South Sudan

Secondary Physics 3

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 3 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.

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Secondary Physics Teacher's Guide 3

South Sudan

Secondary Physics 3

Teacher's Guide

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South Sudan

SECONDARY
3

Physics

Teacher's Guide 3

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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 Contents

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/she interacts 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 then 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 then 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, 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 behaviour 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 crosscutting 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.

A 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 peacefully solving 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. They may be long-sighted, 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. The 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 for them to 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 S3 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
- 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. An example is observing some effects of environmental factors on plant growth illustrated in unit 14. 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 on 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.

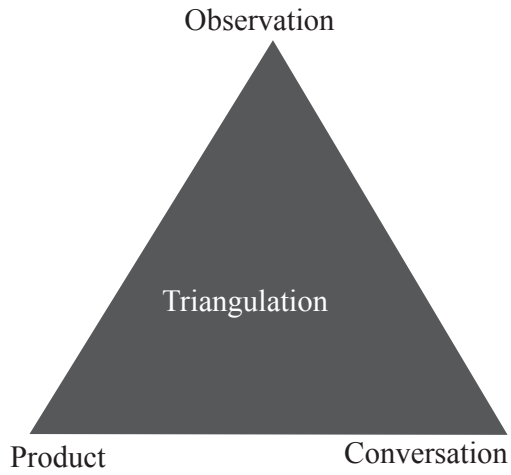
- Modify the teaching activities and instruction in order to enhance learners' achievement of learning objectives.

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 set 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 to 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

Radiation and quantum phenomena

Topics in the unit

Topic 1: Radiation and quantum phenomena

Learn about	Key inquiry questions
Learners should investigate the role of ionisation and excitation in the fluorescent tube; energy levels and photon emission line spectra (e.g. of atomic hydrogen) the Bohr theory of hydrogen as evidence of transitions between discrete energy levels Energy levels, photon emission : $hf = E_1 - E_2$ wave-particle duality. They should know photoelectric effect, work function Φ, threshold frequency fo, photoelectric equation $hf = \Phi + K.E$; collisions of electrons with atoms and the quantum theory of Max Planck. Learners should understand the wave nature of particles and the particle nature of electromagnetic waves; They should know the structure of the atom to include the energy level of electrons and the definition of the electron volt Learners should explain the difference between ionization and excitation and apply this to the operation of a fluorescent tube, the origin of line spectra, and use this as evidence to support the model of discrete energy levels. Learners should know about wave and particle behaviour in light and matter, the practical methods that can be used to demonstrate these properties, and recall the equation for the De Broglie wavelength. They should recognise the effect of particle speed on wavelength and the potential diffraction effect that could be obtained	Why electrons produced during photoelectric effect are called photoelectrons? Why excitation atom looses energy? How an atom gives off light? How did Rutherford experiment reach to explain the arrangement of particles in an atom?

Knowledge and Understanding	Skills	Attitudes
Use understanding of particles to explain radiation, electromagnetic radiation and quantum phenomena	Investigate the role of ionisation and excitation in the fluorescent tube Design a simple photoelectric cell and explain the processes of photoelectric effect.	Appreciate the particulate nature of electromagnetic radiation. Appreciate that nucleon number, proton number, and mass-energy are all conserved in nuclear processes

Contribution to the student's competences

1. Communication and cooperation

Involve learners in group work activities and discussions of the observations and findings obtained. This will promote communication skills and cooperation in the learners.

2. Critical and creative thinking

These competences are enhanced through provision of various exercises, which require students to think creatively and critically, for example, exercise 1.3 questions 4 (a). It is also enhanced through discussion of their findings among themselves before presentations are made in class.

Links to other subjects

1. Geography -waves are used in the study of seismic waves.
2. Medicine - doctors use x-rays and other machines to treat patients in hospitals.
3. Mathematics –learners calculate and solve mathematical problems involving waves.

Cross- cutting issues addressed in this unit

1. Peace Education

The students are encouraged to work and discuss in groups, discuss in groups and present their findings as a group. This promotes the element of peace among them as they realise they need each other in tackling a particular task. In addition, the topic talks about atom and nuclear. You can take the opportunity to talk about nuclear and atomic bombs and their massive destruction. By doing so, you will be promoting peace value among the learners. There is need to live harmoniously with one another!

2. Environmental sustainability

The topic partly deals with the fluorescent tubes and emission of electrons from the surface of metals. You should take this opportunity to sensitize learners on the need to properly dispose of the used fluorescent tubes. Again, sensitise them on the importance of emitting environmentally friendly gases to minimize pollution.

Attention to special needs

As you conduct the teaching, be aware that learners have different intellectual capabilities and varying needs. There are those with visual challenges e.g. short or long sightedness. Let them sit in appropriate positions in the class or during group activities. They should not strain to see. On the other hand, slow learners should also be attended to by either arranging remedial classes with them or offering individual assistance to them while in class just to explain the challenging part of the concept being learned as you give the gifted ones extra work to do. You can read more on this by referring to the introductory part of this book on page 3.

Topic 1 Radiation and quantum phenomena

(Student's book pages 1 – 45)

Background information/prior knowledge

Before Rutherford's experiment with a few pieces of metal fold and alpha particles, the structure of the atom was thought to correspond with plum pudding model. The plum pudding model was hypothesized by J. J. Thomson who described an atom as being a large positively charged cloud that contained small free-floating negatively charged particles called electrons. The faulty aspect of this model is that it was rejected before the nucleus of an atom and its composition were discovered.

Learners have already learnt about atoms in Secondary 1 Chemistry. Most of them have also come across the fluorescent tubes and bulbs in their daily lives. Build on this prior knowledge to help them understand how electrons are emitted from metals and its applications in our daily lives. For instance, fluorescent tubes and burglar alarms are used in homes, offices and any other buildings for security purposes.

Photoelectric effect is as a result of ionisation, You may introduce this section by putting more emphasis on ionisation so that learners may find it easier to understand. Therefore, approach this concept by starting from the known to unknown.

Subtopics

Subtopic	Name of subtopic
1.1	Structure of an atom
1.2	Excitation and ionisation of an electron
1.3	Photo electric effect
1.4	Threshold frequency and work function
1.5	Einstein's photoelectric effect
1.6	Factors effecting photoelectric emission
1.7	Applications of photoelectric emission
1.8	De Broglie wavelength equation
1.9	Project work

Suggested teaching and learning activities

1.1 The structure of an atom

Specific learning outcome

By the end of this section, the learner should be able to explain the composition of an atom and correctly draw its structure.

Teaching guidelines for activity 1.1

- Organise learners into appropriate groups of mixed abilities and ask them to carry out activity 1.1 in the student's book. In case the class is mixed, consider having groups of mixed gender.
- First, ask them to describe the atomic structure amongst themselves and in their respective groups. Listen to their description to gauge whether they remember the structure of an atom as earlier learnt in S1 Chemistry. Ask them questions to explain what an atom is*, or* what constitutes atoms.
- Ask one volunteer learner to draw the structure of an atom on the chalkboard and label it to test if they can recall the composition of the atom.
- Encourage them to use a pair of compasses and a sharp pencil to draw the structure of a carbon atom on a manila paper. Note that these are mathematical skills, which have to be applied in the teaching and learning of this unit. Ensure that they have accurately applied their geometrical skills and that the diagrams drawn have 6 protons and 6 neutrons in the nucleus, 2 electrons on the first energy level and 4 electrons in the second energy level. Advice them to be careful with the pair of compasses so as not to hurt themselves and/or others. Be keen to observe if they are able to explain the structure as drawn. During your interaction with them, ask them *why the structure of the Carbon atom is different from that of hydrogen. You may also want to ask them why electrons are distributed as shown in their diagrams.*
- Inculcate the reading culture in them by asking them to do research from reference books including the class textbook, on the early theories of atomic structure including the atomic models by *J.J. Thompson, Ernest Rutherfold* and *\Weils Bohr*. Let them highlight the *strengths* and *weakness* of these models. In case mobile phones are to be used in accessing the internet, warn them against sending unauthorized messages or accessing prohibited sites. Note that mobile phones can only be used in class under your supervision. Ask them to write a report on the same. Does the research add value to the mastery of the content?

- Guide those who may have challenges in finding the correct reference books or sites for research.

  Allow them enough time within which to carry out the research and come up with valid findings, which they can present in class.
- Ask the learners to use the same materials and model the structures of other atoms of their choice. Ask them questions to test if they can state the composition of an atom. Let them draw the energy levels in an atom.
- After doing the activity and presenting to the class, guide them through a detailed discussion of the atomic structure as discussed in the Student's Book pages 3–5.
- Use charts and models on the atomic structure to demonstrate. In the absence of such models, you can improvise using marbles or beads.
- Ask them to answer questions 1–3 in Exercise 1.1 given in the Student's book.

Assessment

Observations

- Walk around the class as the learners carry on with the activity and observe how they are drawing the structure of an atom. Are they able to draw and label the structure of an atom correctly?
- Check and mark the correct structures in class.

Conversation

- Use probing questions to introduce the concept on atomic structure.
- Talk to the learners while discussing their findings. Can they identify the nucleus, electron and an energy level of an atom on their drawing?
- Let the learners give supportive argument on their findings.
- Engage them in question and answer session to test their understanding of the concept.

Product

- Check the diagrams drawn by the learners. Have they drawn the correct number of energy levels? Are the diagrams labelled correctly?
- Check their answers regarding the composition of an atom and the forces binding the particles together. Mark their work and correct them where necessary.
- Let them understand that the nucleus is found at the centre of an atom while an electron orbits around the nucleus.

1.2 Excitation and ionisation of an electron

By the end of this section, the learner should be able to define excitation and ionization of an electron and explain their applications in the fluorescent tube.

Teaching guidelines for activity 1.2

- Organise the learners in mixed ability groups.
- Ensure that there are enough charts, manila papers and reference sources prior to the start of the lesson.
- Allow the students to carry out research on the definitions of the terms *excitation* and *ionisation* from the dictionary in pairs. Prompt them into looking for even better definitions by asking them leading questions and conducting research.
- Ask them to use the model of the atom or charts to explain excitation and ionisation process of an atom.
- Instruct them to use some marbles or beads to demonstrate excitation and ionisation
- After doing the activity, discuss the terms *ionisation* and *excitation* in details as discussed in the Student's Book.
- You may use a defective fluorescent tube and crack it for the learners to see the phosphorous powder that is used in the tube as you guide them on the a*pplications of excitation*. This enhances their understanding when explaining its operation. In the absence of a model of an atom, improvise one using locally available materials such as marbles or beads**.**
- Guide the through Examples 1.1 and 1.2 to help them fully graph these concepts.
- Ask them to do questions 6–11 given in Exercise 1.1.

Assessment

Observation

- Watch the learners as they carry out the activity. Ensure that they are able to observe the ionisation process and note down their observations.
- Observe them as they locate names in the dictionary and write their meanings. Guide them on the best way of locating a name in a dictionary while looking for its meaning.
- Guide them as they role-play excitation and ionisation of electrons in an atom. Are they doing the correct thing?

Conversation

- Ask learners some probing questions to sustain their interest while discussing ionisation and excitation. Are they right? (*Note: they do not have to be correct, at this level they are only being encouraged to think critically).*
- Probe them to answer the following questions:
  1. *What is excitation of an atom?*
  2. *What is ionisation of an atom?*
  3. *What happens when an electron moves from one energy level to another?*
  4. *What are some of the applications of the excitation process?*
- Ensure that learners do not confuse the excitation and ionisation processes when explaining them. Summarise by mentioning that **excitation** is the movement of electrons of an atom from a low energy level to a higher energy level while **ionisation** is the removal of electrons from energy levels after attaining threshold energy.
- Allow them to discuss the applications of excitation and ionisation according to their understanding. Ensure that all the learners participate in the discussion as these forms a foundation for future learning.

Product

- Check their definitions and applications. Appreciate those who get it right and correct those who do not.
- Explain to them that excitation is the process by which electrons move from lower energy levels to higher energy levels. What is ionisation?
- Check and mark their work. Correct them where necessary.

1.3 Photoelectric Effect

Specific learning outcome

By the end of this section, the learner should be able to write and explain Planck's equation, explain what photoelectric effect is, define threshold frequency and work function and solve problems involving them.

