i.e. a diagram depicting reflection of the waves and an explanation on the diagram
- Ask them to write down a brief procedure for the activity, carry out the activity, record their observations and present their findings to the class.
- After the activity, let them validate their results against the discussion given below the activity in the student's book on page 83.

Teaching guidelines for activity 4.3

- Organise learners to carry out this activity as a whole class or taking turns in groups using a ripple tank or large basin of water or a small pool of water.
- Let them do the activity and represent the reflection of the waves using sketch diagrams showing incident and reflected wavefronts for both convex and concave barriers. Ask them to do activity 4.3 and record their observation.

- Prompt them to write down and explain their observations, giving a clear account for the shape of the reflected wavefronts in each case.
- Prompt them to describe what would be observed if light waves are directed onto concave and convex reflectors. Let them explain how this behavior of light is applied in the design of headlights and a torch.
- Ask them to describe other applications of reflection of waves.
- After the activity, let them validate their results against the discussion given and the diagrams below the activity in the student's book page 84 to 85.

Assessment

Observation

Observe the learners as they do the activity. Is every learner actively participating in the activity? Are they facing any challenges that need your intervention?

Conversation

Listen to the learners as they describe the reflection of waves on straight and curved surfaces. Can they correctly describe and explain the shape and direction of reflected wavefronts?

Product

Look at the wave diagrams drawn by the learners. Do they correctly show the shape and direction of incident and reflected wavefronts?

4.3 Refraction of waves

Specific learning outcome

By the end of this section, the learners should be able to describe and explain refraction of waves.

Teaching guidelines for activity 4.4

- Let the learners carry out this activity as a whole class or taking turns in groups using ripple tank or large basin of water or a small pool of water.
- The aim of the activity is to investigate the refraction of waves. In particular, they are to observe and explain the change in the speed of water waves as they move from deep to shallow region.

- Note that for there to be clearly observable difference in the wavelengths of the waves in the two regions, the difference in the depths of the two must be reasonably wide. So the learners can place a number of glass plates onto one another to continually reduce the depth of the shallow region to till they can observe a difference in the wavelengths of the waves.
- Let them write down their observations and draw a diagram showing the incident and refracted waves in the deep and shallow regions respectively.
- Prompt them to explain the difference in the wavelengths of the waves. Let them explain why the speed of the waves is different in the two regions.

Teaching guidelines for activity 4.5

- The aim of the activity is to investigate and explain the change in the direction of water waves due to refraction.
- Let learners carry out this activity as a whole class or taking turns in groups by repeating Activity 4.4 but put the glass plates at an angle.
- Ask them to write down their observations and draw a diagram showing the incident and refracted waves, the angles of incidence and refraction in the deep and shallow regions respectively.
- Prompt them to explain the change in the direction of the wavefronts as they move from the deep to the shallow region. Ask them to explain why a spoon appears bent when dipped into a glass of water at an angle to the surface.
- Ask the learners to describe some applications of refractions of waves.
- After doing the activity, briefly take the learners through the discussion given below the activity on page 86 to 87 to help them validate their results and cement the learning from the activity.

Assessment

Observation

Observe the learners as they do the activity. Is every learner actively participating in the activity?

Conversation

Listen to the explanations given by the learners. Can they correctly account for the change in shape (shorter wavelength in shallow region in both activities) direction of the waves as they move from the deep to shallow region (bending away from the normal in Activity 4.5) i.e. caused by change in the speed of the waves?

Product

Look at the wave diagrams drawn by the learners. Based on the diagram drawn, did the leaners correctly observe that waves changed in wavelength and direction as they moved from the deep to shallow region?

4.4 Diffraction of waves

Specific learning outcome

By the end of this section, the learners should be able to describe and explain diffraction of waves.

Teaching guidelines for Activity 4.6

- Let the learners do this activity as a whole class activity.
- Ask them to write down their observations and draw a diagram showing the waves and after passing through the gap.
- Prompt them to explain the slight change in shape of the waves after passing through the gap.
- Ask them to predict what would happen to shape of the waves emerging from the gap if the slit is narrowed.

Teaching guidelines for Activity 4.7

- The aim of the activity is to investigate the diffraction of waves trough a narrow slit.
- Let them do the activity by repeating Activity 4.6 using a narrow slit.
- Ask them to write down their observations and draw a diagram showing the waves, before and after passing through the slit.
- Ask them to compare the spreading of the waves after passing through the wide slit (in Activity 4.6) and narrow slit in this activity. Ask them to predict what would happen to shape of the waves emerging from the gap if the gap is narrowed.
- Prompt them to sketch a diagram showing how waves are diffracted at the edge of an obstacle.
- Let them describe some applications of diffraction of waves in real life.
- Briefly take them through the discussion given on pages 88 to 90 in the learner's book on diffraction grating as discussed to cement their understanding.

Assessment

Observation

Observe the learners as they do the activity. Is every learner actively participating in the activity?

Did they observe the difference in the extent of spreading out of the waves in the two activities (more diffraction through the narrow slit)?

Conversation

Listen to their explanations. Can they correctly account for the change in shape (spreading out of the waves) in both activities?

Product

Look at the wave diagrams drawn by the learners. Based on the diagram drawn, did the leaners correctly show the diffraction of the waves?

4.5 Interference of waves

Teaching guidelines for activity 4.8

- Before doing the activity, prompt the learners to predict what would happen when two crest or troughs meet in phase, if a trough and crest interact.
- For them to observe interference of the waves clearly, they should drop the marbles into the water at points that relatively far apart. Otherwise, the interference may be too fast to observe.
- Prompt them to explain what happens when two troughs or two crests meet in phase and when a crest and trough overlaps.
- Guide them through an overview of constructive and destructive interference and the principle of superposition, as discussed in the student's book on pages 91 to 92.
- Ask them to do Exercise 4.1.

Assessment

Observation

Observe the learners as they do the activity. Is every learner actively participating in the activity?

Conversation

Listen to the learners as they explain their observations. Are they able to explain constructive and destructive interference?

4.6 The dual nature of light

Specific learning outcome

By the end of this section, the learners should be able to describe nature of light.

Teaching guidelines for Activity 4.9

- First prompt the learners to say what light is. Then prompt them to say with reasons whether light is a particle or wave.
- Discuss with learners the theories on the dual nature of light i.e the theories describing light as a wave and those describing it as a wave. Help them to understand the strengths and the shortcomings of each theory.

4. 7 Stationary waves on a vibrating string

Specific learning outcome

By the end of this section, the learners should be able to analyse stationary waves on a string and solve related problems.

Teaching guidelines for Activity 4.9

- The aim of the activity is to produce stationary waves on a string and describe them. The learners can do the activity in pairs or individually depending on the availability of rubber bands.
- Ask them insert and stretch the rubber band between the thumb and first finger then pluck it. Let them observe and sketch the wave produced.
- Ask them to identify points where amplitude is zero (nodes) and where it is maximum (antinodes). Let them label those points on the diagram.
- Ask them to explain how the nodes and antinodes are formed.
- Briefly guide them through the description of stationary waves as discussed below the activity in the student's book on page 96.

Teaching guidelines for Activity 4.10

- Before doing the activity, ask the learners to predict how frequency of vibration would vary if the length of the string is increased.
- In the absence of a sonometer, the learners can improvise one by fixing nails on a piece of wood and varying the length of the string by changing the position of one nail while striving to maintain the tension in the string.
- Ensure they obtain and record the values of frequency *(f)* and corresponding values of length *(L)* and plot a graph of f against $\frac{1}{L}$ if they used a sonometer. Incase they used the improvisation described above, they cannot determine the values of frequency hence ask them to sketch the graph of f against $\frac{1}{L}$ based on their observations in the activity.
- Ask them to deduce the relationship between f and $\frac{1}{L}$ from the graph.
- Briefly guide them through the discussion below the activity and Example 4.2 in the student's book on page 99.

Teaching guidelines for Activity 4.11

- Before doing the activity, ask the learners to predict how frequency of vibration would vary when the tension in the string is increased and then allow them to proceed to do the activity.
- In the absence of a sonometer, let them use the improvisation described in activity 4.10 but use a fixed length of the string and vary the number of slotted masses W to vary the tension in the string.
- Let them obtain and record the values of frequency *(f)* and corresponding values of the total weight *(W)* of the slotted mass suspended on the string. Let them calculate the values of $\sqrt{W}$ and plot a graph of f against $\sqrt{W}$ if they used a sonometer. Incase they used the improvised sonometer, they cannot determine the values of frequency hence ask them to sketch the graph of f against $\sqrt{W}$ based on their observations in the activity.
- Taking $W = T$ (tension in the string), ask them to deduce the relationship between f against $\sqrt{T}$ from the graph.
- Briefly guide them through the discussion given after the activity and Example 4.3 in the student's book on page 99. Briefly guide them through the discussion on the variation of the frequency *(f)* with the mass *(m)* of the string as outlined in the student's book on page 100.

Teaching guidelines for Activity 4.12

- Ask the learners to predict how frequency of vibration would vary when the tension in the string is increased.
- Let the learners carry out the activity following the instructions given in the student's book. They should use strings of different thicknesses (radius r)n but maintain the tension and the length of the string constant.
- Guide them to obtain and record the values of frequency *(f)* and corresponding values of the thickness of the string *(d)*. Let them calculate the values of $\frac{1}{d}$ and plot a graph of f against $\frac{1}{d}$.
- Ask them to deduce the relationship between f and $\frac{1}{d}$ from the graph.
- Briefly guide them through the discussion given after the activity and in the student's book on page 102 to 103. Help them deduce the combined relationship connecting f, L, T and m i.e.

$$f = \frac{1}{2L}\sqrt{\frac{T}{m}}$$

- Also guide them through the discussion on how determine the fundamental tones and overtones and resonance as discussed in the student's book on pages 103 to 107 including examples Example 4.5.
- Ask them to do Exercise 4.2.

Assessment

Observation

Observe the learners as they do activities 4.9 to 4.12. Are they following the procedures given carefully? Are they keeping the correct quantities constant and varying the others as instructed? Ensure they are recording the data.

Conversation

Ask the learners some questions and listen to them as they discuss in the groups in the process of deducing the relationship between f and the quantities T, m and L. Can they describe each relationship correctly?

Product

Look at the wave table of values and graph drawn by the learners in each of the activities 4.9 to 4.12. Do the values and graphs depict the correct relationship between the quantities under investigation?