Teaching guidelines to activities 1.3 and 1.4

Activity 1.3

- Ensure that all the necessary materials for the activity are available. Ask the learners to be in convenient groups of mixed abilities and gender if your school is mixed. However, this will also depend on the class roll.
- Guide them through the activity by reading through with them. Involve as many learners as possible in the reading. Ask them to do activity 1.3.
- Ask them some probing questions such as why the zinc has to be cleaned with an energy cloth. Electroscopes could be borrowed in advance in case there is none in your school.
    - Guide them through the activity prior to conducting research on photoelectric effect.
    - Ask them to research on photoelectric effect. This could be done from reference books or otherwise.
- Closely supervise them as they do the activity and conduct the research.
- Let them explain the observations that they have recorded including why the leaf falls when UV light is shone on the zinc plate.

Activity 1.4

- Ask the learners to carry out activity 1.3. Ask them to attach the cleaned zinc plate on the cap of uncharged electroscope. *Why is it important to clean the zinc plate with an energy cloth?*

  Let them shine the zinc plate with ultraviolet radiation. Ask them to note down their observations.
- Ask the learners to repeat the activity with negatively charged electroscope. Refer to topic 2 of this book on how to charge the electroscope negatively and guide the learners to charge it.
- After the activity, guide them to understand that according to Max Planck, the radiation emitted from the metal is not in continuous amount but discrete bundles or packets called **photons**. Planck shows that energy emitted can be given by **E = hf**; where h is Planck's constant which is 6.63×10^{-34} S.
- Guide the learners on how to use the formula, E = hf to solve problems related to this concept. Take them through Examples 1.1 to 1.5 in the learner's book.

Assessment

Observation

- Go around the groups and observe how the groups are discussing their results. Did they observe the leaf of the electroscope deflecting? Did they observe that there was no deflection on the leaf of the electroscope when visible light was shone at zinc plate?
- Let them explain the difference in their observations when the electroscope was negatively charged and when positively charged
- Keenly observe how the learners conduct the research. Are they able to get how Planck came up with the equation, E = hf?
- Check whether they got the values from their research. Was the value close to $\mathbf{6.63 \times 10^{-34} J}$?

Conversation

- Ask them what E, h, and f represent in the equation E = hf. Are they able to give correct answers? Note that learners may not be right at this stage. Always appreciate their efforts.
- Hold a discussion with learners after each activity. Talk to them about the meaning of work function and electron volts. Are they able to define them correctly?
- Explain to them that in activity 1.3 step 3, the leaf rises meaning that the electroscope is charging.
- Ask them questions to gauge their understanding. Are they able to answer the following questions for example in activity 1.4?

1. *What is threshold frequency?*
2. *What is the minimum energy required to completely remove an electron from the metal?*

- Ask three learners to solve a problem on the chalkboard. As a way of developing their confidence, ask them to explain to the class one at a time.
- Listen to their conversation. Ask them to give a reason as to why the leaf of an electroscope deflects. Are they able to give a correct reason in each case?
- Ask them why the leaf of the electroscope did not deflect. Are they able to answer correctly?
- Guide them through a discussion given in the student's book to understand that the leaf of an electroscope deflects due to electron emission from the zinc plate.

Product

- Check their answers. Are they able to say E is energy released during ionization, h is Planck's constant (6.63×10^{-34} J) and f is the frequency? Are they able to solve related problems?

1.4 Einstein's equation of photoelectric effect

Specific learning outcome

By the end of this section, the learner should be able to derive Einstein's equation and use it to solve questions.

Teaching guidelines to activity 1.5

- This section demands some of mathematical skills. You may introduce it by basic equation of energies (Kinetic and potential) i.e.

  $P.E = mgh$

  $K.E = \frac{1}{2} mv^2$

- When the energy of a body changes from potential to kinetic energy, we equate them as follows:

  $mgh = \frac{1}{2} mv^2$ *or* $mgh - \frac{1}{2} mv^2 = 0$

- Ask them to explain to their group members how to calculate the work function of a metal. Let them write the equation used.
- Guide them to locate right sites from the internet and relevant reference materials and carry out research on Einstein's photoelectric equation. In case you are using mobile phones, group the students into appropriate groups according to the number of phones. Give each group a mobile phone and ask them not to use the phones until you say so.
- Go around and guide them on how to access the internet using the mobile phones provided to them. Warn them against unauthorized use of the phones for any other purpose or if they access unauthorised sites.
- Allow them to discuss their findings in their groups. This will enhance their ***communication, cooperation and research skills***.
- After the learners have done research and discussed their findings, guide them to understand and master Einstein photoelectric's equation which is given as $hf = hf_o + mv^2_{max.}$
- Guide the learners in a discussion of examples 1.6 and 1.7 given in the student's book.

Assessment

Observation

- Move around observing whether the learners have accessed the correct sites in preparation for the research.
- Observe whether the learners are able to state Einstein's photoelectric equation. Are they able to state and represent it in an equation form?

Conservation

- Hold a comprehensive discussion with the learners on their findings on how to derive Einstein's photoelectric equation.
- Can they define every term in the equation, $hf = hf_o + ½\ mv^2$? Is the equation comparable to the one they derived?
- Ask them to demonstrate their understanding of the equation $hf = hf_o + ½\ mv^2$ on the chalkboard through a given problem. Guide them through examples 1.6 and 1.7 in the Learner's book. Come up with similar problems.

Product

- Check their answers from the discussions and the activities.
- Ask them to do exercise 1.2 in the student's book. Check and mark their work.

1.5 Factors affecting photoelectric emissions

1.5.1: Intensity of radiation

Specific learning outcome

By the end of this section, the learner should be able to list and explain the factors affecting photoelectric emission.

Teaching guidelines to activities 1.6 and 1.7

Activity 1.6

- Organise the learners in groups.
- Ask the learners some probing questions to gauge if they can recall much about photoelectric effect. Ask them questions such as: *what will happen to the number of electrons ejected if the incident radiation in the activity they have already done is*

increased? Their response will build a foundation to this section .Note that they have already learnt about photoelectric effect.

- In case you do not have, a photocell and red filter in your school make prior arrangements with neighbouring schools and borrow from them.
- Ask them to remind the members of their groups the factors that affect the emission of photoelectrons from a metal.
- Let each group note down the harmonised points and ask one learner in each group to present them to the whole class. Ensure that the learners actively participate in the activity.
- Explain to the learners that factors such as intensity of radiation decreases with distance from the source. This eventually affects the quantity of emission.

Activity 1.7

- This is an investigative kind of activity that is meant to test creativity, problem solving skills, etc of the learners. You should note that as they work in groups their interpersonal relationship improves.
- Organise for the learners to carry out activity 1.7. Ask them to note which other materials they would require in order to complete the activity.
- Encourage them to first write the procedure for the activity. Encourage them to not only be creative but also to look for the right procedure by consulting the reference books. This should be done with your guidance.
- Ask them to place the violet filter in between the window of a photocell and the source of the visible light as shown in Fig. 1.18 in the learner's book.
- Let them measure the photoelectric current and distance, r.
- Ask them to move the filter to different positions between the windows and record the current and distance in tabular form. Let them record their observations.
- Ask them to discuss and present their findings.
- Let them use the data they have recorded to draw the graphs of current against the reciprocal of the square of the distance. Ask them to discuss their graph and draw conclusions.

Assessment

Observation

- Observe whether the learners are able to recall the factors that affect photoelectric effect. Are they able to list them?
- Ask them to look at the diagram showing a photocell in Fig. 1.14 in the learners' book. What can they see?

- Have a look at the learner's findings. Are they able to take accurate readings from the ammeter? What about the distance?

Conversation

- Involve learners in a class discussion. Ask them to list the factors that affect photoelectron emission. Are they able to list them? Can they explain how each factor affects the emission of photoelectrons?
- Discuss the graphs drawn by the learners.
- Let them answer the following questions:
  1. How does intensity, frequency of the radiation, anode – cathode potential difference affect photoelectric emission?
  2. How is light intensity related to photoelectric effect?

Product

- Check their findings and guide them appropriately. Ensure that they are able to record in tabular forms.
- Check the graphs drawn and make a conclusion about the activity.

  Are they straight-line graphs? Why?

  Note that from the equation obtained, the number of ejected photoelectrons is directly proportional to the intensity of the radiation used.

1.5.2: Anode-cathode potential difference

Specific learning outcome

By the end of this section, the learner should be able to find out the effect of anode – cathode potential difference and frequency on photoelectric effect.

Teaching guidelines for activities 1.8, 1.9 and 1.10

Activity 1.8

- Maintain the groups of learners constituted in activities 1.6 and 1.7. Organize the learners to do activity 1.8. Ensure that each group has the requisite materials needed to do the activity.
- Guide the learners in setting up the materials suggested and through the steps of the activity. Ask them to place the coloured filter in between the quartz window of a photocell and the source of visible light. Ask them if they can identify the light passing through the filter.

- Let them measure the photoelectric current when the switch is closed. Are they able to measure and take readings?
- Allow them to do the activity on their own and record their findings such as potential difference and the corresponding values of current in a table such as table 1.3. Note that this can be achieved well by steadily increasing the potential difference between the anode and the cathode. Why does the ammeter reading change?
- Discuss the observations with individual groups as you go round the class. Offer individual assistance to those with difficulties.
- Ask them to represent their findings by drawing a graph of the photocurrent, I against the potential difference.
- Allow them to discuss the shape of their graphs and findings.
- Hold a discussion with them about their findings. Ask them the following questions:
  1. How does intensity of the radiation affect the number of ejected photoelectrons?
  2. What is the name of the voltage when no electron is able to reach the anode from the cathode?

Activity 1.9

- This activity aims at teaching learners that frequency of radiation has an impact on photoelectrons. Review activity 1.8 with them.
- Retain the learners in their previous groups. Use the question and answer technique to gauge their understanding of the previously taught concepts. This should serve as a reminder to them.
- Replace the red filter used in activity 1.8 with a violet one. Ask them if they notice any change.
- Ask the learners to repeat what they did in activity 1.8 and record their findings in a table.
- Move around observing what they are doing and guiding them accordingly.
- Ask them to use the same axes to plot a graph of current, I against potential difference. (See Fig. 1.22 in the learner's book).

Ask the learners to compare the two graphs. Are they the same? How about the values of the stopping potentials?

- Ask one learner from each group to present their findings.

Activity 1.10

- Review the previous concepts.
- Organize the learners in mixed ability groups in readiness for activity 1.10.
- Together with the learners look at Fig. 1.24 in the learners book. Ensure that the learners can identify all the major parts of the diagram.
- Guide them as they carry out the activity on their own. Encourage them to record their readings for stopping voltage and the corresponding frequency in a table like table 1.4 in the learner's book.

  Find out if they are able to calculate the kinetic energy of the emitted photoelectrons.
- Guide them to use their results to plot a graph of energy (in eV) against the frequency in (Hz). Verify the graph drawn. Ask them to calculate the slope of the graph. Let them read the intercepts of the graphs.

Note: The graphs drawn should be straight line graphs. The y-intercept represents the work function while the x- intercept represents the threshold frequency, fo. Hence, comparing with the equation of a straight-line $y = mx + c$, $W = hf_o$.

- Mention to the learners that the graphs for different metals would be straight line graphs as shown in Fig. 1.26.
- Ensure that each group through a representative has presented its findings in class. Correct them appropriately.
- Take the learners through example 1.8. Emphasise to them the importance of capturing the SI Units in the calculations.
- Ask the learners to do related questions from exercise 1.3 in the learner's book page 29.

Observation

- Observe the groups as they do the activities. Ensure that all are actively participating.
- Observe them as they read the ammeters. Are they taking the readings correctly?
- Observe how learners are plotting and drawing the graphs.

Conversation

- While discussing their findings, are learners able to explain the relationship between intensity of the radiation used, potential difference between anode-cathode and frequency of the radiation?
- Note that at this point some learners may not understand the relationship between intensity of radiation and anode-cathode potential difference. It is not a must that they have to get everything correct.

- Discuss and ask them questions about the graphs they have drawn and the activities in general.
- Discuss with the learners example 1.8 in the learner's book.
- Discuss and define all the key words such as photoelectric effect, stopping voltage, frequency, threshold frequency, work function etc.

Product

- Check their observations, graphs and answers. Have they drawn the correct graphs? Are they able to come up with the relationship between intensity and photoelectric current; frequency of radiation and photoelectron emission, and anode-cathode potential difference and the photoelectrons emitted? Are the learners able to determine Plank's constant of a metal?
- Guide them as they analyse and interpret the graphs. What is work function? Can it be calculated from the graphs?
- Correct them appropriately and where necessary.
- Conclude the section by emphasising that when current becomes constant after increasing continuously such current is referred to as **saturation current**. On the other hand, stopping voltage, Vs, occurs when the current is zero and no electrons can reach the anode. It is therefore a measure of the maximum kinetic energy of the photoelectrons.
- Check, mark and correct the work done by learners in exercise 1.3.

1.6 Applications of photoelectric effect

Specific learning outcome

By the end of this section, the learner should be able to explain the applications of the photoelectric effect in our daily lives.

Teaching guidelines to activity 1.11

- This section is very important to the students .Ensure that they have understood it well. Use any locally available material (improvise) if it can help you to deliver this section as required.
- Organise the learners in convenient groups in preparation for the activity. Prompt them to apply the knowledge they have learnt on photoelectric effect to come up with instruments such as burglar alarm, automatic opening of door, among others.

- In the absence of computers that are connected to the internet, you may ask the learners to use smart phones loaded with data bundles. Resource persons could also come in handy in providing information about the same. Remember to caution them against accessing unauthorized sites.
- Bring to class some of the applications of photoelectric effect such as solar panels to the learners for them to see.
- In groups, ask them to research more on the applications of photoelectric effect. Guide them in finding the relevant reference materials. In case you are using mobile phones, group the students appropriately according to the number of available resources.
- Ask them to state and explain two applications of photoelectric effect. Let them discuss their findings in groups. This will enhance **communication skills, cooperation and research skills** among the students.
- Ensure that all learners actively participate in the discussion and guide them accordingly.
- Let them answer the following questions:
  1. How is photoelectric effect applied in a photocell?
  2. What are some of the applications of a photocell?

Assessment

Observation

- Watch the learners as they observe some of the applications of photoelectric effect.
- Observe the pairs discussing the answers. Can they apply the ideas learnt in photoelectric effect?

Conservation

- Discuss their findings on the applications of photoelectric effect. Can they explain the applications?

Product

- Check their noted observations and findings.
- Use related questions and ask anew of them to volunteer and write the working on the blackboard. Guide them accordingly.
- Ask them to do some questions from Exercise 1.4. Mark their work and guide them appropriately.

1.7 De Broglie wavelength equations

Specific learning outcome

By the end of this section, the learner should be able to state De Broglie wavelength equation and apply it in solving problems.

Teaching guidelines for activity 1.12

- Organise the learners in convenient groups.
- Ask them some probing questions related to light, for example if light is a wave?
- Guide them to research on De Broglie wavelength equation from relevant reference materials.
- Ask them to note their findings and present them to the whole class.
- Ask the learners to do some questions from exercise 1.4 and Unit Test 1given in the learner's book.

Assessment

Observation

- Observe the learners as they carry out the activity. Are all the learners actively participating?
- Have a look at the various reference materials being used. Are they relevant to the topic of discussion?

Conversation

- Ask the learners some questions to test their understanding of light, for example, name the characteristics of light. Are they able to state and explain the characteristics of light?
  1. *Light travels in a straight line.*
  2. *Light travels at a speed of 3×10^8 m/s.*
- Explain to the learners that light behaves like a wave as well as a particle. It exists as photons.
- Introduce them to the activity involving De Broglie equation. Ask them some probing questions.

- While learners are discussing and analyzing their findings, ask those questions. Are they able to state De Broglie wavelength equation correctly?

The equation relates the wavelength to the momentum due to the mass of the particles.

- Guide them through example 1.9 on the chalkboard to emphasise on the relevance of De Broglie wavelength equation in solving problems. You may use other related questions to help the learners to master the concept.

Product

- Mark their work done from there exercises and do corrections with them appropriately.
- Recapitulate as you conclude the lesson.

Project work: Construction of a burglar alarm

Specific learning outcome

By the end of this section, the learner should be able to construct a burglar alarm using local materials.

Teaching guidelines for the project work

- This part is very important in gauging whether your learners are able to apply what they have learnt, therefore ensure that all the students take the project very seriously.
- Ensure that the suggested materials are assembled in advance. Again organise the learners in convenient groups. The project should take at most two weeks. Advice every group to give all their results after then.
- Provide them with the suggested materials. Ask them to improvise where necessary.
- You may decide the time the learners should work on their project or let them plan their time but maximum period should be two weeks from the time they start. At the expiry of two weeks, arrange for each group to show their working and explain to the whole class how the burglar alarm works. Let them demonstrate.

Assessment

Observation

- Supervise them as they do the project.
- Allow learners observe other groups' burglar alarms. Are they able to explain its operation?

Conversations

- After each group has demonstrated how burglar alarm works emphasise on the blockage of light rays from reaching the cathode by the intruder causing the soft iron core to lose its magnetism that it had acquired.
- Ask one learner to take others through the unit summary.
- Review in class some of the questions from Unit Test 1.

Product

- Check the burglar alarms made from local materials. Advise them on how to improve them for proper working.
- Mark the answers given by the learners from Unit Test 1.

Answers to numerical questions

Exercise 1.1

6. 9.7×10^{-8} m , Ultraviolet
7. 6.562×10^{-5} m violet
8. 1.282×10^{-6} m
9. 5.48×10^{-14} Hz
10. n = 2
11. (a) 4.582×10^{-19} J
12. (b) 4.341×10^{-7} m

Exercise 1.2

6. 8.8×10^{5} m/s
7. 5.303×10^{17} photons

Exercise 1.3

5 (b) (i) 4.8×10^{14}HZ

(ii) 6.56×10^{-34}Js

7. (b) 0.66V

9 (c) (i) 6.9×10^{-34}Js

(ii) 6.767×10^{-7}H m

(iii) 2.8×10^{-19}J

Exercise 1.4

2. (a) 2.779×10^{6} m/s

Topic test 1

4. (a) 4.13×10^{-10}J

(b) 2.6 eV

5. 1.24×10^{-6}J
6. 4.85×10^{-19}J
7. 1.4×10^{-7} m
8. 6.67×10^{-34}J
9. 4.95×10^{-19}J or 3.094 eV
13. (c) (i) 6.64×10^{-34}J

(ii) 5.31×10^{-19}J or 3.21 eV

UNIT 2

Electrostatics

Topics in the unit

Topic 2: Nature of electrostatic

Learn about	Key inquiry questions
Learners should investigate the constituents of an atom, the position of nucleus, electrons and protons and the process of electrification using different methods e.g friction, contact and induction and test for an object whether it is charged or uncharged using appropriate devices. They should know the activities of electrons inside insulators and conductors, the two types of charges are positive and negative, and that like charges repel, unlike charges attract. They should know the characteristics of nuclei, and why a substance can be charged by friction. Learners should know Coulomb's law, and use it to calculate the forces between charges and know that an electric field has magnitude and direction. They should use the formula for electron volts to calculate the energy change when particles move, and understand electric fields and capacitors. The students will investigate the process of capacitors in groups and individually how make it, factors affecting it, when to charge and discharge it and how to connect them in series and parallel. Solve problems on series and parallel connection of capacitor.	• How can we test the presence of charges on an object? • Why alpha particles directed towards an atom of an element deflected • away from the centre of the atom? • Why charging by induction is temporary? • How does lightning conductor protect our house from lightning strikes? • Why is it easy to charge polythene by rubbing, but not copper? • How can we charge and discharge capacitor

Knowledge and Understanding		Attitudes
• Understand the nature of electrostatics. • Know that an electric field has magnitude	• Investigate the constituent of an atom, the position of nucleus, electrons and protons • Investigate the process of electrification using different methods • Investigate the process of capacitors • Use Coulomb's law to calculate the forces between charges • Use the formula for electron volts to calculate the energy change when particles move • Solve problems on series and parallel connection of capacitor	• Appreciate the importance of electrostatics.

Contribution to the student's competences

1. Creativity and critical thinking

These competences are enhanced in the learners in this unit as they carry out experiments and activities on charging and discharging objects and capacitors, measure quantities accurately, analyze data and draw logical conclusion from the experiments, and solve the problems provided on capacitance in the exercises provided.

2. Communication and cooperation

These skills are acquired as learners discuss with one another and express themselves while collaboratively doing the activities on charging and discharging objects and capacitors in the unit and making presentations to the rest of the class.

Links to other subjects

1. Geography- Lighter, positively- charged particles form at the top of the cloud. Heavier, negatively charged particles sink to the bottom of the cloud. When the positive and negative charges grow large enough, a giant spark occurs between the two charges within the cloud. This causes lightning.

2. Mathematics –learners calculate and solve mathematical problems involving waves.

Cross-cutting issues addressed in the topic

1. Environment & Sustainability

The unit has concepts dealing with the flow of charge in the environment including earthling and the working of lightning arrestors. The activities provide the teacher with the opportunity to sensitise the learners on the importance of learning how to protect our living environment from charges from the environment. In addition, the teacher should sensitise the learners on the need to dispose electronic waste including used up capacitors in environmentally friendly manner.

2. Peace and values

The unit provides numerous pair and group activities that require learners to work together. This will enhance peaceful coexistence and teamwork among them.
Attention to special needs.

This topic provides numerous activities and exercises of varying levels of difficulty to cater for learners of different learning abilities i.e. the average, gifted and slow learners. The teacher should ensure that all learners including those with physical and mental challenges participate in one way or another in the tasks they are able to do in the activities. For more information, refer to the introduction given in this Teacher's Guide.

Topic 2 Electrostatics

(Student's Book, pages 48 - 79)

Background information/prior knowledge

- Learners in their daily lives with charges and/or their effects, for example, they must have observed dust particles sticking on glass, the sparking of clothes as they remove them and lightning. This topic will help them understand better what causes these phenomena. This familiarity with prior knowledge on charges should help them to easily understand the concepts. Therefore, teach the concepts by following the known to unknown approach.
- Learners have already learnt about charges and atoms in Secondary 2 Chemistry. This section should therefore be more of a review of the concepts. You can improvise an atomic model to facilitate your teaching in this section.

Subtopics

Subtopic No.	Name of Subtopic
2.1	The origin of charge
2.2	Methods of charging object
2.3	Coulomb's law
2.4	Testing of charges
2.5	Effects and applications of methods of charging

Suggested teaching/learning activities

Specific learning outcome

By the end of this section, the learner should be able to explain the constituents of an atom.

Teaching guidelines to activity 2.1

- This is an investigative activity where learners have to find out the composition of an atom. You may rely more on the concepts taught in unit 1 and Secondary 2 Chemistry.
- Organise learners into convenient groups. Encourage them to choose their own materials as they investigate the composition of an atom. In the absence of marbles, let the learners improvise by using differently coloured beads or small fruits.

- First, give them an opportunity to describe atomic structure in their respective groups. Listen to their description in order to know whether they remember the structure of an atom as earlier learnt in Chemistry 2 and Unit 1 of this book. Are their descriptions up to date?
- Ask them to sketch the structure of a carbon atom on a manila paper. Observe their diagrams to see whether they have drawn six protons and six neutrons in the nucleus, two electrons on the first energy level and four electrons in the second energy level.
- Ask them to use the materials such as marbles and fix them on the atomic structure diagram to represent the electrons, protons and neutrons. Let them use different colours to represent these different types of particles.
- Help those who may be facing challenges in fixing the correct marbles, or beads in the correct positions to represent the particles. Caution them against holding beads and/ or marbles by the mouth as they can accidentally slip down the throat.
- Ask the learners to use the same materials and model the structures of other atoms of their choice.

Assessment

Observation

- Observe the groups as they are doing the activities and discussing their work. Do the sketches drawn demonstrate an understanding of an atomic structure?
- Observe their models to see if they have correctly represented 6 electrons, 6 protons and 6 neutrons in the right positions in the structure.

Conversation

- Talk to the learners by asking them questions while they are doing the activity. Also, observe them as they present their findings to the rest of the class. Can they describe the atomic structure of an atom correctly? Discuss the sketches.
- Listen to them as they explain how an atom gets charged.
- Explain to them where they have not understood.