4.8 Vibrating air columns

Specific learning outcome

By the end of this section, the learner should be able to analyse stationary waves produced by vibrating air columns and solve related problems.

Teaching guidelines for Activity 4.13

- Organise the learners into groups depending on the availability of apparatus.
- Let them set the tuning fork into vibration and place it over the mouth of the inner tube. This produces a wave that is reflected back by the water surface in the inner tube producing a stationary wave. Ask them to sketch the wave produced in the tube.
- Let them gradually remove the inner tube out of the water until resonance is produced at the open end of the inner tube. An alternative way of doing this is to use a set up with water in burette clamped on a stand where one places the vibrating fork on the open end and pours out the water from the burette gradually using the tap until resonance is produced. Prompt them to explain how the loud sound is produced.
- Let them measure the length (L) of the tube, sketch the stationary wave in the tube at this point and use it to determine the frequency of the waves produced (fundamental frequency) in terms of the length of the tube.
- Let them continue raising the tube and determine the frequencies of first, second and third overtones in the same way they determine the fundamental frequency with the help of a sketch of the stationary wave in each case.
- Guide them through the discussion on how to determine the frequencies of the harmonics as discussed in the student's book on pages 110 to 116 i.e. the production of resonance in open pipes and how to incorporate end correction of the tubes during determination of the frequencies.
- Guide them to discuss examples 4.6 and 4.7. Then ask them to do questions 1 to 4 in Exercise 4.3.

Assessment

Observation

Observe the learners as they do the activity. Are they able to produce resonance in the tube? Ensure they are recording the data.

Conversation

Listen to the learners' conversations as they discuss how to deduce the frequencies of the harmonics. Do they know how resonance is produced and the relationship between the wavelength and the length of the pipe?

Product

Look at the sketches of the stationary waves they draw and the derivations of the frequencies. Are they factually correct?

4.9 Beats

Specific learning outcome

By the end of this section, the learner should be able to explain the concept of beats, solve problems involving beats and explain its applications

Teaching guidelines for activity 4.14

- The aim of the activity is to produce beats and describe their production.
- Let the learners carry out the activity by following the instructions given in the students book. Let them explain the effect of fixing some plasticine on the frequency of the tuning fork. Let them state which of the two forks produces sound of higher frequency than the other.
- Prompt them to explain why two sounds of same frequencies cannot produce a beat with the help of a diagram.
- Briefly guide them through the discussion given after the activity and in the student's book on page 118 and 119 to illustrate the process of beat formation.
- Ask two learners to guide the class through Examples 4.8 and 4.9. Ask them to do Exercise 4.3.

Assessment

Observation

Observe the learners as they do the activity. Are they able to produce beats using the tuning forks?

Conversation

Listen to the learners' as they explain beat formation. Are they able to explain beat formation correctly?

Product

Look at the sketches illustrating beat formation as drawn by the learners. Are the diagrams correct?

Answers to numerical questions

Exercise 4.2

5. (a) 128.05 N	(b) 1862.46 Hz
6. (a) 0.334 m	(b) 802.67 Hz
7 15.91 Hz	
8. (a) 4.477 Hz	(b) 17.91 Hz

Exercise 4.3

2. (a) 0.7074 Hz	(b) 2.122 Hz
3. (a) 0.4 m	(b) 0.4 m
4. (a) 0.75 Hz	(b) 2.25 Hz

Topic Test 4

10. (a) 1.042 m	(b) 288 Hz
11. 1.412 Hz	
12. (a) 9.609 Hz	(b) 28.83 Hz
15. (a) 0.34 m	(b) 0.34 m

UNIT 4

Electric Fields and Capacitance

Topics in the unit

Topic 5: Electric field and capacitance

Learn about	**Key inquiry Questions**
Learners should revisit their understanding about electrostatic, current electricity and their applications and should investigate electric fields, electric potentials, electric flux, capacitors and capacitance. They should draw electric field lines between two like and unlike charges, define electric flux and electric flux density. Learners should know and derive formula for the Coulomb's law of electrostatics, electric potential and potential energy due to point charges and deduce the Gauss law. They should describe and derive the mathematical formula for capacitance with and without dielectrics, the energy stored in a capacitor, and electric fields between parallel plate capacitor. Learners should design and carry out investigations to demonstrate and practice the connections of capacitors in series and in parallel and find the equivalent capacitance for both series and parallel connections, understand that capacitors can be charged and discharged, and know that the different types of capacitors.	How do we relate electric force to electric potential? How can we experience that presence of electric field? Why is it advisable not to touch a person who is hit by thunder lightning?

Learning Outcomes		
Knowledge and Understanding	**Skills**	**Attitudes**
Understand electric fields, capacitance, magnetic fields and electromagnetic induction	• Design investigations on electric field to electric potential, electric field, flux density and capacitance. • Draw electric field lines between two like and unlike charges • Carry out investigations to demonstrate and practice the connections of capacitors in series and in parallel • Interpret results in terms of Coulomb's law	Appreciate the importance of electric fields

Contribution to student competencies

- **Creativity and critical thinking:** These competences are enhanced as the learners go through activities, concepts and examples that require them to think critically to work them out. This will prepare them in the use of creativity and critical thinking in solving real life problems.
- **Communication:** Speaking skills are acquired as learners discuss with one another and make presentation to the class. They improve their writing as they write reports in the activities.

Links to other subjects

- **Geography:** This unit will help learners understand the causes of thunderstorms, which they study in geography and how to stay safe through the use of lightening arresters.
- **Chemistry:** This unit will help learners to understand the forces of attraction and repulsion between charged particles as they learn the structure and bonding in chemistry.

Cross cutting issues addressed in this unit

- **Environment and sustainability:** The unit involves learning about the applications of with electrostatics such as uses of lightening arrestors. This sensitizes the learners on how lightning arrestors protect the homes and schools from the lightning which is an environmental phenomena.

- **Life skills:** Again, learning how to protect oneself from the hazards of lightening and high quantities of charge equips the leaners with a life skill they will apply for the rest of their lives to keep safe.
- **Peace and value education:** This unit has numerous activities, which are done by learners in groups. This enhances unity among the learners. During class discussions, learners respect each other's opinions. This makes them to peacefully co-exist.

Attention to special education needs

Identify the special needs in your class and address them guided by the section given the introductory section of this guide on how to address such needs.

Topic 5 Electric Fields and Capacitance

(Student's book page 124-170)

Background information and/or prior knowledge

Learners in their daily lives interact with electric fields and capacitors on circuit boards of electronic components. This topic will help them understand the physics behind the concepts.

Learners were introduced to the basic concepts of electrostatics in Secondary 1 and 2. They will apply some of those concepts especially the basic law of electrostatics to understand the concepts they will learn in this unit. They will also apply the knowledge on resistors in series and parallel learned in secondary 3 to analyse parallel and series arrangement of capacitors in a circuit.

Subtopics

No.	Subtopic
5.1	Electric field
5.2	Electric field patterns
5.3	Electric field strength
5.4	Electric field potential
5.5	Charge distribution on conductors
5.6	Capacitors and capacitance
5.7	Charging and discharging a capacitor
5.8	Combination of capacitors
5.9	Discharging action at points
5.10	Applications of electrostatics

Guidelines to suggested learning and teaching activities

5.1 Electric fields

Specific learning outcome

By the end of this section, the learner should be able to define electric fields and draw electric field patterns between charges and charged objects.

Teaching guidelines for activity 5.1

- Organise the learners to do this activity as a whole class activity due to the limitation in the materials required.
- Guide the learners to set up the apparatus as shown in Fig. 5.1 in the student's book. Let individual learners play different roles in the activity and involve as many learners as possible in the doing
- Guide them to apply a high d.c voltage from a car battery or simple d.c generator. You must guide them to observe safety to avoid electric shock from the voltage.
- Let them sprinkle the grass seeds or semolina powder on the surface of the liquid and observe what happens to them. Let them draw the pattern.
- Prompt them to explain the distribution of the seeds in the pattern and what the pattern represents.
- Briefly guide them through the discussion following the activity on pages 126 and 127.

Assessment

Conversation

Listen to the learners as they explain the pattern formed by the seeds in the activity. Can they tell that an electric field exists between the two electrodes due to the charges they carry? Can they explain it in terms of the electric field between two unlike charges?

Product

Check the electric patterns they have drawn. Do they represent the electric field between two unlike charges?

5.2 Electric field patterns

Specific learning outcome

By the end of this section, the learner should be able to draw and describe electric fields patterns between and around charged particles.

Teaching guidelines for activity 5.2

- Let the learners make use of a simple research from reference sources including their student's book to draw electric field patterns between:

    (i) A point positive charge and point negative charge.

    (ii) Two positive charges.

(iii) Two negative charges.

(iv) A positively charged point charge and a negatively charged plate.

- Prompt them to explain the pattern in terms of distribution and direction of lines of force.
- To cement the learning through from the activity quickly guide them through the electric field patterns between point charges and charged objects as discussed in the student's book on pages 128 to 130.

Assessment

Conversation

Listen to the learners as they explain the electric fields between charges. Can they explain the electric fields in terms of distribution of the field lines and the correct directions of the lines of force?

Product

Check the electric fields patterns they have drawn. Can they represent the field lines and the directions of the lines of force correctly?

5.3 Electric field strength

Specific learning outcome

By the end of this section, the learner should be able to define electric field strength, derive its formula and determine it for distance from a charge.

Teaching guidelines for activity 5.3

- Let the learners make use of a simple research from reference sources including their student's book to define electric field formula, derive its formula and state its SI Units.
- Prompt them to describe and explain how electric field strength varies with the distance from the charge to the rest of the class.
- Through a class discussion guide the learners through the discussion of electric field strength in the student's book on pages 130 to 132 including Example 5.1, to help those who may have had challenges understanding the concept from the research.

Assessment

Conversation

Listen to the learners as they define electric field strength to the class. Can they define it and state its SI units correctly?

Product

Check the student's workings for the derivation of the formula for electric field strength. Can they derive the formula correctly?

5.4 Electric potential

Specific learning outcome

By the end of this section, the learner should be able to define electric field potential, derive its formula and determine it a given condition.

Teaching guidelines for activity 5.4

- Let the learners make use of a simple research from reference sources including their student's book to define electric potential (also called electric field potential).
- Ask them to state and explain the factors that affect electric field potential. Using the relationship between these factors and electric field potential. Let them derive its formula and state its SI units.
- Through a class discussion, guide them through the discussion of electric field potential and the derivation of its formula, as given in the student's book on pages 133 to help those who may have had challenges.
- Ask two learners to guide the class through Examples 5.2 and 5.3.

Assessment

Conversation

Listen to the learners as they define electric field strength to the class. Can they define it and state its SI units correctly?

Product

Check the student's workings for the derivation of the formula for electric field potential. Can they derive the formula correctly?

5.5 Charge distribution on conductors

Specific learning outcome

By the end of this section, the learner should be able to describe distribution of charges on conductors.

Teaching guidelines for activities 5.5, 5.6 and 5.7

- Before doing this activity, introduce the proof plane and its working to the learners as they will use it in the activity and in the others in this section.
- The learners may do this activity as group or whole class activity depending on the availability of apparatus.
- Let them place the hollow metal sphere on an insulated stand. Guide them in charging it. Ensure they hold it with an insulator so that it is not discharged through earthing.
- Let them use the proof plane to touch the inside of the sphere and its outer surface then place the proof plane on the cap of an uncharged electroscope. Let them explain the observation they make in each case. Let them compare the two cases and draw a conclusion on how charge is distributed on a spherical conductor.
- Ask them to repeat the procedure but now with a pear shaped conductor (activity 5.7). Let them place the proof plane pointed point and at the points in the non-pointed surfaces and compare the charge distribution. Ask them to draw a conclusion on the distribution of charge on pear shaped objects.
- Give them an opportunity to present their results to the rest of the class.
- Guide them through the discussion given in the student's book after each activity to cement the learning. Guide them through the definition of the terms surface charge density, electric flux and electric flux density as discussed in the student's book on pages 136 to 138.

Assessment

Observation

Observe the learners as they do the activities. Can they test the distribution in the right way?

Conversation

Listen to the learners as they present their findings and conclusions. Can they describe how charge is distributed on a:

- hollow conductor? (Charge resides on the outer surface).

- surface of a sphere? (Charge is evenly distributed on the surface).
- pear shaped object? (Charge is concentrated at the sharp pointed end).

5.6 Capacitors and capacitance

Specific learning outcome

By the end of this section, the learner should be able to explain, describe and identify capacitors and define capacitance.

Teaching guidelines for activity 5.8

- Provide the learners with motherboards of radios, television or any other that contains capacitors. You can open the back cover of an operational radio to reveal the other motherboard for the students to observe. Let them observe safety as they handle the motherboards to avoid being hurt by any sharp pointed protrusions.
- Ask them to identify capacitors on the motherboard(s) and show their classmates. Ask them to sketch the capacitors.
- Let them explain the purpose of capacitors in circuits. Prompt them to describe how they are connected in a circuit i.e. do they have polarity.
- Prompt them to do a quick research from reference books including this textbook on the meaning of the term capacitance and its SI units.
- Guide them through discussion given after the activity on pages 141 to 142 including examples 5.4 to 5.6 to help them understand the concept of capacitance.

Assessment

Observation

Observe the learners as they handle the motherbaords. Can they identify capacitors on the motherboards? Can they state the purpose of capacitors in circuits?

Conversation

Listen to the learners conversations as they discuss the parts of the motherboard. Can they identify capacitors on the motherboards? Can they state the purpose of capacitors in circuits?

Product

Look at the sketches drawn by the learners. Are they true diagrammatical representation of the capacitors on the motherboards?

5.7 Charging and discharging a capacitor

Charging a capacitor

Specific learning outcome

By the end of this section, the learner should be able to charge a capacitor.

Teaching guidelines for activity 5.9

- Guide the learners to connect the charging circuit as shown in Fig 5.21 in the student's book.
- Let them carry out step 2 of the activity taking readings at regular intervals and complete table 5.1 and draw a graph of volts against time.
- Prompt them to explain the charging process in terms of charge gain in the capacitor with time. Let them identify the point of maximum charge of the capacitor from the graph.
- Guide them through the discussion given after the activity on pages 143 to 144 in the student's book.

Assessment

Conversation

Listen to the learners conversations. Can they accurately describe the charging process?

Product

Look at the graphs drawn by the learners. Do the graphs show the learners took the correct values? Are the graphs smooth exponential curves?

Discharging a capacitor

Specific learning outcome

By the end of this section, the learner should be able to charge a capacitor.

Teaching guidelines for activity 5.10

- Guide the learners to connect the charging circuit as shown in Fig 5.23 in the student's book.
- Let them carry out steps 2 and 3. Let them ensure that when the micro-ammeter reading decreases to zero, they open switch S_1 and carefully without touching the terminals of the capacitor close switch S_2 and simultaneously start a stopwatch. Let

them take readings at regular intervals and complete table 5.1 and draw a graph of volts against time

- Prompt them to explain the discharging process in terms of charge gain in the capacitor with time.
- Guide them through discussion given after the activity on pages 145 to 146.

Assessment

Conversation

Listen to the learner's conversations. Can they accurately describe the discharging process?

Product

Look at the graphs drawn by the learners. Do the graphs show the learners took the correct values? Are the graphs smooth exponential decay curves?

Factors affecting the capacitance of a capacitor

Specific learning outcome

By the end of this section, the learner should be able to explain the factors affecting the capacitance of a capacitor.

Teaching guidelines for activity 5.11

- Ask the learners to conduct a research from reference sources on the factors that affect the capacitance of the parallel plate capacitor. They should identify the factors and how each of them affects the capacitance.
- Prompt them to derive the expression for the capacitance based on the relationships between the factors and capacitance which they have established from the research.
- Let them make a presentation to the rest of the class.
- Guide them through discussion given after the activity on pages 146 to 149 to help those who may have had challenges coming up with expression for capacitance.
- Let two learners guide the class through Examples 5.7 and 5.8.

Assessment

Conversation

Listen to the learner's presentations. Can they state the factors and explain how the affect capacitance accurately?

Product

Look at the students written derivation of the expression for capacitance. Are the facts and steps followed logical? Is the final expression correct?

Types of capacitors

Specific learning outcome

By the end of this section, the learner should be able to describe different types of capacitors.

Teaching guidelines for activity 5.12

- Ask the learners to conduct a research from reference sources on the different types of capacitors, their shapes and uses.
- Ask them to sketch them.
- Let them make a brief presentation to the rest of the class.
- Guide them through the discussion given after the activity on pages 149 to 151 in the student's book.

Conversation

Listen to the learners presentations. Can they describe different types of capacitors and their uses accurately?

5.8 Combination of capacitors

Specific learning outcome

By the end of this section, the learner should be able to set up circuits with a number of capacitors in series and also in parallel and determine their effective capacitance.

Teaching guidelines for activity 5.13

- This activity should be done as a student planned/driven investigation with you as a facilitator.
- Ensure the students have the materials they need for the activity based on the number of groups as guided by the available materials.
- Allow them to refer to the textbook or any other reference materials when discussing the derivation of the effective capacitance for capacitors in series and also in parallel.
- Ask them probing questions as they derive the equations to ensure they come up with the correct equations, otherwise they will not be able to do step 2.

- As they do step 2 i.e. setting up circuits with the given effective capacitance, check their circuits and ask them guiding questions to help them get it right.
- Through a class discussion guide them through a summary of the derivation of the expressions for effective capacitance from parallel and series combination of capacitors guided by the discussion in the student's book on pages 151 to 153.
- Pick various learners to guide the class through Examples 5.9 to 5.12.
- Ask them to do Exercise 5.1 as a take away assignment.

Assessment

Observation

Observe the learners as they set up the circuits. Are they observing safety measures? Can they connect capacitors in series and in parallel correctly?

Product

Look at the circuits set up by learners. Are the circuits logically set? Can they give the desired values of effective capacitance?

5.9 Discharging action at points

Specific learning outcome

By the end of this section, the learner should be able to explain discharging action at points.

Teaching guidelines for activity 5.14

- Organize the learners into groups depending on the availability of an electroscope. If need be this activity can be conducted as a whole class activity.
- Let them carry out the activity following the steps given as you observe to guide them.
- Prompt them to explain why the leaf of the electroscope collapsed when the charged optical pin was placed on the cap yet no earthing was done. Let them explain what would have been observed if instead an uncharged metal sphere was placed on the leaf of the charged electroscope.
- Guide them through discussion given after the activity on pages 158 to 159. To help them cement their understanding of discharge action at points.

Assessment

Conversation

Listen to the learner's conversations. Can they factually describe discharge action at points?

5.10 Applications of electrostatics

Specific learning outcome

By the end of this section, the learners should be able to explain various applications of electrostatics.

Teaching guidelines for activity 5.15

- Ask the learners to conduct a research from reference sources on the how various concepts on electrostatics are applied in electrophotography, defibrillators, photocopy, electrostatic precipitator and lighting arresters.
- Prompt them to identify and explain other applications apart from the ones listed above.
- Let them make a presentation to the rest of the class.
- Guide them through discussion given after the activity on pages 160 to 165 to cement the learning.
- Let them do Exercise 5.2 in class and topic test 5 as a take away assignment.

Answers to numerical questions

Exercise 5.1

4. 5 μF
9. (a) 6 μF (b) 25 μF
10. (i) 4 μF (ii) 24 μC
    (ii) 4V and 2V across 6 μF and 12 μF capacitor
11. (a) 4.5 μF , 13.5 μF
    (b) 54 μC, 108 μC

Topic test 5

4. (b) 1 600 C
6. 4.5 V
9. Charges: 3.75 μC in 15 μF capacitor
   2.50 μC in 2μF capacitor
   1.25 μC in 1 μF capacitor

UNIT 5

Magnetic field and electromagnetic induction

Topics in the unit

Topic 6: Magnetic effect on electric current

Topic 7: Electromagnetic induction

Topic 8: Electric power transmission and house installation

Learn about	Key inquiry Questions
Learners should revisit prior learning about magnets and current electricity and carry out investigations to develop their understanding about magnetic fields and properties of magnetic field, magnetic force on a current-carrying conductor, and motion of a charged particle in magnetic field. They should apply the Biot-Savart law of magnetic fields, and understand magnetic force between two parallel conductors, single loop, solenoids, and magnetic flux, and derive mathematical formulae for them. They should know Faraday and Lenz's law of electromagnetic induction and their applications in electric motors and generators and in determining the direction of induced electromotive force, and induced current using the Fleming's left and right hand rules. Students should carry out practical investigations on generators and transformers, and magnetic field and magnetic induction, and apply their learning to the supply of electricity to house-holds, generators, and the use of electricity in moving objects.	How does Lenz's law relate to conservation of energy? Why does a current carrying conductor generate fields around it? How does an emf induce in a moving wire that cuts magnetic field? Why transformers are important in the transmissions of electricity?