Product

- Look at the atomic structure of Carbon that the learners have sketched. Are the sketches correct? Are they able to label the sketch accordingly? Are they creative enough as to use locally available materials suggested?

- Look at their models on the Manila paper. Have the learners represented 6 protons and 6 neutrons in the nucleus, 2 electrons on the first energy level and 4 electrons in the second energy level?

(a) Charging by friction method

Specific learning outcome

By the end of this section, the learner should be able to describe charging materials by friction.

Teaching guidelines for activity 2.2

- Organise the learners into groups considering gender, ability and class roll.
- Ask them to carry out activity 2.2 in the learner's book. Let them bring the pen near the pieces of paper. Advise them to keenly observe what happens.
- Ask them to rub the pen on their hairs and then bring it near the pieces of paper. For those who may have shaved their hair completely, let them do the activity with a partner who has some hair. What happens? Ask them to explain.
- Let them explain to the group members what happened to the pen on rubbing against the hair and why it attracts the pieces of paper. Ensure participation of all the learners. Listen to their explanations to assess whether they know that materials get charged by rubbing against another material. Emphasise to them that this is called charging by friction.
- Ask them to name other materials that charge by friction.

Assessment

Observation

- Observe the learners as they do the activity. Are they able to charge a material by friction?
- Encourage the learners to observe every happening to the pieces of paper as they bring the charged pen close.

Conversation

- Ask the learners some questions as they do the activity. Can they explain how friction charges a material?
- Take them through examples 2.1 and 2.2 as you discuss every step.

Product

- Ask the learners to do exercise 2.1.Are they able to answer them appropriately?
- Read and mark their answers? Do their written answers depict mastery of the method of charging objects by the given method?

Note that charging by friction involves rubbing one material against another. One material losses electrons becoming positively charged, while the other object gains the electrons becoming negatively charged.

(b) Charging by induction method

Specific learning outcome

By the end of this section, the learner should be able to describe charging materials by induction.

Teaching guidelines for activity 2.3

- Organise learners into appropriate groups in preparation for activity 2.3.
- Remind the learners what they have recently leant by asking them related questions. Can they explain the friction method of charging?
- Ask them to rub a glass rod with a silk cloth. Let all the members of a group actively participate in the activity. Let them explain which charge the glass rod acquires.
- Ask them to bring the charged glass rod close to but not touching the uncharged metal sphere. What happens?
- Let them withdraw the conducting wire (the finger) first then the glass rod. Why?
- Ask them to bring charged polythene and glass rods in turns close but not touching. Let them observe and explain what happens.
- Give them time to discuss how charging of a metal sphere by induction method is done.
- Let them present their findings to the rest of the class.
- Give them some questions to do as assignment.

Assessment

Observation

- Observe how learners are charging a rod and the metal sphere by induction. Are all of them engaged in the activity? Are they following the instructions?
- Encourage them to observe all that happens to the rods and the sphere.

Conversation

- Talk to the learners by asking those questions as they do the activity. Can they explain the process of charging a metal rod by induction with ease? What about Figure 2.4 (a) to (d)?
- Discuss the findings with them in class and draw a conclusion.

Product

- Listen to the answers given by learners during discussions. Are they demonstrating mastery of charging by induction method?
- Did the conductor acquire charge? If so which one?
- Mark the assignment you gave to the learners.

Note that the charge acquired must be opposite to that of the charging rod.

(c) Charging by contact (conduction) method

Specific learning outcome

By the end of this section, the learner should be able to describe charging materials by contact.

Teaching guidelines for activity 2.4

- Let the learners be in convenient groups. Review the previous activities together with them. Ask them to do activity 2.4 on their own.
- Ensure that they follow all the steps explaining what happens at every step. Learners should be monitored to ensure that their set ups confine to Fig. 2.5 in the learner's book.
- In Fig. 2.5 (a), let them charge the glass rod and bring it in contact with the uncharged conductor. Let them observe what happens.
- In Fig. 2.5 (b), let them remove the charged glass rod.
- In (c), let them bring the glass rod and a polythene rod in turn close to the conductor and observe what happens. Encourage them to comment on their observations.
- Allow them to hold a discussion on charging a metal sphere by contact method.
- Ask them to write down and explain their observation in each step.
- Give them an opportunity to present their findings to the rest of the class.

Assessment

Observation

- Observe as you move around while learners carry out the activity. Are all learners doing something about the activity?
- Observe how the learners are discussing the process of charging a metal sphere by contact method.

Conversation

- Talk to the learners as they discuss their findings. Can they explain charging by contact with ease? Are they able to describe the process? Can they accommodate the views of others?
- Ask them questions during and after the activity. Let the learners explain what is happening in every step of the activity particularly figure 2.5 (a) to (c).

Product

- Did the body in question get charged? Which charge was acquired? Explain.
- Gauge the learner's answers. Are they depicting mastery of content i.e. charging by contact method?

Note that in this method of charging objects the charge acquired is the same to the one on the charging glass rod.

(d) Charging by separation method

Specific learning outcome

By the end of this section, the learner should be able to describe charging materials by separation method.

Teaching guidelines for activities 2.5 and 2.6

Activity 2.5

- You may choose to maintain the groups used in activity 2.4 or make new ones.
- Ask learners to carry out activity 2.5.

Ask them to place two spheres on an insulated stand in contact with each other.

Let them bring a negatively charged polythene rod close but not touching a sphere labelled A.

Ask them to move B away while holding the charged polythene rod in position so as to break the contact.

- Ask them to test the two spheres (A and B) using the negatively charged polythene rod. Let them observe and explain what happens.
- Let them hold a discussion in their groups. How can one charge a material by separation method?

Activity 2.6

- Similarly, discuss with them how to know that a body is charged by guiding them through activity 2.6.Why are the two bodies rubbed by a silk cloth?
- Encourage them to record their findings in a table such as Table 2.1 in the learner's book.
- Give them an opportunity to present their findings to the rest of the class and discuss the same.
- Ask them to do exercise 2.2 from the learner's book.

Assessment

Observation

- Observe the learners as they do the activities. Are they able to do all the steps in the activities aimed at charging the materials by using the method stipulated in the activity?
- Can they confirm with ease that a body is charged? Let them give some observations.

Conversation

- Ask the learners some questions as they do the activities. Can they explain each step of the activity?
- Discuss with them the type of charge acquired by each material in activity 2.6.
- Let them explain some of their findings.

The ebonite was negatively charged while the glass rod was positively charged.

Product

- Read and mark their answers. Do their written answers depict mastery of the method used for charging objects by contact method?
- Review the topic by asking them questions as they answer. Ensure that they can tell when a body is charged.

- Mark table 2.1 for each group, Make corrections where necessary. Are they able to fill the table appropriately?
- Review exercise 2.2 together and after marking their answers.

Specific learning outcome

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

Teaching guidelines for activities 2.7 and 2.8

Activity 2.7

- Review with the learners charging of objects by asking them questions as they answer. Test their understanding of the same before proceeding to the next concept.
- Organise the learners in groups of mixed abilities.
- Ask them to carry out activity 2.7 in the learner's book. Let them charge polythene rods A and B as per the instructions given. Caution them against falling stands especially when toppled over.
- Ask them to note the observations. What happens in every step?
- Encourage them to explain their observations in each activity. Which factors influence the force between two charges?

Activity 2.8

- Ask them to do activity 2.8 by following the instructions in the learner's book.
- Summarise the observations in the two activities in form of a law. Can they state Coulomb's law?
- Guide them through examples 2.3 and 2.4.
- Ask them to do exercise 2.3.

Assessment

Observation

- Observe the set-ups made by the learners. Guide them accordingly. Pay attention to those who may be experiencing difficulties.
- Observe the learners as they do the activities. Are they making the correct observations? Is every learner participating?

Conversation

- Ask the learners some questions as they do the activities and present their findings to the rest of the class. Can they state Coulomb's law correctly? Can they explain the law?
- Also, allow them to ask you questions as you respond. This will encourage the slow learners.

Product

- Check if the learner has written the derivation of the expression for Coulomb's law. What is your rating of the equation?
- Check the answers given by the learners. Do their written answers depict mastery of Coulomb's law?

Specific learning outcome

By the end of this section, the learner should be able to test the type of charge on an object using a gold leaf electroscope.

Teaching guidelines for activities 2.9 to 2.12

Activity 2.9

- Group learners into convenient groups.
- Let them familiarise themselves with the gold leaf electroscope while checking its various parts.
- To achieve observable results, ensure the gold leaf and the plates are dry before doing each of the activities. In activity 2.9, discuss with the learners what an electroscope is. Observe the diagrams being drawn by the learners. Give guidance where necessary. Let them discuss amongst the group members all the parts of an electroscope and their functions, how does an electroscope work?
- Are they able to state the functions of each part?
- Ask them to use the provided chart and draw an electroscope in their exercise book. Ensure that the drawing is accurately labelled.

Activity 2.10

- Ask the learners to say what they remember on the previous activity.
- Ask them to do activity 2.10 to investigate the distribution of charges on metallic conductors by applying the methods of charging and discharging an electroscope i.e. by contact and induction.

- Ensure that the steps in the procedure are followed. Can they successfully charge the electroscope? Can they discharge it? Note that in Part 2 steps 4, 5, 6 and 7 have results which can be observed by the learners.
- Move around the class observing and guiding them accordingly.

Activity 2.11

- In activity 2.11, learners are being trained to design their own activity and work on it to achieve results. Guide them accordingly.
- Discuss their observations in each step. Why does the divergence decrease when the hand is placed on the cap of the gold leaf electroscope?
- Discuss with them some of the uses of a gold leaf electroscope.

Activity 2.12

- In activity 2.12, learners are to work in groups and identify insulators and conductors. Note that one of the uses of the gold leaf electroscope is to identify insulators and conductors.
- Ask the learners to explain their observations in each step. Was there repulsion or an attraction? What does each observation mean? Discuss the observations with the rest of the class.

Note: Conductors are materials that allow electric charges to flow through them.

Insulators do not allow (electric charges) electrons to pass through them.

- Ask them to answer questions from exercise 2.4.

Assessment

Observation

- Observe the learners as they do the activities. Are they following the instructions given? Are all the learners actively involved?
- Encourage them to record their observations.

Conversation

- Ask the learners some questions as they do the activities and present their findings to the rest of the class. Can they explain the processes of charging/discharging an electroscope? Can they tell how to identify the charge in an object, conductors or insulators?
- Refer the learners to the various figures as you discuss their findings.

Product

- Check the learners' written observations from the activities. Are the observations correct and logical? Draw conclusions for the activities.
- In activity 2.11, repulsion is the only sure test that a body is charged based on the following observations:
- Ask the learners as you review exercise 2.4.

Charge on the gold leaf	Charge brought near cap	Leaf divergence
+	+	Increases
–	–	Increases
+	–	Decreases
–	+	Decreases
–	Uncharged body	Decreases

Specific learning outcome

By the end of this section, the learner should be able to describe some applications of methods of electrostatic charging.

Teaching guidelines for activity 2.13

Learners interact with many applications of electrostatic charging as mentioned early in the topic.

- Guide by reviewing with the learners through some of the methods of charging objects.
- Ask them to carry out activity 2.13.Let them explain why the particles stick on the mirror. What is the significance of sprinkling the mirrors with fine chalk dust?
- Let them note down their findings, explain and present them to the whole class. What else can be used instead of the mirrors?

Assessment

Observation

- Observe the learners as they do the activity. Are they able to get some findings? Are they making correct observations?
- Move around the class marking a few of the questions in class.

Conversation

- Ask the learners some questions as they do the activities? Can they explain some applications of electrostatic methods of charging?
- Guide them as the groups present their findings to the class and during class discussions.
- Ask the learners to attempt question from the unit Test 2. Encourage them to consult if in difficulty. Offer individual assistance to those facing challenges.

Product

- Ask the learners to do question 6 from exercise 2.4 in the learner's book. Mark their written answers. Do their answers show understating of applications of methods of charging?
- Check the learners' answers to the unit test.

Project work

Specific learning outcome

By the end of this section, the learner should be able to make a simple gold leaf electroscope.

Teaching guidelines

- This work should take about two weeks. Facilitate the learners by ensuring that the materials required for this project are available. You are encouraged to improvise in case of scarcity, for instance a nail could be used instead of the copper or brass rod.
- Ask them to record all their observations.
- Ask them to discuss their findings.

Assessment

Observation

- Check the learners as they go on with the project. Are they able to set up the leaf electroscope?
- Supervise the discussion..

Conversation

- Let them discuss as they do it. Ask them some probing questions about the project work. Are their answers satisfactory?
- Ask them to do some selected questions from Unit Test 2.

Product

- Have a look at the result of the project of the leaf electroscope.

Can it pass for some of the activities?

- Mark and review questions done from Unit Test 2.

Answers to numerical questions

Exercise 2.3

2. 2.1621×10^{-5} N
3. 1.99 m
4. 2.939×10^{-1} N
5. 2 m
6. 2.1621×10^{-4} N
7. -129.6 N
8. 5.12×10^{-10} N
9. 9×10^{3} N
10. 2.304×10^{-8} N
11. 7.465×10^{-8}N
12. 2.0×10^{-4}C
13. -3.6×10^{-4}N
14. 0.027 N

Topic test 2

14. 0.0176 N
15. 923.5×10^{-7} N

UNIT 3

Electricity

(Student's book, pages 76 - 146)

Topics in the unit

Topic 3: Current Electricity (II)

Topic 4: Basic Electronics

Learn about	Key inquiry Questions
Learners should investigate the conditions for current flow using appropriate electric equipment to measure current, electromotive force, resistance, resistivity and also the units of electric current the ampere, quantity of electricity (coulomb), volt, Ohms and ohm-metre and how to use P = It to solve problems. They should verify Ohm's law experimentally and write the relationship between the résistance, length of a conductor and its diameter, derive the equation and apply it in calculations. Learners should investigate electromotive force emf E E = V + Ir and series and parallel circuits and apply it to the domestic electricity supply. They should solve problems in series and parallel circuits and apply the Kirchhoff`s rules. Students should apply current electricity to electronics in semi-conductors: conduction types, p-n junction, I – V characteristics, and applications, Transistors: functioning and applications, operational amplifier, functioning and applications.	• Why do we study electric current? • Why are electrical appliances always connected in parallel at home? • How do we connect a voltmeter in an electric circuit? • How can we verify ohm's law? • How do we differentiate the various sources of e.m.f?

Knowledge and Understanding	Skills	Attitudes
• Understand the nature of current electricity. • Understand the effects of the internal resistance of a source of e.m.f. on the terminal potential difference and output power.	• Investigate the conditions for current flow using appropriate electric equipment to measure current • Verify Ohm's law experimentally • Design and make circuits to include ammeter, switch, battery, fuses and lamps, test insulators and conductors and use the units ampere, volt, ohm. • Solve problems in series and parallel circuits and apply the Kirchhoff's rules • Apply current electricity in electronics for semi-conductors	• Appreciate the importance and uses of electricity

Contribution to the student's competences

1. Cooperation

Learners are required to work in pairs and groups in different activities in the topic. This will promote cooperation among the learners, as they will require each other in carrying out the tasks asked.

2. Communication

Learners are asked to discuss their findings among themselves. They are also required to present their findings to the whole class. This will enhance their communication skills as well as their self-esteem.

3. Critical and Creative thinking

The unit comprises of exercises and questions that provoke the learner's thinking. They are required to think critically and creatively before providing their answers. For instance, exercise 4 questions 3.

Links to other Subjects:

1. Geography-Hydroelectric sources
2. Chemistry -Electrolysis

Cross-cutting issues addressed in this topic

1. Peace and value education

Make learners aware that the materials provided to them to carry out activities should not be used to hurt others. People should live in peace and harmony in order to develop. Inform them that they should be willing all the time to accommodate the views of others. Make them aware that it is not possible to always agree on everything especially in-group discussion. Therefore, it is advisable to condone others particularly in areas where disagreements arise.

2. Life skills

When we use locally available materials to make different tools, our work becomes easy and cheaper. Encourage learners to develop a habit of making their own tools. Also, encourage them to develop a culture of working together irrespective of gender. You should also involve all learners in various activities irrespective of their physique.

Attention to special education needs

As a teacher, you should know all your learners well. Do not assume that all of them are well and can carry out any task given to them with ease. You may have learners with special needs. Know how to handle them so that they can also benefit from the learning activities, for instance, those who may have eye problems should be asked to hold while others observe. They should also sit close to the board to avoid straining. Refer to the introduction part of this Teacher's Guide for more information.

Topic 3 Current electricity (II)

(Student's book pages 82-125)

Background information/prior knowledge

In this unit, they shall cover Current electricity. In Secondary 1, the learners were introduced to simple circuits. They also measured current and voltage in simple circuits. Here the learners shall find circuit connections interesting as these are hands-on activities. Resistors are either connected in series or parallel. This section deals with determining the effective resistance of resistors. Mathematical skills of the learners will be very instrumental in the derivation and application of the expressions for effective resistance. You may therefore have to review some mathematical concepts to guide the learners understand better. Try as much as possible to exploit their prior knowledge and /or experiences when introducing concepts in this topic.

Subtopics

Subtopic No.	Name of Subtopic
3.1	Ohm's law
3.2	Electrical resistance
3.3	Resistors
3.4	Arrangement of resistors in electric circuits
3.5	Kirchhoff's laws
3.6	Factors that affect resistance of materials (wires)
3.7	Internal resistance, r

Suggested teaching/ learning activities

3.1 Ohm's law

Specific learning outcome

By the end of this section, the learner should be able to state and explain Ohm's law.

Teaching guidelines to activities 3.1 and 3.2

Activity 3.1

- Review the concept on Electricity I learnt in Secondary I Physics. Do they remember simple circuits that they connected? Ask them questions related to measuring current and voltage. Test their understanding of the concepts.
- Organise the learners in mixed ability groups. Ask them to read the instructions of activity 3.1 before attempting to do it.
- Guide them to assemble the materials provided and connect the circuits as shown.
- Guide them on how to take measurements of voltage and current accurately. Can they adjust the variable resistor so as to vary the potential difference across the wire? Ensure that they note and record their observations in a tabular form.
- Discuss with them their results and make conclusions that result into Ohm's law.

Activity 3.2

- Review activity 3.1 together with the learners. Let them retain the groups they had in activity 3.1.
- Ask those probing questions about graphs, for example, on which axis should a constant be placed?
- Ask them to reconnect the circuit in activity 3.1. Ensure that the learners grasp steps 2 and 3 of the activity. Ask them to adjust voltage and read the ammeter at the same time?
- Encourage them to record their observations in a table such as the one shown in the activity.
- Let each group draw a graph of potential difference against current. Guide them as they discuss the graphs drawn by the various groups. Ask them to say the type of a graph it is. Let them calculate the slope of the graph for different sections. Prompt them to find out if they know what the slope or gradient of the graph signify.
- Guide them to analyse their graphs and present their presentations in class. Are they able to relate current and potential difference across a given conductor?

Note that the graphs cement the relationship between voltage across a conductor and current passing through the conductor. This relationship shows a constant which is referred to as **resistance**. The slope of the graph of voltage against current represents resistance.

1. This is a straight line graph. Only Ohmic conductors produce such graphs.
2. Non-Ohmic conductors do not obey Ohm's law and so they do not produce straight-line graphs.

- As an assignment, ask the learners to draw the following graphs:
  1. Current vs. voltage
  2. Current vs. time

Assessment

Observation

- Observe the learners as they do the activity. Are they connecting the circuits correctly and noting down correct observations?
- Observe how they connect the voltmeter and ammeter. Are they connected in series or in parallel?
- Observe how they record their findings in the tables.

Conversation

- Guide the learners as they do the activity. Engage them with questions that would provoke their reasoning. Ask the learners some questions as they present an analysis of their graphs. Can they explain the shapes of the graphs in relation to how current varies with potential difference?
- Are they able to correctly state Ohm's law? Discuss the law with them. Have further discussions on the same using activity 3.2.

Product

- Look at the graphs of potential difference, V against current, I drawn by the learners. Are the graphs accurately drawn? What shape are the graphs? Do they accurately represent Ohm's law?
- Check the calculations of slopes by the learners. Remind them that,

$$\text{Slope} = \frac{\text{Change in V}}{\text{Change in I}}$$

- How can you verify Ohm's law using the learner's findings? Show that V = IR.

3.2 Electrical resistance

Specific learning outcome

By the end of this section, the learner should be able to explain and solve problems that involve electrical resistance.

Teaching guidelines for activities 3.3 and 3.4

Activity 3.3

- Let the learners be in mixed ability groups. Ask them to read activity 3.3 before doing it. In this activity, learners are to come up with their own procedure before assembling the circuits. Mention to them that a wrong procedure will obviously give wrong results. They should also be cautioned about careless handling of electricity.
- Ask them to carry out activity 3.3.
- Move around and read the procedure for each group. Guide them to assemble the correct circuits.
- Guide them to proceed to draw a circuit for measuring electrical resistance of the wires.
- Guide them on how to take collect readings of current for copper, tungsten and nichrome wires. Ensure that they record their observations in a table such as table 3.1 in the learner's books. Ask them questions that involve comparing the resistance of the wires.
- Define to them the word 'resistance'. This should usher them to activity 3.4 where they are required to determine the resistance of a resistor.

Activity 3.4

- Ask the learners to work in convenient groups as in the previous activity. Move around the class observing the circuits that the learners have connected. Correct and guide them accordingly.
- Ensure they record their observations in a table such as table 3.2 in the learner's book. Engage them as they carry out the activity i.e. why is it necessary to adjust the variable resistor?
- Let them plot graphs of potential difference against current, I and calculate the slopes. What does the value of the slope represent?
- Are the learners able to explain electrical resistance? Ask them questions to test their understanding of the concept. What is the resistance of the nichrome coil?
- Let them analyse their graphs and present them to the class.

- Take them through examples 3.1, 3.2 and 3.3 Gauge their understanding of the concepts.
- Ask them to do some questions from exercise 3.1 in the learner's book.

Assessment

Observation

- Introduce the learners to key components such as resistors, ammeters, voltmeters so as to familiarise with them. Encourage them to touch, feel and see their structures.
- Observe the learners as they do the activities. Are they connecting the circuits correctly? Are they making the right observations?
- Have a look at the graphs drawn by the learners. Do they conform to Ohm's law?

Conversation

- Engage the learners with questions that are meant to sustain their interests while carrying out the activities. The questions should provoke critical thinking.
- Ask them questions as they present an analysis of the graphs? Can they explain the shapes of the graphs in relation to the electrical resistance? What do the slopes of the graphs represent?
- Discuss their graphs and their slopes. When compared, Do all the values of V/I give a constant value? Why?
- Also, discuss new words with the learners. What is electrical resistance?

Product

- Check the graphs drawn by the learners. Are the graphs accurately drawn? Do they accurately depict electrical resistance? Guide them appropriately.
- Check the work done by the learners. Have they mastered the concepts? Mark and review in class all the attempted questions from exercise 3.1.

3.3 Resistors

Specific learning outcome

By the end of this section, the learner should be able to explain the meaning of resistors and solve problems involving resistors.

Teaching guidelines for activities 3.5 and 3.6

Activity 3.5

- This activity should be done in manageable groups to enable the learners to share the materials.
- Provide the learners with resistors to observe. Ask them probing questions such as:

  What is a resistor? What is it used for? Name any type of resistor that you know.

  Let them categorise them into two; fixed and variable resistors.
- Allow them time to ask you questions. Always be positive in your responses so as to encourage them.
- Ask them to sketch the symbols of fixed and variable resistors.
- Let them answer the following questions: What do you think the colour strips on the resistors represent? How can you determine their resistance? How can the learners make use of improvisation in this process?
- Guide them to understand how to determine the resistance of a resistor by using colour codes. Take them through example 3.4 in the learner's book.
- Let them answer some related questions from exercise 3.2.Observe and mark their working.

Activity 3.6

- Introduce the learners to variable resistors by asking probing questions.
- Assemble a variable resistor in class as the learners get a chance to observe it. Demonstrate to them how to vary the resistance using the device.
- Ask them to organise themselves in convenient groups in preparation for activity 3.6.
- Allow them to first read through the procedure before doing the activity.
- Ensure that the activity is done under your watch to prevent accidents that could come up. You are encouraged to improvise where necessary.
- Remind them to record their observations in tabular form for ease of presentation.
- Ensure that all the steps are followed to the letter.
- Analyse and discuss with them all the observations recorded.
- Ask them to answer the remaining questions in exercise 3.2.