Learning outcomes		
Knowledge and Understanding	**Skills**	**Attitudes**
Understand magnetic fields and electromagnetic induction.	Design and carry out investigations on electromagnetic induction, induced current mutual induction. Apply the Biot-Savart law of magnetic fields. Carry out practical investigations on generators, transformers, and magnetic field and magnetic induction. Interpret results in terms of laws of electromagnetic induction.	Appreciate the need to conserve energy.

Contribution to student competencies

- **Creativity and critical thinking:** These competences are enhanced as the learners go through activities, concepts and examples that require them to think critically to be able to solve them.

  Examples are developed in such a way that after working them out, learners can use the knowledge to solve some of the problems they face in the society.
- **Communication:** The unit has numerous activities that through discussion enhance communication skills. As learners discuss, their listening, speaking and writing skills improve. Learners can interpret and comprehend what other person is communicating.
- **Cooperation:** This unit encourages learners to collaboratively work together in groups. This improves cooperation when they are dealing with an issue. Learners will realize that doing some tasks in a group make them less tasking.
- **Culture and identity:** This unit has activities that have made use of locally available materials like the living human hand, screw, and magnets. This makes it possible for learners to comprehend concepts well.

Cross-cutting issues addressed in this unit

- **Life skills:** This topic has many activities that require learners to work together. This encourages interpersonal relationships among learners. This will make them know that they need each other in life in one way or the other in solving problems facing them.

- **Peace and values education:** Activities in this unit are developed in such a way that learners work in groups and discuss their results in groups. As they work, they have to respect other people's views. This leads to a peaceful coexistence among learners. The groups are made up of learners of different abilities to encourage each other improve.

Attention to special education needs

- Encourage quick learners to help the slow learners in understanding of concepts.
- Plan remedial teaching for slow learners and gifted learners be given more task that require more of critical thinking.
- Accommodate those learners with varied special needs during teaching and grouping them.
- Provide large print for learners who have visual impairment

Topic 6 Magnetic Effect of an Electric Current

(Student's book page 172-190)

Background information and/or prior knowledge

Learners in their day-to-day lives interact with magnetic effect of electric current. This unit will explain the working of loudspeakers and electric motors.

Subtopics

No.	Subtopic
6.1	Magnetic field due to a straight current carrying conductor
6.2	Magnetic field due to a current carrying solenoid
6.3	Magnetic field around a current carrying circular coil
6.4	Charged particle in a magnetic field
6.5	Biot-Savart's law of magnetic field
6.6	Force on a current -carrying conductor in a magnetic field
6.7	Application of the electric motor effect

Guidelines to suggested learning and teaching activities

6.1 Magnetic field due to straight current-carrying conductor

Specific learning outcome

By the end of this section, the learner should be able to understand magnetic fields due to a straight current carrying conductor.

Teaching guidelines for activities 6.1

- Ask the learners to set up the apparatus as shown in the learner's book. Ensure that they clamp the cardboard well so that it does not fall or slant during the activity.
- Let them sprinkle the iron filings on the cardboard and switch on the source of current. Ensure they tap the card gently as they observe the pattern of the iron filings. Are they able to draw the pattern taken by the iron filings?
- Now let them use plotting compasses in place of iron filings. In what direction do the compasses face? How can they explain this observation?

Assessment

Conversation

- Watch learners as they are doing the activity. Are they able to observe the way iron filings align after current is passed through the wire? Ask learners to explain why the iron filings align in circular way in the above activity.
- Are the learners able to explain what happens when they reverse the terminals of the source of current? How well are they explaining this observation?

6.2 Magnetic field due to a current-carrying solenoid

Specific learning outcome

By the end of this section, the learner should be able to understand magnetic fields due to current carrying solenoid.

Teaching Guidelines for activity 6.2

- The space in between the solenoid should be enough for the learners to make the observation as they do the activity.
- After they have done the activity give them an opportunity to discuss as a class the magnetic field pattern of current-carrying solenoid. How well can they explain the pattern? Are they able to explain what happens when they reverse the current?
- Are they able to note that when the amount of current is increased the strength of the magnetic field also increases?

Assessment

Observation

Watch learners as they are doing the activities. Are they able to observe the way iron filings align after current is passed through the solenoid, coil?

6.3 Magnetic field around a current-carrying circular coil

Specific learning outcome

By the end of this section, the learner should be able to understand and explain the magnetic fields around a current-carrying circular coil.

Teaching guidelines for activity 6.3

- Let the learners set the apparatus as shown in the learner's book.
- Ensure they sprinkle the iron filings on the cardboard and tap it. Let them draw the patterns the iron filings make. Are they able to draw the right diagrams?

Assessment

Conversation

Copy examples

Product

Check the drawings the learners have made. Have they drawn the correct drawings? How well have they represented the drawings? Do the drawings show a concentration at the center?

6.5 Biot-savart's law of magnetic field

Specific learning outcome

By the end of this section, the learner should be able to explain, derive and solve problems involving Biot-savart's law of magnetic field.

Teaching guidelines for activity 6.4

- Pair up learners and allow them to research about what will happen to a charged particle in a magnetic field. Are they able to use their research skills to get the right explanation?
- Let them discuss their findings in pairs, then one of them to present the findings to the class.
- Ask them to use a diagram to show the motion of a charged body. Does the diagram they have drawn show a good understanding of what they are discussing?
- Learners through class discussion should know that a charged particle move in a magnetic field it experiences a force which makes the particle to deflect almost in circular motion. Help them to derive the relationship.
- Let them do example 6.1 and 6.2 after deriving Biot-savart's law.

Assessment

Product

Check learners' participations in research. Ask learners questions about the law. Let them solve as many problems as they can. Ask learners to do exercise 6.1. Check and mark their work. Use it to gauge how much the learners have understood.

6.6 Force on a current-carrying conductor in a magnetic field (motor effect)

Specific learning outcomes

By the end of this section, the learner should be able to describe, explain and solve problem-involving force on a current-carrying conductor in a magnetic field.

Teaching guidelines for activity 6.5

- Give the learners an opportunity to carry out the activity in their groups. Ensure that the magnets they use are of verifying strength so that they can note the difference.
- Allow them to discuss in groups about their observations from the experiment of motor effect. Do the effects they give show that they understand the concepts?
- Ask them: what happens when current flows through a conductor in a magnetic field?
- Can they state Fleming's left hand rule correctly?

Assessments

Conversation

Are learners able to see what happens to a conductor when current flows through it? Why?

Are learners able to explain how the conductor gets deflected? In a class discussion involve them in question answer methodology.

6.7 Applications of the motor effect

Specific learning outcome

By the end of this section, the learner should be able to explain applications of motor effect.

Teaching guidelines for activity 6.6

- Provide a simple d.c electric motor and the moving coil loudspeaker to learners to observe. Ensure learners note down their observations after observing a motor and moving coil loudspeaker.
- Pair up learners and let them research on the simple d.c electric motor and the moving coil loudspeaker.
- Let them discuss the research findings.
- Now, ask them to research on how a moving coil loud speakerworks. Are they able to explain how the motor works?

Assessment

Conversation

- Ensure learners note down the observations after observing a motor and moving coil loudspeaker.
- Listen to the learners as they are doing the class discussion. Are they able to describe the working of the simple d.c electric motor. The learner should also explain the working of the moving coil loudspeakers.

Product

- Ask them to do Exercise 6.2 in groups. Advice them to do a constructive discussion. Ensure that each learner in the group is participating. Through this discussions the learners will improve their communication skills.

Answers to numerical questions

Exercise 6.1

3. 12×10^{-7} T
4. 4.189×10^{-4} T

Unit Test 6

6. 2×10^{-7} T

Topic 7 Electromagnetic Induction

(Student's book page 191-226)

Background information and/or prior knowledge

Learners have interacted with electromagnetic waves and how waves behave in both electric and magnetic fields. This topic will help the learner understand electromagnetic induction, its applications in transformers etc.

In topic 6 the learners learned about the direction of a magnetic field. This knowledge is very useful in this topic, as it will help us determine the direction of the induced current, thus it is important to remind the learners what they learned.

Subtopics

No.	Topics
7.1	Demonstrations of electromagnetic induction
7.2	Factors affecting magnitude of induced e mf.
7.3	Laws of electromagnetic induction
7.4	Transformers
7.5	Other applications of electromagnetic induction

Guidelines to suggested learning and teaching activities

7.1 Demonstrations of electromagnetic induction

Specific learning outcomes

By the end of this section, the learner should be able to explain magnetic fields, electromagnetic induction and describe the magnitude of induced e.m.f in a magnetic field.

Teaching guidelines for activity 7.1

- Provide the learners with a U shaped magnet to use in this activity. Let the learners place a conductor in between the poles of a magnet and observe the galvanometer reading when the wire is stationary. Is their any deflection in the galvanometer? Can they explain why the galvanometer deflects?

- Remind them to be very keen and note the direction in which the galvanometer deflects.
- Ensure they pull the conductor horizontally away from the poles and stop. Can they explain why there was a deflection on the galvanometer? Do they note the same observation when they pull the wire in opposite direction?
- How do they explain the observation they make when they move the wire vertically?

Teaching guidelines for activities 7.2

- Let the learners make a coil using an insulated copper wire. Ensure that the coils the learners make are as close as possible. Remind them that they should ensure that the hollow space in the coils they make can allow a magnet to pass through.
- Ensure that they connect the ends of the coil to a sensitive center zero galvanometer. Let them connect the wire
- Now let them introduce a bar magnet into the coil. Can they note that the galvanometer pointer deflects to one side? Can they explain why the pointer stops and moves to the zero mark when the bar magnet stops moving?
- What can they note that happens to the galvanometer pointer as they withdraw the magnet from the coil?
- Do they make the same observation when the magnet and the coil are moved to one direction?