Assessment

Observation

- Allow the learners' time to look at the resistors provided in class. Let them familiarize with them. Observe them as they carry out the activities. Let them compare with their sketches (drawings).
- Observe them as they present their findings. Do they portray an understanding of resistance and resistors?
- You are encouraged to observe as they do the calculations so as to attend to those in need.
- In activity 3.6, are the learners observing and taking accurate readings from the ammeter? Are they recording observations properly? How bright is the bulb with every move of the slider?

Conversation

- Ask the learners some questions as they carry out and present their findings of the activity. Can they explain the meaning of resistors? What about resistance?

  Explain to them that **resistors** are devices specially made to offer resistance to the flow of current in a circuit.
- Allow them to ask as many questions as possible regarding the resistors .Explain to them the colour codes of the resistors. Mention to them that there are different types of resistors namely,

  1. Fixed resistors
  2. Variable resistors

  What is the difference between the two types of resistors?
- Use examples familiar to the learners to exhaustively discuss this section.
- Guide them to solve problems involving resistors.

Product

- Ask oral and give written questions to test their mastery of content. Are the learners able to differentiate between fixed and variable resistors?
- Ensure that the learners can differentiate the colour codes for tolerance on different resistors.
- It would be interesting for the learners to know that these devices are incorporated in radios, TVs and other devices that we use at home, schools etc.

- Mark and revise questions done from exercise 3.2 in class. This way the learners will have a better understanding of the concepts.

3.4 Arrangement of resistors in electric circuits

Specific learning outcome

By the end of this section, the learner should be able to connect resistors in series and parallel and determine their effective resistance.

Teaching guidelines to activities 3.7 and 3.8

Activity 3.7

- Organise the learners in mixed ability groups in readiness for the activity .Ensure that all the materials required for the activity are available.
- Facilitate them to connect the circuit in Figure 3.17.Ask them to first record the ammeter reading when the switch is closed. You may also encourage them to check for the readings when the switch is open so as to get to know that current only flows when the circuit is complete.
- Discuss series connection of resistors with them. A short class demonstration will enhance the learner's understanding of the same. Use an example that is familiar to them to illustrate series arrangement on the chalkboard. You may use the common batteries in a spotlight to represent resistors in series. Explain to them that in series arrangement, effective resistance is obtained by adding all the values of resistance for all the resistors in the circuit.
- Ask learners to draw on the board simple circuits when given three resistors to be connected in series, an ammeter and connecting wires. Note that the ammeter must always be connected in series.
- Guide them through examples 3.5 and 3.6. In these examples show that total resistance can be obtained by adding all the values of resistors. Encourage those having difficulties to participate by asking them questions. You can also ask them for their views.
- Let them attempt related questions from exercise 3.3.

Activity 3.8

- Introduce parallel arrangement of resistors by asking probing questions.
- Carry out a simple demonstration in class to show how resistors are arranged in parallel.

- Ask one member from each group to draw a particular circuit on the chalkboard, for example, given 2 resistors connected in parallel with a third one. Let them derive the expression for the effective resistance in the circuits they draw.
- Guide them through example 3.7 on parallel arrangement. Ask learners to volunteer to work out similar problems on the board as they discuss with others. Ensure that they understand the concepts being discussed.
- Ask them to do some related questions from exercise 3.3.

Assessment

Observation

- Observe how the groups are discussing circuits of resistors in series and parallel connection. You also have to observe as they draw the circuits both on the board and in their exercise books. How accurate are they?
- You are required to supervise the connections. Observe how they connect the wires to the terminals. How is the ammeter connected in both cases?
- Observe their body language. Some may be afraid to touch the wires or simply not following.

Conversation

- Discuss with the learners their answers and drawings. Can they describe the circuit connections and how to determine the effective resistance?
- Guide them as they discuss the examples on board. You may use many other examples so as to drive the point home.
- Engage the learners with questions while supervising and especially when dealing with a given group.
- Revise the questions done in class.

Product

- Give to the learners some questions on calculation of resistance for further practice. Test their understanding through exercise 3.3 in the learner's book.
- Mark their work and revise with them where necessary. Do their written answers demonstrate an understanding of series and parallel arrangement of resistors?

How is effective resistance determined in each case?

3.5 Kirchhoff's laws

Specific learning outcome

By the end of this section, the learner should be able to explain the Kirchhoff's laws and solve problems involving them.

Teaching guidelines to activity 3.9

- Ensure that all the materials required for this activity are available. Organise the learners in convenient groups.
- Ask them to read through the instructions as they assemble the materials suggested.
- Guide them to assemble the materials and connect the circuit to investigate Kirchhoff's laws.
- Guide them to carry out activity 3.9 and ensure they record their observations in a table.
- Guide them to determine potential differences across the resistors.
- Introduce them to Kirchhoff's current law. Ask them to state and discuss Kirchhoff's first law.
- Take them through examples 3.8 and 3.9. In your discussion define key words such as nodes, circuit, path, loop, branch etc.
- Discuss Kirchhoff's second law which is widely referred to as **' The Voltage Law**. Take the learners through examples 3.10 to 3.12. Encourage learners to participate in the discussions by asking them questions.
- Let learners attempt some questions from exercise 3.3.

Assessment

Observation

- Observe the learners as they do the activity. Are they able to observe that current entering in a circuit is equal to the current getting out of a circuit?
- Observe them as they record their observations.

Conversation

- Review the previous lessons by asking them questions related to the flow of current in a wire, resistance to current and the potential difference across the wire.

- Involve them in a class discussion to discuss Kirchhoff's laws and solve problems involving the laws. Ask them probing question to determine whether they have mastered the concepts.
- Use examples to discuss the application of the laws in solving problems. Encourage some learners to try to solve other questions on the blackboard. Can they solve related questions?

Product

- Look at the solutions given by the learners on the board. Are they accurate? Do they accurately depict the Kirchhoff's laws?
- Ask them to solve questions involving Kirchhoff's laws. Mark their work and give individual assistance to those experiencing difficulties.

3.6 Factors that affect resistance of materials (wires)

Specific learning outcome

By the end of this section, the learner should be able to state and explain the factors that affect resistance of materials (wires).

Teaching guidelines to activities 3.10 to 3.12

Activity 3.10

- These activities are better done in groups so as to share the resources available. Group work is a booster to teamwork as well as cooperation among learners.
- Guide the learners on how to do activity3.10 on finding out a factor such as length affect the resistance of a conductor. Ensure that the wires are of different length. Encourage them to tabulate their results in a table similar to table 3.7. For easy representation and presentation of results.
- Ask them to plot a graph of resistance of wire against its length using the results in the table.
- Let them present their findings to the rest of the class. Discuss how length of a wire determines the amount of current flowing through.
- Ask them to explain how the length of the wire affect resistance of the material (wires)

Assessment

Observation

- Observe as they present their findings that have been tabulated.
- Observe and guide them as they draw the graphs. What type of a graph is obtained?
- From the graph, can they deduce the relationship between the length of the wire and its resistance?

Conversation

- Discuss with the learners the results of the activity. How does the length of the wire affect the resistance of the conductor?
- Discuss with them examples related to the concept. Ensure that they understand the terms as they are used. Emphasise to them that units are part of the solution and must always be written.
- Ask them some questions as they present an analysis of the graphs? Can they explain how length determines the resistance of material?

Product

- Check the graphs drawn by the learners. Discuss the same with them. Note that a longer wire poses a higher resistance to current.
- Look at the learners' written answers. Mark them and review their work together with them
- Ask them to do question 2 from exercise 3.4. Check and mark their work. Guide them where necessary.

Activity 3.11

- Prepare the learners for activity 3.11.
- Ask them to carry out the steps in the procedure. Ensure that they connect the ammeter in series while the voltmeter should be across the conductor.
- Let them record the results in a table such as table 3.8 in the learner's book.
- Ask them to use their results and plot a graph of resistance against the reciprocal of cross sectional area.
- Guide them to make a conclusion about the relationship the relationship between the resistance conductor and its thickness. Engage them with questions and explain to them what resistivity is and how it is related to resistance.
- Explain more by taking them through example 3.13.
- Ask them to attempt questions 3 and 4 from exercise 3.4.

Assessment

Observation

- Observe and guide the learners as they carry out the activity. Are they confident as they connect the circuits? Observe their participation. Are all actively involved? Are the circuits the required ones?
- Look at their results and how they have been tabulated. Are the results accurate?

Conversation

- Engage them in a question and answer session during and after the activity. Review example 3.13 and using similar examples solve problems involving cross sectional area of a conductor.
- Discuss with the learners how the thickness of a conductor affects its resistance to current flow. Use the results obtained during the activity and analyse the table.
- Analyse and make conclusions from the graph plotted.

Product

- Analyse the graphs plotted and deduce the relationship between resistance and thickness of the conductor. Ensure that all have drawn straight-line graphs.
- Mark the work done by the learners and revise in class.

  Note that the thicker the conductor the less the resistance.

Activity 3.12

- Organise the learners in groups of mixed abilities .Guide them to set up the activity as shown in figure 3.43.
- Ask them to first record the ammeter readings before starting to heat. Remember to ask them to change the temperature of the conductor by heating the water before taking readings for the ammeter and voltmeter at intervals of 20 degrees.
- Encourage the learners to always tabulate their results for ease of presentation and calculations.
- Guide them to plot a graph of resistance against temperature.
- Deduce the relationship that exists between the resistance of the conductor and the temperature.
- Ask the learners to attempt some questions from exercise 3.4.

Assessment

Observation

- Observe them as they do the activity.
- Observe their results as written in the suggested tables**.**
- Look at the graphs plotted by the learners. Are they straight-line graphs?

Conversation

- Engage the learners in question and answer session.
- Discuss the results obtained by the learners. How is the trend? Have they drawn the correct graphs?
- Analyse them in class. Ask them what they can deduce.

Product

- Mark the results obtained by the learners. Are they the same across the board?
- Check the plotted graphs. Analyse them. What conclusion can you make for each of the graphs?
- Mark questions done in class and review the graphs.

  Note that resistance of a conductor depends on:

  1. Nature of the material of the conductor.
  2. Length of the conductor.
  3. Thickness of the conductor.
  4. Cross sectional area or thickness of the conductor.

3.7 Internal resistance, r

Specific learning Outcome

By the end of this section, the learner should be able to define internal resistance, r, derive its mathematical expression and solve problems involving it.

Teaching guidelines to activity 3.13

- This activity shall be done in groups constituted depending on different factors among them the ability of learners, class roll, resources available etc .You are encouraged to improvise where necessary.
- Ask the learners to carry out activity 3.13 in the learner's book.

- First, ask them to measure the e.m.f. of the cell using a high resistance voltmeter by connecting the cell to a known resistor. Note that the voltmeter should always be connected in parallel to the load. See figure 3.45 (b) in the learner's book.
- Ask them to record the ammeter and voltmeter readings in a table such as table 3.11 in the learner's book. To achieve this, let them set the variable resistor at its maximum.

More results can be obtained by adjusting the variable resistor (sliding the contact in order to change the resistance).

- Ask them to use their data and plot the graphs of V against I. From the graphs guide them to deduce the equation for internal resistance, $E = I(R + r)$.Guide them to calculate its internal resistance.
- Take them through examples 3.14 and 3.15. Ask them to discuss similar examples on the chalkboard.
- Ask them to attempt questions from Unit Test 3.

Assessment

Observation

- Observe the learners as they do the activity. Are they connecting the circuits correctly and noting down correct observations? Are the learners able to vary the resistance by adjusting the variable resistor?
- Observe as they record the findings in a table. Can they record the results accordingly?
- Observe and guide them as they work out some examples on the blackboard.

Conversation

- Advise the learners to correctly connect the terminals otherwise, they shall get wrong readings. Let them draw and discuss their graphs. Ask them questions related to the graphs.
- Ask the learners some questions as they present an analysis of their graphs? Can they explain the shapes of the graphs in relation to how current varies with potential difference?
- Facilitate them as they discuss examples 3.14 and 3.15. Are they able to correctly derive expressions and formula of internal resistance? Guide them where necessary.