Teaching guidelines for activity 7.3

- Let the learners make two coils using an insulated copper wire. Let them connect the ends of one of the coils to a sensitive center zero galvanometer. The ends of the other coil should be connected to a source of current.
- Ensure that they bring the two coils as close to each other as possible. Do the learners note that when the switch is closed the galvanometer pointer deflects even though the two coils are not touching? Are they able to explain why this is so?
- Do they make the same observation when they close the switch?

Assessment

Conversation

Watch the students as they are working in groups. As they give the explanation for their observations, do they seem to know what they are doing? How well can they use scientific terms to explain their observations?

7.2 Factors affecting the magnitude of e.m.f induced

Specific learning outcome

By the end of this section, the learner should be able to explain the factors affecting the magnitude of e.m.f induced.

Teaching guidelines for activity 7.4

- In activity 7.1 the learners made a coil using an insulated copper wire. They investigated the effect of introducing a bar magnet into a conductor. In this activity they will investigate the factors affecting the amount of the induced current.
- Ensure that the learners use magnets with different strengths and note the difference in the deflection of the galvanometer pointer. Are they able to explain how the strength of a magnet affects the induced current?
- Let them repeat the activity but varying the speed at which the magnet approaches the coil. What happens when they introduce an iron core in the coil? Can they explain the observations they make and why this observation is made?
- Give them an opportunity to discuss the observation they make and make a summary of the results. Are they discussing constructively?

Assessment

Product

- Talk to students to see if they understand factors that affect induced e.m.f.
- Let the learners understand the factors that affect the magnitude of the induced e.m.f. Are they able to explain how area of the coil, rate of cutting the magnetic flux affect the magnitude of the e.m.f induced?

7.3 Laws of electromagnetic induction

Specific learning outcome

By the end of this section, the learner should be able to state the laws of electromagnetic induction.

Teaching guidelines for activity 7.6

- Give the learners an opportunity to research from the internet and reference books on the following laws of electromagnetic induction:

  (a) Lenz's law (b) Fleming's right hand rule

  (c) Faraday's law
- Are they able to state the laws correctly?
- Let them try to apply the laws in activity 7.2 and 7.3, do the laws apply? Are they able to explain how each observation confirms the Faraday's law of electromagnetic induction?

Assessment

Observation

Observe as the learners apply the laws they have discussed to evaluate if the apply in activity 7.2 and 7.3. Are they able to apply the laws correctly? Are they able to explain the laws of electromagnetic induction after stating them?

Product

Ask the learners to discuss and solve exercise 7.1 in the learner's book. They should note down the correct answers after they discuss. Are their answers correctly stated? Guide those who may be having difficulties. You may create remedial classes to help those who may be having problems applying the laws.

7.4 Transformers

Specific learning outcome

By the end of this section, the learner should be able to explain how transformers work.

Teaching guidelines for activity 7.6

- Provide the learners with pictures of transformers let them observe them and explain how transformers work. In case the transformers from spoiled electronic gargets are available, you can provide the learners with them so they can have the practical aspect of the transformers.
- Give them an opportunity to discuss their findings. Are they able to explain how a transformer works? Are they able to identify some of the energy losses in a transformer and how they can be minimized?

Teaching guidelines for activity 7.7

- Can they be able to sate the different types of transformers and how they work?
- Now that the learners know how the transformers work, ask them to name some of the transformers that they know. Are they able to identify the different types of transformers?
- Can they state the main difference between the transformers? Are they able to explain how a transformer uses the concept of induced current?

Assessment

Conversation

Listen to the learners as they discuss. Are they doing a constructive discussion? Can they explain how the different transformers work? Can they state some of the uses of the transformers?

Teaching guidelines for activities 7.8 and 7.9

- Ask the learners to make two coils. One with more turns than the other using an insulated copper wire. Ensure that they connect to a galvanometer and the other one a source of current.
- Let them bring the two coils close to each other but not touching. As they close the switch in the coil that has the source of electricity, are they able to note that the galvanometer deflects? Remind them to be keen to note the much the galvanometer deflects.
- Ask them to interchange the galvanometer and the source of current. As they repeat the procedure are they able to note the difference in the deflection of the galvanometer?
- When is the deflection high? Can they explain what causes this difference?
- Now provide the learners with some charts that show transformer equations. Ensure that the chart is showing the formula of the efficiency.
- Give the learners an opportunity to discuss the equations and how they can be solved. Are they able to comprehend the equations? Are they able to write and solve the transformer equations? Can they be able to calculate the efficiency of the transformer?

Assessment

Conversation

- Talk to the students to probe them if they know how to calculate the efficient equations of transformer.
- Copy examples 7.1 on the board. Ask the learners to close their textbooks, choose the learners at random to solve the examples on the board as the others follow. Are the learners able to discuss the examples constructively? How well have they organised their work as they solve the examples? This helps the learners to master the concepts. It also helps them to develop good oral skills.

Product

Ask the learners to solve exercise 7.2 in their exercise books. Are they able to solve the questions correctly? How well have they organised their answers? Do their answers depict mastery of the concepts?

7.5 Other applications of electromagnetic induction

Specific learning outcome

By the end of this section, the learner should be able to describe other applications of electromagnetic induction other than transformers.

Teaching guidelines for activity 7.10

- Provide the learners with a model of an a.c generator. Ask them to explain clearly:
  - (a) The purpose of the slip rings and carbon brushes.
  - (b) How the inversion of the signal is achieved in the generation. Sketch the output signal.
  - (c) How the voltage output in an operational a.c. generator is increased.
- Are they able to use a well-labeled diagram to explain how the concept of electromagnetic induction as applied in the working of a microphone?

Assessment

Product

Ask the learners to do exercise 7.3 Check written work. Are they giving the right answers? How well have they answered the questions? Does the answers depict mastery of concepts?

Answers to numerical questions

Exercise 7.2

2. (a) 750 W (b) 12.5 A

5. (b) 400 V

6 (b) 1 440 turns

7. (a) 30 V (b) 90 %

Topic Test 7

12. (a) 6.25 V (b) 80 A

14. (a) 240V (b) 3.333 A (c) 44.44 W

15. (a) 95 000 W (b) 2.88 A (c) 7044.31W

Topic 8 Electric Power Transmission and House Hold Installation

(Student's book page 227-250)

Background information and/or prior knowledge

Learners in their daily lives comes across with transformers, electric overhead cables and transmission. This topic will help the learner to understand the transformers and the working of transformers.

The learners have learned how electric power is generated. In this topic they will learn how the electricity is transmitted from the generation point to the household or industries where it is used. They will also learn about the electric installation in the household. Use some of the instances that the learners can relate to make them have curiosity to learn this topic. Have the learners at some point come across a team that is doing electrical installation in a house? Can the learners be able to explain some of the activities that were taking place during the installation? This topic will make the learner's appreciate these activities.

Subtopics

No.	Subtopic
8.1	Electric power transmission
8.2	Household electrical installation
8.3	Household wiring
8.4	Dangers of electricity
8.5	Electrical safety

Guidelines to Learning and teaching activities

8.1 Electric power transmission

Specific learning outcomes

By the end of this section, the learner should be able to explain the electric power is transmitted.

Teaching guidelines activities 8.1 to 8.3

- Fist prompts the learners to remember if they have seen the electric cables outside. Can they remember some of the electric cables they have seen?
- Now provide the learners with a variety of cables from the local environment that are used for electric transmission.
- Let them identify and explain, in order of preference the cables that are used for electric transmission. Are the learners able to identify the cables that are most suitable for electric transmission?
- Give the learners an opportunity to explain how electricity is transmitted from the power generating station to the houses or industries where it is used. Are they able to give the correct explanation of the transmission channels?
- Now let them do research and from their research explain the power losses when electricity is being transmitted and the dangers during transmission.
- Through asking and answering questions, allow learners describe electric power transmission by overhead cables. The learner should discuss dangers of high voltage transmission. Dangers such as risk of electric shock, risk of fire, childhood leukemia, cancer and depression. Let the learners discuss the impact of power generator and transmission as a pollutant etc.

Assessment

Conversation

- Listen to the leaners as they present their findings to the class. How well are they presenting their work?
- Talk to learners to probe if they have understood the electric transmission. Can they explain the power losses during transmission? Can they state some of the ways that the power loss can be reduced?

Product

Give the learners an opportunity to discuss exercise 8.1 and indicate their answers in their books. How well can they solve the questions? Are they able to give their answers in a scientific way?

8.2 Household electrical installation

Specific learning outcomes

By the end of this section, the learner should be able to describe how electrical installation is done in households.

Teaching guidelines for Activity 8.4

- Now the learners already know how the electricity is transmitted from the power generation station to the households. Ask them to think of the person who recently build his house and wants to install electricity.
- They can also think of that new house in the school compound or in the neighborhood that requires electric installation.
- Ask them to name some of the materials that will be used during the installation of electricity in the new houses. Are the learners able to name the materials? Are they able to explain how the materials and some of the devices will be used?

Assessment

Conversion

Listen to the learners as they are explaining how the materials and devices they have named are used. Are they able to explain correctly how the materials are used? Engage them with questions to check whether they have mastered the concepts.

Teaching guidelines for Activity 8.5

- Provide the learners with a variety of electrical devices that can be found in the local environment. Are the learners able to identify the devices that you have given to them?
- Allow the learners to draw the symbols of the different devices as they are used in an electrical circuit.
- Give them an opportunity to discuss the uses of the devices they have. Are they doing a constructive discussion?

Assessment

Product

Look at the learner's books; check the drawings they have made. Have they represented the devices correctly in the circuit? How well have they used the symbols to represent the devices?

Teaching guidelines for activity 8.6

- Provide the learners with different kinds of lamps. Ask them to discuss the different structure and appearance of the lamps.
- Let them discuss the importance of energy saver lamps and how they help to save energy.
- Are the learners able to describe the different types of lamps? Can they be able to give some uses of bulbs?
- Let the learners identify importance of energy saving lamps. Are the learners able to state some of the gases that are used in the lamps?

Assessment

Conversation

Listen to the learners as they are discussing the different types of lamps. Are they able to explain the correct gases that are used in the lamps? How well can they explain how energy saving lamps help in conserving energy?

Teaching guidelines for activity 8.7

- Give the learners an opportunity to discuss what a fuse is and how it is used in an electrical circuit. Are they discussing constructively? How well can they explain how the fuses are used in a circuit? Are they able to note that fuses with different values are used in different circuits depending on the amount of current required?
- Provide the learners with fuses of different ratings. Let them record their voltage and current. Are they able to note the correct values from the fuses?
- Ask them to state the amount of current that can be allowed to pass through each fuse that they have. Are they able to note the correct current?

Assessment

Observation

As the learners are identifying the different ratings on the fuses, do they seem to know how to identify the current and voltage rating on the fuses? How well can they describe how fuses are used in a circuit? Are they able to note the correct amount of current that can be allowed to pass through a given fuse without destroying it?

Teaching guidelines for activity for 8.8

- Note that that this activity will be carried outside the class so it is necessary to prepare the learners in advance.

- It may also cause some interruption to others in the school so it is important to inform everybody in the school about the power disruption.
- You may also opt to identify a circuit breaker that only affects a small portion for instance a single room to avoid the disruption that may be caused by cutting of the electric supply as the learners carry out the activity.

Assessment

Product

Ask the learners to do exercise 8.1 in their book. After they are done let them exchange books with their neighbors. Discuss with them all the questions as they mark each others book. Are they giving the correct answers for the exercise? How well have they answered the questions?

Teaching guidelines for activity for 8.9

- Provide the learners with electric cables.
- Let the learners identify wires in the cable using their color codes. Are they able to note the wires as live, neutral and earth?
- Let them discuss functions of live, neutral and earth wires.
- Ask the learners to connect the wires on the plug. Can they do the right connection?

Assessment

Product

Check the connection the learners have made on the plug. Have they identified and connected the three wires to the right place? For those who may be having problems connecting, bring to their attention that the right place to connect the wires is indicated on the plug.

8.3 Household wiring

Specific learning outcomes

By the end of this section, the learner should be able to understand how wiring is done in households.

Teaching guidelines for activities 8.10 and 8.11

- Let learners observe wiring of some premises with electricity. Ensure they note their observations. Are they making the right notes?

- Let the learners observe and discuss the diagram on the chart showing domestic wiring. If the school has electricity let them state where each of the components in the picture is located. Are they able to give the correct location? Do the locations they are giving show that they know the components?
- Through questions and answer, help the learners identify main switch, meter box, sockets, circuit breakers
- Now that the learners have known how wiring is done, give them the opportunity to fix a faulty socket.

Assessment

Conversation

Are learners able to explain the wiring of some of the premises with electricity? Use questions, class discussion to cement learning in this area.

Product

- Are learners able to explain the wiring of premises? Ensure they draw how wires are wired in the buildings.
- Let them practice replacing faulty socket. While they are doing this ensure you take caution. Switch off electricity when they are doing that. To avoid shocks and electrocution. Have they replaced it correctly?

8.4 Dangers of electricity

Specific learning outcomes

By the end of this section, the learner should be able to understand and be aware of dangers of living under electric transmission lines and how to avoid them. That is safety.

Teaching guidelines for activity 8. 12

- Give the learners an opportunity to do research on dangers of electricity. Are they able to do a constructive research?
- Guide the learners to give some of dangers of the electricity.
- Let the learners explain some of the dangers of electricity as death, destruction of properties, harming human and animals.

Assessment

Product

Let the learners do Exercise 8.3. Mark the learners' written work. Are the learner's answering the questions correctly? Do their answers show understanding of the concepts?

Answers to numerical questions

Exercise 8.1

2. 10 J

3. (a) (i) 66 A (ii) 5 A (iii) 1 kV, 1 000V (iv) 5 kW (v) 655 kW

   (b) (i) 66 A (ii) 33 A (iii) 6.6 kV (iv) 217.8 kW (v) 442.2 kW

Exercise 8.2

4. 7A

Topic Test 8

10. 3.125 A No.

11. 25 V, 9 bulbs

12. (a) 0.125 A

    (b) Yes

    (c) 3 W

UNIT 6

Cathode Ray Tube

Topics in the unit

Topic 9: Cathode Ray Tube

Learn about	Key inquiry Questions
Learners should revisit their prior learning about electric and magnetic fields and investigate cathode rays and the structure and the function of the cathode ray tube. They should explain the working principal of cathode ray tube, describe how cathode rays are produced by the process of thermionic emission, the functions of the various components of the tube, and the importance of the fluorescence screen. They should investigate the characteristic and behaviour of the electron beams and how it can be deflected by varying magnetic field or electric field. Learners should know that the freely accelerated electron from a cathode to an anode gains kinetic energy. They should understand the use of the cathode ray oscilloscope for example as voltmeter, for measuring time intervals, displaying wave forms, measuring of phase relationships and for comparison of frequencies.	Why cathode ray tube is evacuated? Why use florescence screen in cathode ray tube? Why are cathode rays deflected by magnet?

Learning Outcomes

Knowledge and Understanding	Skills	Attitudes
Understand cathode ray and the structure and function of cathode ray tube.	Investigate the characteristic and behaviour of the electron beam and how it can be deflected by varying magnetic field or electric field.	Appreciate use of CRO

Contribution to student competencies

- **Creativity and critical thinking:** The competence will be enhanced when the learners try to analyze and answer questions. Interpreting problems, steps and results require learners to critically thinking. .
- **Communications:** Through group discussion, learners enhance their communication skills as they express themselves through speaking and writing.
- **Cooperation:** The unit has numerous activities that bring the learners together and cooperate in solving problem through discussions. During the process on discussion each is given fair share of time and this makes the learners tolerant to each other's views. They cooperate by making each member to contribute in working out the activities.
- **Culture and identity:** The topic deals with cathode rays which may not be common in schools but it is encouraged that the learners be taken to places where they are found. Some cathode rays are found in local markets.

Cross cutting issues addressed in this unit

- **Peace and value education:** The unit has made learners to work in unity during working out activities. The learners work in groups and respect other opinion during discussion of activities result. The teacher has to moderate opinions. This will help the learners to develop values like humility and respect for each other.
- **Life skills:** This topic has dealt with cathode rays and their use. The topic through activities has helped to build interpersonal relationship since they work in groups. As the secretary of the group gives the findings, leadership skills is enhanced among learners. During discussions, learners' self-esteem is enhanced.

Teaching methodology

- Group discussion
- Group work
- Questions and answers
- Class demonstrations

Attention to special education needs

- Engage quick learners to help the slow learners in understanding of concepts.
- Identify learners with special need and try to accommodate them by either relocating them or rearrange class.
- Plan remedial teaching for slow learners and gifted learners be given more tasks.

Topic 9 Cathode Ray Tube

(Student's book page 252-274)

Background information and/or prior knowledge

Learners in their day-to-day life encounter or are involved in cathode ray tube and its applications. For example, they see and watch old televisions and desktop computers with cathode ray tube. This experience will help them understand and analyse the working cathode ray tube.

In unit 4 of this book, learners were introduced to concepts of charges and electrons. Remind them that they will apply this knowledge to the cathode ray tube. Ask them probing questions to review their understanding of these concepts and guide them where necessary.

Subtopics

No.	Subtopic
9.1	Production of cathode rays
9.2	Properties of cathode rays
9.3	Cathode Ray Oscilloscope (C.R.O)

Suggested teaching and learning guidelines

9.1 Production of cathode rays

Specific learning outcomes

By the end of this section, the learner should be able to explain how cathode rays are produced.

Teaching guidelines for activity 9.1

- Help them identify the cathode and anodes on the charts.
- Let them research and discuss the production of cathode rays.
- Through question and answers,
- Ask them: how are the cathodes rays produced?
- Let them explain why the tube is evacuated i.e. has no air.

- This activity shows that charges can flow through the vacuum - as long as one terminal is heated and that this heated terminal is a cathode.
- Explain to learners how the cathode rays are produced emphasizing the *thermionic emission process.*
- It is reasonable to infer that the charges originate from the heated element (because with the heater switched off, there is no current).
- Given that charges only flow through the vacuum when the heated electrode is a cathode, it is also reasonable to infer that the charges are negative. Positive charge would not flow from a cathode to an anode, whereas negative charges will (being attracted to the positive anode).

Assessment

Observation

- Provide the cathode ray tube to learners to observe. Ensure they observe how the cathode rays are produced. Are they able to see the produced electrons on the screen?
- While they are observing and handling the CRT, remind them that the cathode ray tubes are fragile and expensive. Therefore, they should be handled with care. Use the stands specifically designed for holding them.

Conversation

- Ask the learners questions about the production of cathode rays. Involve them in a class discussion to discuss their findings.
- You can explain the results of the experiment using the idea of electrons. These tiny negative particles are free to move in the metal. As the metal is heated up, some of them 'evaporate' from the surface. They form a 'gas' of electrons above the surface of the hot plate. If the heated plate is put in a circuit and made negative with respect to another plate, the electrons are pulled through the vacuum and so a current flows between the plates. If the heated electrode is positive, the negative electrons are pulled back to the electrode's positive surface.

Product

- Mark learners' written work, reports and other findings. Use the explanations they are giving in their answers to assess how much the learners have understood.

9.2 Properties of cathode rays

Specific learning outcomes

By the end of this section, the learner should be able to explain the properties of the cathode rays.

Teaching guidelines for activity 9.2

- Guide learners to conduct a research about properties of the cathode rays. Allow them to discuss their findings in a class discussion.
- This activity is best demonstrated to the students in groups of four to five in a darkened room if full value is to be obtained.
- After class discussion, ask the questions: how can the properties be applied? Learners should be able to describe the motion of cathode ray in a magnetic field. HT (high-tension) power supplies (generally supplying voltages up to 400 V) can cause fatal electric shock.
- If the tube has been unused for some time, the cathode might not emit electrons. Carefully increase the heater voltage by about 1 V, monitoring it. Do not allow the heater current to rise much above the recommended values.
- There are sometimes problems with the shadow of the cross turning into a 'clover leaf' shape. This can be prevented by connecting the cross to the anode and turning down the high voltage supply a bit.
- If the fluorescence disappears, this may be because the cross is getting negatively charged by electrons. The fluorescence will reappear if the cross is momentarily connected to the anode.
- If you have an old cathode ray (CR) TV, it is entertaining to bring a powerful magnet near the screen or close to the tube. This will distort the picture. It is advisable not to do this with your best TV. This can cause permanent distortion of some shadow mask colour TVs. It is best to show it on a monochrome TV or old colour TV.

Assessment

Observation

- Watch learners as they doing the research. Are they able to describe some of the properties of the cathode rays?