Product

- Look at the graphs drawn by the learners. Are the graphs accurately drawn?

- Check their work done from Exercise 3.5 in the student's book. Mark and attend to those with difficulties in answering the questions. Review the exercise.
- Check work done by the learners in the Unit Test 3 questions given at the end of the topic. Mark their work and assess the extent to which they have mastered the concepts learnt in the unit. Organise remedial teaching for those who may still be having challenges.

Answers to numerical questions

Exercise 3.1

2. 8 Ω 3. 6 V 4. 6 V 5. 100 Ω

6 . (a) 0.75 A (b) $4.688 \times 10^{18}\ s^{-1}$

Exercise 3.3

2. Currents through: R1, R2, R3 are 10.5, 24.7 and 14.8 A respectively
3. 25 mA
4. 3 A
5. (a) 1.44 V, 0.72 V (b) 2.16 V
6. (a) 0.6 A (b) 7.2 V (c) 18 V
7. (a) 1.5 A (b) 6 V
8. (a) V = 4 V (b) 1.2 V
9. (a) 30 Ω (c) 0.4 A (b) 0.4 A (d) 4V, 8 V
11. (a) 31.3 Ω
    (b) Current through 30 Ω is 0.0479 A
    Current through 40 Ω is 0.016 A
    Current through 2 Ω is 0.032 A

Exercise 3.4

2. 5 Ω 3. 9.051 m

Exercise 3.5

1. (a) 1.5 V (b) 1.3 V (c) 0.6 Ω 5. 1.67 A

Topic test 3

1. 4 Ω 3. a) 10 A b) 5 A c) 2.4 Ω 4. 9 Ω 9. 2.92 m

Topic 4 Basic: electronics

(Student's book, pages 126-153)

Background information/prior knowledge

Learners are familiar with some of the components in basic electronics, for example, bulbs, cells, conductors, semi-conductors and insulator materials, diodes among others. Most of them may also be electronic circuit boards of their radio or TV sets at home. This topic should therefore be interesting to learners.

Subtopics

Subtopic No.	Name of Subtopic
4.1	Definition of electronics
4.2	Conductors, semiconductors and insulators
4.3	Intrinsic and extrinsic semi—conductors
4.4	Doping in semi-conductors
4.5	Electronic components
4.6	Transistors
4.7	Operational/amplifier

Suggested teaching and learning activities

4.1 Definition of electronics

Specific learning outcome

By the end of this section, the learner should be able to explain what electronics are.

Teaching guidelines to activity 4.1

- Organise learners into appropriate groups to do activity 4.1 in the learner's book.
- In the event the electronic instruments suggested are not available in your school, use any other locally available material that can be found in the school or at your home to do this activity. Alternatively, you can use a chart with well-drawn electronic instruments that are suggested here.

- Ask the learners to identify electronics from the materials provided to them. Let them give a reason for any identified material.
- Ask them to name any other electronic devices that they know.
- Guide them to conduct a meaningful research on electronics. Allow them to ask you questions as you answer.
- Let them to discuss their findings before presenting them.

Assessment

Observation

- Observe the groups discussing the concept of electronics. Listen carefully to their answers as you check the way they relate to each other. Are they able to identify and define electronic materials?
- Observe all the electronic devices identified by the learners. Do they understand what electronics are?

Conversation

- Talk to the learners while discussing their answers. Can they explain what electronic components are by giving examples?
- Answer questions from them. This will enhance their confidence and public speaking.
- Take the learners through the discussion given in the student's book.

Product

- Read the answers written down by the learners. Are their answers depicting the mastery of the concept on electronic instruments?
- Check their findings .Review the meaning of electronics in class.

4.2 Conductors, Semi-conductors and insulators

Specific learning outcome

By the end of this section, the learner should be able to distinguish between conductors, semi-conductors and insulators and give examples of each of them. They will also explain how conductors and semi-conductors conduct electricity while insulators do not.

Teaching guidelines to activity 4.2

- This activity can be done in groups so as to share the scarce resources such as reference books and laptops. Set rules that should be followed while using the reference materials.

- Organise learners into convenient groups depending on the availability of materials and their abilities.
- Ask the learners to do activity 4.2 in the learner's book.
- Observe how learners connect the bulb, cell holder and switch using connecting wires to make a simple circuit. Guide those who may have difficulties. Let them know that the switch has no polarities.
- Ask them to open the switch and in turn connect the materials across the switch to complete the circuit.
- Let them observe the materials that will light the bulb and which ones will not when connected to the circuit. Ask them to tabulate their observations.
- Allow them to discuss their findings and ask them to give a reason as to why the bulb lights when some materials are connected.
- Guide them to locate the relevant reference materials from which they can carry out research on good and bad conductors of electricity. Did you come across some that are semi-conductors? In case laptops are being used, organise the students into appropriate groups so as to share the devices.
- Go round the class observing if they are using the phones properly. Caution them against accessing unauthorized sites.
- Allow them time to discuss their findings in their respective groups.

Assessment

Observation

- Guide the groups of learners as they design a simple circuit on paper. Observe as they connect the circuit. Are they connecting as required? Guide them accordingly.
- Observe the groups discuss their findings. How many are conductors? Which ones are they? Can they distinguish between conductors, semi-conductor materials and insulators?
- Observe them as they carry on with the activity.

Conversation

- Engage the learners in question and answer session as they carry out the activity. Talk to the learners while discussing their findings. Can they give reasons why they have categorised materials provided at this point.)
- Take them through the discussion about the conducting ability of different materials given in the student's book.

- Ask learners the following questions:
    1. What is the name given to materials that allow electric current to pass through them?
    2. What is a semi-conductor?
    3. How do semi-conductors work?

Product

- Read the findings in the tables drawn by the learners. Have they understood the concept on semi-conductors, conductors and insulators?
- Let the group the materials provided into conductors, insulators and semi-conductors.

Note that conductors allow electric current to pass through them. Examples are copper wires. Insulators do not allow current to pass through them. Examples are wood and plastic; semi-conductors include materials like silicon. What is current?

4.3 Intrinsic and extrinsic semiconductors

Specific learning outcome

By the end of this section, the learner should be able to explain intrinsic and extrinsic semi-conductors.

Teaching guidelines to activity 4.3

- Ask learners to be in pairs and research on the types of semi-conductors. Instruct them to write the reference materials used in the research. For those with reference books, guide them to check the table of content of the book for intrinsic and extrinsic semi-conductors so as to locate the content page faster.
- Ask them to carry out a research on 'doping of each semi-conductor' from the books given to them.
- Guide them in the discussion on doping of semi-conductors .Let them discuss among themselves and write down their findings. Let them state the differences between intrinsic and extrinsic semi-conductors. Can they give examples of each?
- Allow learners to note down their findings and discuss them.
- Let them make a short report and present their findings to the whole class. You should accommodate all the views from the learners. However, be keen to rectify mistakes in a friendly but firm manner.

- Discuss extrinsic and intrinsic semi-conductors stating their differences .Gradually introduce them to the concept of doping.
- Ask them to attempt questions from exercise 4.1 in the learner's book.

Assessment

Observation

- Observe the groups as they discuss their findings. Are they able to explain intrinsic and extrinsic semi-conductors well?

Conversation

- Guide them in a discussion regarding intrinsic and extrinsic semi-conductors.
- Can they explain intrinsic and extrinsic semi-conductors? (Note that they may not but we are provoking them to think.)Take them through a discussion of doping, lattice, bonding, holes, n-type semi-conductors, p-type semi-conductors etc.
- Engage them in a session of questions and answers.

Product

- Read the answers written down by the learners. Are their answers depicting mastery of concept on intrinsic and extrinsic semi-conductors? What are some of their applications?
- Are the learners able to state the different semi-conductors and differentiate between them?
- Mark their work done from exercise 4.1.Review it for ease of understanding.

4.4 P – n junction diode

Specific learning outcome

By the end of this section, the learner should be able to explain the working of a p-n junction diode, its characteristics and applications.

Teaching guidelines to activities 4.4 and 4.5

Activity 4.4

- Organise the learners' in-group of mixed abilities in readiness for the activity. Ensure that all the materials required are available.

- Ask them to read through activity 4.4. Observe them as they connect to the terminals of the cell. Explain to them that this determines whether the p-n junction diode is forward biased or reverse biased mode.
- Instruct them to write their observations.
- Briefly review the concept of doping of semi-conductors to enable them to understand better.
- If one of the materials suggested is not available, let the learners suggest how to improvise one, for instant, if there is no switch in the school laboratory they can improvise one using wires and piece of wood.
- Ask them to connect a p-n junction in a forward basis. Let them note down what happens to the bulb as in figure 4.16(a).
- Ask them to reverse the connection of the diode. Let them also record their observations on the bulb as in figure 4.16(b).
- Give them time to discuss their findings in their respective groups before asking them to present to the whole class. This will promote communication skills and cooperation among them.

Activity 4.5

- In activity 4.5, the learners are required to investigate the relationship between current through and voltage across a p – n junction diode. Note that they have to show their creativity*, responsibility* and collaborative skills. Retain the previous groups of learners.
- Guide them as they write the procedure with which to do the activity.
- Ask them to use the set up in Fig. 4.19 in the student's book to guide them while carrying out this activity.
- Ensure that the learners connect the p-n junction in a forward bias by moving around and guiding those with challenges. Also, check their notes regarding the steps in their procedure. Emphasise on the importance of following the correct steps.
- Let them close the switch once the connection is complete and note down the potential difference and current.
- Ask them to reverse the connection of the p-n diode and repeat the steps.
- Let them record their findings in a table such as table 4.1 for ease of representation and analysis.
- Ask them to draw a graph of current against the potential difference.

- Guide them in analysing the graph they have drawn and suggest some applications of a p-n junction diode.

Assessment

Observation

- Does the bulb light up in activity 4.4?
- Observe the groups discussing their answers. Are they able to explain the working of a p-n junction diode? Can they list the characteristics of a p-n junction diode? What of the applications?
- Move around the class observing the connections made by learners.
- Also, be keen to check their results and the way they have recorded them.

Conversation

- Review the previous lesson through question and answer. Gauge their understanding and decide how to guide them through this activity.
- Engage them as you look at their procedures for the activity. Have they written the correct procedures? Emphasise the importance of having the right steps, as they will result in the correct findings.
- Talk to the learners while discussing their results. Can they explain the working of a p-n junction diode? What of its characteristics? Can they explain them?
- Discuss with them the graph they have drawn. Are they able to explain it?

Product

- Check and read the answers written by the learners.
- Check the graphs drawn by the learners. Is the graph the expected one?
- Check the analysis of their graphs.

Teaching guidelines to activities 4.6 and 4.7

Activity 4.6

- Attract the learners' attention that they are required to convert a.c to d.c using a single diode. In the event the cathode ray oscilloscope (CRO) is not in your school, arrange with the administration of the school and borrow one from nearby schools or colleges.

- Organise learners into convenient groups. Let them carry out activity 4.6.
- Ask them to connect a resistor to an a.c power supply. Then connect a cathode ray oscilloscope across the resistor as in figure 4.23 (a).
- Ask them to draw a sketch of the signal displayed,
- Add a p-n junction diode to the a.c power supply as in figure 4.23(b). Ask them to write what they see on the display.
- Observe how learners are connecting and help those who may have difficulties in connecting the circuits.
- Let them observe the CRO. Ask them to reverse the connection of the diode and observe what happens. Ask them to sketch the graphs each time as shown on the CRO.
- Using their sketched graphs ask them to discuss in their groups what half and full rectification is.
- Ask them to present their findings to the whole class about Activity 4.7.
- Retaining the groups in 4.6, ask the learners to do activity 4.7. Guide them to connect as shown in figure 4.26.
- Emphasise to them that observations are instant and must be recorded as soon as they are made. Let them observe the displayed graph on the CRO.
- Discuss with them the findings in relation to full rectification of the alternating current to direct current.

Assessment

Observation

- Observe as the learners do the activities according to the laid down steps. How well are they connecting the circuits?
- Observe them as they draw sketches of graphs displayed.
- Observe as the groups discuss their findings. Can they explain half and full rectification?

Conversation

- In activity 4.6 can the learners explain the shape of the signal?