Conversion

- Involve them in class discussion to discuss the properties of the cathode rays. Ask them questions to test their understanding. How they travel, deflected in an electric field, deflected in a magnetic field, ionize the gases, their effect on florescence materials.

Product

- Check learners' written work (their observations and findings about the properties of cathode rays).

9.3 Cathode ray oscilloscope (C.R.O) and its uses

Specific learning outcomes

By the end of this section, the learner should be able to draw cathode ray oscilloscope, name its parts, explain how it works and its uses.

Teaching guidelines for activities

- Group the learners in groups of three or four depending on the number of charts and the cathode ray oscilloscopes.
- Let them examine the parts of the oscilloscope drawn on the chart as well as the oscilloscope physically.
- Let them draw their own oscilloscope and name the parts and their functions.
- In group discussion, allow learners to discuss the X and Y plates. How they work and the deflection action.
- They discuss about the uses of the cathode ray oscilloscope.
- If you are using HT in this experiment, it is essential that all HT connectors and cables are rated at the voltage to be used. The HT connectors should be the shrouded type so that accidental contact is highly unlikely. Any meter used in the HT circuit should be a type rated for the voltage used, and with shrouded connectors.
- All HT connections should be made with the HT switched off, and no adjustments made to the HT connections or wires once the HT is switched on.
- Teachers with a good knowledge of HT electricity and the dangers should only undertake the practical work with HT supplies. Students should observe well away from the apparatus when it is being used.
- Always reduce the anode to zero volts when not actually observing the beam, because the tube has a finite lifetime.

- Also, remind the learners, that the cathode ray tubes are fragile (and expensive!) and should be handled carefully.

Assessment

Observation

- Display the oscilloscope learners to see. Are they able to identify some of the parts of the oscilloscope? Ensure they note their observations.
- It is worth hanging on to an old cathode ray (CR) TV for the demonstration. You might even be able to get hold of cheap or free CR TVs from friends, as people upgrade to LCDs and plasma TVs.

Conversation

- Assist learners to realize that cathode rays have parts like, the grid, gun, Y-plates, x-plate, the fluorescent etc. they then explain how it works and its uses. They should explain why the CRO is evacuated. The learner through questions and answers should give uses of cathode rays as used in measurement of voltage, frequency and a small time interval.
- Take them through example 9.1 and allow them to discuss examples 9.2, 9.3, 9.4 and 9.5.
- Use questions to cement the concepts.

Product

- Check what learners have drawn. Have they correctly drawn the parts of CRO?
- Ask them to do topic test 9. Mark their written work.

Answers to numerical questions

Topic Test 9

5. 6.4×10^{-16} J b) 3.75×10^{7} m/s

12. 66.6 beats/minute

UNIT 7

Radioactivity and Nuclear Energy

Topics in the unit

Topic 10: Radioactivity and Nuclear Energy

Learn about	Key inquiry Questions
Learners should investigate nuclear radiation, radioactive materials, types of nuclear radiations, such as alpha particle, beta and gamma radiations and radioactive decay, which includes alpha and beta, decay. They know about the rate of decay and half-life time and stability of the nucleus and the danger of nuclear radiation and background radiation. Learners should carry out practical investigations to detect radiation using Geiger Muller tube (GM) for detecting alpha, beta and gamma radiation and the cloud chamber to study alpha particles. They should know the uses of radioactivity such as tracers, radiotherapy, testing for cracks in metal, monitoring the thickness of material, carbon dating and dating rocks. Learners should understand about the nuclear energy and the production of nuclear energy through nuclear fission of radioactive elements like uranium, the chain reaction in nuclear fission, fission in nuclear reactor, nuclear waste, nuclear hazards and the future nuclear fusion of hydrogen-2 and hydrogen-3 to form helium-4 as alternative nuclear energy production, and consider the moral issues about nuclear energy and whether it is cheaper than other sources of energy	Why are radioactive wastes hazardous? Why is nuclear energy not common in South Sudan?

Learning Outcomes		
Knowledge and Understanding	**Skills**	**Attitudes**
Understand radioactivity and its use in providing nuclear energy Explain the detection of radioactive emission Describe the types of radiations emitted in natural radioactivity Know the uses of radioactivity.	Write balanced nuclear equations.	Consider the moral issues of nuclear energy

Contribution to student competencies

- **Critical thinking:** Developing the equation for radioactive decay, which include alpha and beta decay and determining the half-life time for some of the radioactive isotopes?
- **Communication and cooperation:** Group working conducting experiments and presentation of the results.

Links to other subjects

Biology: By use of carbonating, checking the function of body organs, chemistry by dating rocks. Environment and sustainability: the impact of nuclear energy.

Cross cutting issues addressed in this unit

- **Life skills:** This unit deals with radioactivity and nuclear reaction, their effect to the environment. Through working together in doing activities, the learners will build interpersonal relationships. As the secretary of the group gives the findings, leadership skills is enhanced among learners. The unit also educates learners on the safety measure while handling radioactive elements.
- **Environment and sustainability:** This unit highlights that nuclear energy polutes the environment less compared to other sources of energy; also give direction on how to safely dispose wastes. A warning has been given to those who use nuclear energy about its dangers.

- **Peace and value education:** In this unit learners should work in unity as they work out activities. Working in groups enhances respect to others opinion during class discussions. The teacher has to moderate opinions. This makes the learners to develop values like humility, good listening skills and respect for others. There is a warning against nuclear war in this unit.
- **Culture and identity:** This unit deals with radioactivity and nuclear energy, which uses locally available material to explain them. From this localy available materials learners are able to identify with the community as they learn how these materials are obtained.

Attention to special education needs

Ensure that the learners with disabilities are well taken care of and they are participating in the class activities. Encourage other students to form groups with them reminding them that disability is not inability. For more information about attention to special needs, refer to the introduction part.

Topic 10 Radioactivity and Nuclear Energy

(Student's book page 276-318)

Background information and/or prior knowledge

The learners have knowledge on elements compound and nucleus. They also learnt about production of energy. In this section, we will deal with radioactive decay and half-life. Most of the radioactive experiments are dangerous so take caution while carrying them out. Others are completely not encouraged to be conducted in school. Help the learners to understand this topic by explaining the concepts. Using sealed sources, you can demonstrate most of the properties of alpha, beta and gamma radiation. The experiments in this collection allow students to see their ranges, penetrating powers and, in the case of beta radiation, how it is deflected in a magnetic field. They can link these properties to the nature of each type of radiation, and start to form a picture of why these types of radiation behave in the way they do.

Subtopics

No	Subtopic
10.1	Definition of radioactive decay
10.2	A model of radioactive decay
10.3	Half life
10.4	Types of radiations emitted and their properties
10.5	Detectors of radiations
10.6	Equations to describe radioactive decay
10.7	Natural and artificial radioactivity
10.8	Nuclear fission and nuclear fusion
10.9	Applications of Radioactivity

Suggested teaching/learning activities

10.1 Definition of radioactivity

Specific learning outcome

By the end of this section, the learner should be able to define radioactivity.

Teaching guidelines

- Ask the learners to do some research from the internet and reference materials on what is radioactive decay.
- Are they able to make the right definition?

Assessment

Conversation

- Listen to the learners as they discuss are they able to define radioactive decay as the disintegration of an atom as it emits particles and energy.
- Are they able to tell that radioactivity is a spontaneous process?

Product

- Mark their reports from the research and their explanations about radioactivity.
- Do they demonstrate a good understanding of radioactivity?

10.2–10.3 A model of radioactive decay and Half life

Specific learning outcome

By the end of the lesson, the learner should be able to explain and solve problems involving radioactive decay and half-life.

Teaching guidelines for activity 10.1

- In this activity, students model radioactive decay using bottle tops. Students can see that the model helps to explain the way in which a radioactive substance decays. The model provides an insight into what might be happening within radioactive atoms.
- This activity is a good analogy of radioactive decay as it is based on probability. The decaying trend will be noticeable and so will the random natures.
- Let the learners use bottle tops collected from the local environs to show the analogy of radioactive decay.
- Ask them to put the bottle tops in a carton, shake them and empty them into the floor.
- Ensure they pick those facing upwards and record them as decayed. Let them take those that were facing upward and put them back into the box. They should keep repeating the procedure to fill able 10.1.
- The more bottle tops each group has, the better the analogy of radioactive decay.

- Let them use the data they have collected and draw a graph of the number of bottles tops remaining against the number of throws.
- Use the activity to explain the downward trend of the decay curve. Only coins that are left can 'decay'. As there are fewer of them each time, fewer will decay. The activity raises the interesting question about how long a radioactive source will last and what happens to the last 'atom'.
- An alternative to shaking the bottle tops is students shaking coins in their palms or to flick them. However, this takes longer.
- You could repeat the experiment with small dice to give a longer half-life. Combining results gives a smoother curve.
- Ask the learners to do research from the internet and reference materials on half life.
- Does their research contain calculations of half-life? Are they able to do the calculations? Are they able to note that different elements have different half-life?

Assessment

Observation

- Are learners able to observe and count the bottle tops well?
- As the learners are doing the research, you can go round each group and ensure they are doing the right research. Ensure that they are noting down the right points on half-life. How well have they understood how to calculate half-life?

Conversation

- During the discussion, point the following key points. Ask them question after the discussion to test their understanding.
- Are they able to choose a good scale for the graph?
- What can they note on the shape of the graph?
- Can they be able to explain why the graph takes such a shape?
- How can they relate this to decay of particles?
- Guide them appropriately.
- Draw out the similarities with the protactinium experiment. The trend is the same and there is some randomness. The close match between the results from this model and the results from *measuring the half-life of protactinium* show that radioactive atoms have a chance of decaying in any fixed time.
- How well have they understood how to calculate half-life?

- Ask the learners to copy questions in examples 10.1 to 10.5. Let them discuss these examples in their groups without referring to the solution in the books. After they have done the examples, let them compare their working with the solution in the books. Are they able to get the same answers as those provided? How well have they organized their work?

Product

- Check the graphs the learners have drawn; are they able to draw an exponential graph from their data?
- Are they able to explain why a decay curve is an exponential curve?
- Guide them where necessary.
- Ask the learners to do exercise 10.1 individually. This will help learners self evaluate themselves how much they have understood it will also help them note the areas they may be having difficulties so that they can consult. Encourage them to do more questions from other sources e.g. revision materials so that they can improve their calculation skills.

10.4 Types of radiations emitted and their properties

Specific leaning outcome

By the end of this section, the learners should be able to state the different types of radiations emitted and their properties.

Teaching guidelines for activity 10.2, 10.3 and 10.4

- Ask the learners to put a small amount of element americium-241 at the bottom of a small hole drilled in lead block. Let them leave the whole arrangement in the evacuated chamber.
- Apply a strong uniform magnetic field to the chamber acting at right angles to the plane of the paper and directed into the paper, away from the reader.
- Are they able to note how the radiations move?
- Let them replace americium-241with Strontium-9 and Cobalt – 60 one at a time and note their observation.
- Are they able to note the direction in which the radiation from the source moves? Can they be able to identify the particle emitted in each case?

- Remind students that this is alpha radiation, which is the most ionizing of the three main ionizing radiations. Link this with the observations that you have made. Alpha radiation collides with and ionizes many particles in the material through which it passes. Because of this, it loses its energy quickly and is slowed down and absorbed.
- Relate the range and poor penetration of alpha to its strong ionisation. You can also refer to cloud chamber tracks if students have seen the experiment or photographs of the tracks.
- Discuss the dangers of radioactivity in general. Radiation harms people by making ions in our flesh and thereby upsetting or killing cells. The more ionising the radiation, the more harmful it is.
- Relate the hazard to the safety precautions that you are taking during the demonstration. Unstable radioactive atoms send out particles. The remaining atom is different from the initial atom, and it becomes an atom of a different chemical element.
- Remind learners that in order to protect themselves from gamma radiation they should move away from the radiation.

Assessment

Product

Check the diagrams the learners have drawn to show the observation. Do they show a good understanding of the properties of the particles the learners have observed?

10.5 Detectors of radiation

Specific learning outcome

By the end of this section the learners should be able to explain how radiations are detected using various methods.

Teaching guidelines for activities10.5, 10.6 and 10.7

- Ensure that the learners bring a radioactive source that emits alpha particles only near the cap of a positively charged leaf electroscope?
- What do they note about the leaf of the electroscope?
- Are they able to explain why the leaf falls?
- Ensure there are no radioactive elements around before you ask the learners to switch on a Geiger-Muller tube connected to a counter. Are they able to note that the counter records some reading?

- Can they explain why this is possible even though there are no radioactive elements around?
- Caution learners to be careful when handling the Geiger-Muller because the tubes are very delicate, especially if they are designed to measure alpha particles. The thin, mica window needs a protective cover so that it is not accidentally damaged by being touched.
- Ensure the learners have recorded the background count before they start the activity. Can they recall why this is important?
- Let them place the radioactive source S inside a thick lead block, in front of a Geiger-Muller tube, at a fixed distance x from the window. Let them switch on the counter and then record the reading at intervals of 1 minute.
- Let them calculate and correct count rate. Are they able to do this calculation for all data?
- Let them plot a graph of corrected count rate per minute against time. Are they able to plot a logical graph from the data they have collected? Can they be able to get the half-life from the graph?

Assessment

Observation

- Observe the learners as they do the activity; are they able to use the leaf electroscope to detect the alpha particles?
- How are they explaining what happens in the leaf electroscope to make the leaf fall?

Conversation

- Listen to the learners as they explain why the counter records some reading even though there are no radioactive elements around. Are they able to logically explain this observation?
- Do they think this reading is the same everywhere? Why?
- Remind students that gamma radiation is much less ionizing than alpha.
- Give the learners an opportunity to discuss example 10.6 in their groups. Does their discussion depict mastery of the concepts in this section?

Background data

Specific learning outcome

By the end of this section the learners should be able to explain how background radiations are detected using various methods.

Teaching guidelines for activities 10.8, 10.9 and 10.10

- Remind the learners to record the background data before they start the activity.
- Ask the learners to put a small amount of element americium-241 at the bottom of a small hole drilled in lead block. Let them read the reading on the counter.
- Are they able to explain what happens when the distance between the source of alpha particles and the detector is increased?
- What happens when a thin aluminum shield is introduced in between? Is the count the same if the thickness of the aluminum shield is increased?
- Can they explain their observation?
- Let the learners repeat the same procedure for activity 10.8 and 10.9 replacing americium-241 with strontium-90 and cobalt-60 respectively to investigate the penetration power of beta and grammar particles respectively.
- Remind students that this is alpha radiation, which is the most ionizing of the three main ionizing radiations. Link this with the observations that you have made. Alpha radiation collides with and ionizes many particles in the material through which it passes. Because of this, it loses its energy quickly and is slowed down and absorbed.
- Are they able to explain the respective penetration distances?
- Refer to cloud chamber photographs of alpha particle tracks, showing them being deflected in a magnetic field. The deflection is too small to measure in the school laboratory, but shows that they have a positive charge. The small deflection shows that they have a relatively large mass. Collisions with helium produce 90° forks showing that they have the same mass as helium (nucleus). You can say that alpha particles are thought to be a doubly ionized helium atom.
- If the students have already met the idea of nuclei, then you can call alpha particles a helium nucleus.
- Discuss the uses of gamma and beta radiations in industry and for medical imaging and treatment. The applications are based on its penetrating power.
- Discuss the dangers of radioactivity in general. Radiation harms people by making ions in our flesh and thereby upsetting or killing cells. The more ionizing the radiation, the more harmful it is. This makes sources of alpha radiation very hazardous – especially if they are ingested.

Assessment

Observation

Observe as the learners are calculating the corrected count each time, are they able to get the right count?

Conversation

- Listen to the learners, as they present. Are they able to explain the penetration distance of each particle?
- Can they explain why the different particles have different penetration distance?
- Guide the learners to discuss example 10.7.

Product

Ask the learners to do exercise 10 .2 in the learners book. Mark their work and hold a class discussion to do a revision of the exercise. This will help the learner's especially those who may be having difficulties in this section to comprehend.

10.6 Equations to describe radioactive decay

Specific learning outcome

By the end of this section, the learners should be able to illustrate the equations describing radioactive decay

Teaching guidelines

- Use visual aid materials e.g. charts to show the learners different equations that describe the radioactive decay.
- Let them discuss different equations as you guide them through.
- Are they able to balance the equations to know which particle is emitted?
- Take them through the examples for them to understand the concepts well.

Assessment

Observation

- Through a class discussion, the learners should observe while a learner is working out and showing them problems involving nuclear equations.
- Take them through examples 10.8 – 10.10.

Product

Let the learners work out Exercise 10.3. Mark their work and guide them accordingly.

10.7–10.8 Natural and artificial radioactivity, nuclear fission and nuclear fusion

Specific learning outcome

By the end of this section, the learner should be able to explain Natural and artificial radioactivity, differentiate between nuclear fission and nuclear fusion.

Teaching guidelines

- Ensure learners are able to access the Internet or resource persons.
- Let the learners do a research on natural and artificial radioactivity Are they able to differentiate between the two?
- How well can the learners explain the difference and how they occur?
- Group the learners into groups and let them research on nuclear fission and nuclear fusion.
- Allow them to discuss their findings.
- Can they differentiate between nuclear fission and nuclear fusion?

Assessment

Observation

- Ensure every learner is observing charts on nuclear fission and nuclear fusion.
- Are they able to differentiate the processes?

Conversation

- Let learners discuss the two processes. Ask them questions to check their understanding.
- Does their discussion depict mastery of the concepts discussed?

Product

- Let the learners do Exercise 10.4 individually. Mark learners' written work. Ask them to discuss as a class the solutions they have.
- Do their explanations demonstrate a good understanding of nuclear fission and fusion?

10.9 Applications of radioactivity

Specific learning outcome

By the end of this section, the learners should be able to state and explain the applications of radioactivity.

Teaching guidelines

- Ensure that all the required materials are available.
- The learner has enough knowledge on radioactive decay, half-life, background radiation and types of radiation. Let them state some of the application of radioactivity and its dangers.
- Through class discussions, the learner should explain applications of radioactivity in industries, generating electricity etc.
- They should also explain advantages and disadvantages of nuclear energy.

Assessment

Observation

- Ensure every learner is observing charts on applications of radioactivity.
- Are they able to observe, identify and explain the applications?

Conversation

- Guide learners to state and explain applications of radioactivity. Are they able to explain how radioactivity is applied in medicine, biology and agriculture, archeology, industries and others?
- Guide them to have a debate if nuclear energy is good for South Sudan or not.
- Are they able to give constructive reasons for or against nuclear energy?

Product

- Let the learners do Exercise 10.4 and topic test 10. Mark their written work. Ask them to discuss as a class the solutions they have.
- Do their explanations demonstrate a good radioactivity as per the concepts discussed in this unit?
- Help those with difficulties during remedial lessons.

Answers

Answers to numerical questions

For non-numerical questions, the learners can get most of the answers from the discussions given in student's book or from the Internet and any other reference books. Mark the student's work and use it to guide them appropriately.

Answers to numerical questions

Exercise 10.1

3. $\frac{1}{16}$
4. 4 half lives – 18 000 million years
7. 8 days
8. 2.8 hours
9. 4 days
10. 8 g
    (i) 256 g
    (ii) 248 g
11. 48 s
12. (a) 5.7 mm (b) 560 counts/min

Exercise 10.3

1. $^{24}_{11}Na \rightarrow {}^{24}_{12}Y + {}^{0}_{-1}Na + \text{energy}$
2. $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$
7. (a) $^{238}_{92}X \rightarrow {}^{230}_{88}Y + 2\,{}^{4}_{2}He = {}^{238}_{92}X \rightarrow {}^{230}_{89}Y + 2\,{}^{4}_{2}He + {}^{0}_{-1}e$
   (b) $^{230}_{88}X + {}^{230}_{89}Y + {}^{0}_{-1}e$

Topic Test 10

1. (a) $^{138}_{56}Ba$, ^{95}Kr
   (b) $^{3}_{2}He$
   (c) $^{0}_{-1}e$
   (d) ^{3}H $_{10}n$
2. 16 620 years
4. (a) $^{216}_{84}Po$ (b) $^{0}_{-1}e$ or β
   (c) $_{84}P_{o}$, ^{206}Pb

5. 15 counts/c
6. 8 half lives – 8 days
7. 15 hours
8. (a) 1 hour

   (c) Background radiation = 22 counts