  What do we call a situation where current is restricted only to flow in one direction in a circuit?

- Talk to the learners as they are discussing their findings. Are they able to explain half and full rectification correctly as highlighted in the student's book?
- Explain the key words in this section.
- Allow them to ask many questions as possible.

Product

- Check the sketches made by the learners. What do they depict?
- Read the answers given by the learners. Are the answers showing mastery of concept on half and full wave rectification?
- Listen and check the learner's answers as you explain and guide them.

4.5 Transistors

Specific learning outcome

By the end of this section, the learner should be able to explain what a transistor is, its structure, operation and use.

Teaching guidelines to activity 4.8

- Ask learners in advance to research on the working of a transistor.
- Organise to bring to class a motherboard of the electronic device. You can get a transistor from the radio, which is not in use, or from the local radio technician.
- Organise the learners into convenient groups to do activity 4.8. Note: This activity aims at testing the creativity of the learner and his/her problem solving skills.
- Guide them to describe the structure of a transistor. Guide them as you mention the type of transistors available. Explain to them some of the uses of a transistor such as a switch.
- Ask them to discuss their observation in their groups.

  How does a transistor behave?

Assessment

Observation

- Observe the learners as they carry out the activities. Observe the groups discussing their answers. Can they define a transistor? Can they explain its operation and uses?

Conversation

- Ask them some probing questions about transistors. Do they have any prior knowledge of transistors?
- Talk to the learners while discussing their answers. How accurate are their responses? Can they explain the working and uses of a transistor well?
- Engage the learners to state the working and roles of transistors in our daily lives.

Product

- Read the answers given by the learners from their discussion.
- Explain to them the role of transistors in day-to-day lives.

4.5.2 Uses of transistors

Specific learning outcome

By the end of this section, the learner should be able to explain the working of an operational amplifier

Teaching guidelines to activities 4.9 and 4.10

Activity 4.9

- Organise the learners in convenient groups in readiness for carrying out activity 4.9. Ensure that all materials required are available.
- Ask them to familiarize themselves with the circuit by allowing them to read through.
- Review together with the learners the concept on the transistor as a switch.
- Guide them on the relevant reference materials and carry out research on a transistor-operated switch. Move around the class guiding those in need and motivating others as you ask them questions.
- Give them time to discuss their findings in their groups.
- Ask them to present their findings/report in class.

Activity 4.10

- Discuss about the operational amplifier in the same context.
  What are the basic building blocks of an analogue electronic circuit?
- Also, guide them to find out more on the working of an operational amplifier.

In a linear operational amplifier, for the output signal the amplification factor is known as the **amplifier gain.**

An operational amplifier is used to make audio power amplifier among others.

- Guide them through the discussion given in the student's book to verify some of their points. Discuss with them some of the applications of an operational amplifier.
- Ask them to do the questions in exercise 4.2 and some from Unit Test 4.

Assessment

Observation

- Observe as the learners carry out activity 4.9. Ensure that all members of a group participate in the activity. This is because we learn more by observing.
- Observe groups as they discuss their findings. Are they able to explain well what an operational amplifier is? Guide them where they may find difficulties.

Conversation

- Ask the learners discuss their findings and be sure to clarify the key points to facilitate the teaching and learning process.
- Discuss the various reports by the learners.

Product

- Read the answers written by the learners from the activities and discussions.
- Mark the answers given for exercise 4.2 and the Unit Test 4.

UNIT 4

Mechanics, motion and laws of linear motion

(Student's book, Pages 147 – 209)

Topics in the unit

Topic 5: Mechanical properties of solids

Topic 6: Motion and momentum

Learn about	Key inquiry questions
Learners should investigate the application of vectors for the analysis of static equilibrium and analyse structural elements like trusses, frames and beams. They should understand the principles of kinematics and kinetics of particles and coplanar rigid bodies including the principles of static equilibrium to particles and rigid bodies such as truss and frame structures. Learners should investigate frictional forces using shear force and bending moment diagrams, apply the principles of kinematics and kinetics of particles, work, energy, and impulse and momentum to particles. Learners should analyse planar rigid body kinematics and kinetics. Learners should apply measurement techniques and formulate tests, to a range of common structures. They should design and conduct experiments to test the rigidity of structures. They should use the techniques, skills, and modern engineering tools in practical situations involving structures.	1. How do we demonstrate the application of vectors for the analysis of static equilibrium? 2. How do we analyse structural elements like trusses, frames and beams? 3. How can we demonstrate an understanding of the principles of kinematics and kinetics of particles and planar rigid bodies? 4. Why do we identify techniques for measurement?

Knowledge and Understanding	Skills	Attitudes
Understand the laws of linear motion. Understand the principles of kinematics and kinetics of particles	Investigate the application of vectors for the analysis of static equilibrium Investigate frictional forces using shear force and bending moment diagrams Analyse structural elements like trusses, frames and beams Analyse planar rigid body kinematics and kinetics. Design and conduct experiments to test the rigidity of structures	Appreciate the impact of the laws of

Links to other subjects

1. Mathematics: For the learners to be able to derive and solve the equations of motion they will require the knowledge on integration and differentiation, which is covered in Mathematics. Application of vectors in analyzing static equilibrium.
2. Chemistry: Composition of rigid body kinematics and kinetics
3. Geography: A check on the environment.

Contribution to student competences

1. Communication skills and cooperation: This unit comprises activities and exercises that require the participation of learners in discussing and presenting their findings amongst themselves and to the whole class. When the learners are discussing amongst themselves and then presenting while the teacher listens, their communication skills are enhanced.
2. Critical thinking: This unit gives the learners a variety of activities and questions that require them to think critically. For instance, the learners are to state Newton's equations of motion and use them to solve the given questions.
3. Co-operation: As the learners are doing the activities, they should be able to work collaboratively, and harmoniously to help each other in the learning process. Encourage them to take turns when discussing the different concepts e.g. when deriving the equations of motion each one in the group should be allowed to make his or her contribution. This also enhances learner-to-learner inter-relations.

Crosscutting issues addressed in this topic

1. Life skills: The topic has covered different structures and how to test their rigidity. The learners have used local materials such as straws to make different structures and test their rigidity thereby improvising. These skills are very important in the lives of learners since some of them will become structural engineers. They will apply these concepts to make standardised and quality structures.
2. Peace and value education

   Learners will interact with each other as they carry out the activities. This teaches them the importance of teamwork, peaceful co-existence and respect for other person's views.

Attention to special education needs

- This unit involves many activities, which are intensive. It is important to be aware of your class and the physical needs of your learners. Ensure that the learners with disabilities are well taken care of and they are participating in the class activities. Remedial classes for slow learners are highly encouraged. However, the gifted learners must be given extra and more challenging questions.
- For more information about attention to special needs, refer to the introduction part.

Topic 5 Mechanical properties of solid

(Student's book, pages 156 – 176)

Background information/prior knowledge

Learners have encountered these concepts in their daily lives without their knowledge. It shall be interesting for them to work with, structures such as beams, frames and trusses that they have been seeing with undue regard for them. Therefore, approach this topic from known to unknown while incorporating locally available materials in most of your examples.

Subtopics

Sub topic No.	Name of the sub topic
5.1	Static Equilibrium
5.2	Structure of elements-Bending of beams
5.3	Shear force
5.4	Notch effect
5.5	Struts and ties
5.6	Shapes and strength of structures

Suggested teaching/learning activities

5.1 Static equilibrium

Specific learning outcome

By the end of this section, the learner should be able to explain what static equilibrium is and solve related problems with ease.

Teaching guidelines to activity 5.1

- In part one of the activity, ensure that the learners organise themselves in groups of 10. Let each group having five members pulling the rope in opposite directions. Let them observe what happens.

- Ask them some probing questions to stimulate their thinking, for example, ask them why the two groups are not pulling with the same force.
- Give them a chance to explain what would happen if the groups pull with equal strengths and when they pull with unequal strengths.
- For the second part of the activity, guide them as they fix three springs on a loop at different sides as shown in Fig.5.1.
- Ensure that they pull in three different directions. Engage the learners in a question and answer session so as to gauge their understanding, Ensure that the ring is strong enough not to tear apart while pulling is in action as the learners can be hurt.
- Give them time to discuss their results in their respective groups.
- Ask one member of each group to give a summarised report about the activity in class.
- Guide them through examples 5.1, 5.2 and 5.3 in the learner's book.
- Ask the learners to do exercise 5.1 in the learner's book.

Assessment

Observation

- Observe the groups carry out part one of the activity and as they discuss their results. Are they able to define static equilibrium?
- Encourage the learners to observe together under your guidance what happens in part two of the activity.

Conversation

- Talk to the learners while discussing their results. Can they explain what static equilibrium is? Can they effectively solve a question related to equilibrium?
- Ask them questions to test their alertness, for instance:

What can you observe as you pull? Are the forces balanced? What would happen if all the three forces were equal?

- Discuss with them different situations where balanced and unbalanced forces are experienced. Take them through example 5.1 on the chalkboard. As you discuss the example, give them a chance to participate.
- Allow them to discuss examples 5.2 and 5.3 in the student's book with their partners. This will give them an opportunity to master the calculations and enhance their self-esteem as well. You can then review the examples on the chalkboard for clarification.

Product

- Let the learners state that an object at equilibrium is either:
  (i) At rest or staying at rest.
  (ii) In motion and continuing in motion with the same speed and direction.
- Let them read the answers that they have written for exercise 5.1.Ensure that their answers reflect mastery of concept of static equilibrium.
- Mark their answers that they have given for the exercise 5.1.

  Note that an object is said to be in equilibrium state if all forces acting on it are balanced.

5.2 Bending of beams

Specific learning outcome

By the end of this section, the learner should be able to understand different structures of elements such as beam and what happens when a beam is loaded.

Teaching guidelines for activity 5.2

- This activity aims at testing the creativity of learners as well as their mastery of content and its application.
- Organise the learners in convenient groups.
- Guide them to use the set up in Fig.5.14 to carry out an investigation on what happens when a beam is loaded.
- Ensure that their procedure (which they will have written) has all the steps as listed herein:
  (i) To list all the materials to be used in the activity i.e. two wooden blocks, rectangular rubber blocks and masses.
  (ii) To draw parallel lines on the sides of the rubber block and place it on the wooden blocks as in the figure.
  (iii) Place masses at the middle of the rubber block until it bends significantly.
  (iv) Observe all the changes in the pattern of lines on the rubber and record them.
- Guide the learners to observe the new shapes of patterns of lines. Are they able to explain the shape?
- Let the learners discuss their findings within their groups.

- Ask them to sketch the new shape of the pattern of lines and explain the shapes.
- Involve learners by asking them to do basic activities for example, observing how a table or desk is made and draw it. Ask them to identify the supporting parts of the drawing.
- Ask them to examine their structures including their desks. Caution them against hitting themselves against wooden blocks.
- The activity may be done outside the classroom where there is enough space for all groups.
- Ensure that the learners draw equally spaced parallel lines on the rubber.
- Let them place a load such as a stone or wooden block in the middle of rubber block and observe what happens.
- Let them note the length of the upper line and lower line on the rubber block. What can they say about their lengths? How do they differ from the initial lines that they had drawn on the rubber? Can they be able to explain what causes this observation?
- Now guide them to conduct a meaningful research from reference books on the bending of beams. Let them note down their findings. Allow them to discuss their findings and ask them later to present in class.

Assessment

Observation

- Observe the learners as they discuss their findings. Can they explain the reason for the change in the observation they make?
- Observe the drawings of the students. Are they adequate?
- Observe the learners as they discuss their findings. Can they explain the various structures? Are they familiar with them? Are they cooperating and working as a team?
- This is an extra activity meant to offer an insight into the daily lives of learners.

Conversation

- Talk to the learners while discussing their findings. Can they explain what beams are?
- Read the answers provided by the learners. Are their answers depicting the understanding of beam concept?
- Talk to the learners while discussing their findings. Are they in a position to explain what happens to the block while loaded?

Product

- Mark the questions given to the learners. Revise and correct where necessary

Note that when a beam is loaded, it is under stress. This is because it is experiencing either compressional or tensional forces. Stress lines can be seen on such a structure.

5.3 Shear force

Specific learning outcome

By the end of this section, the learners should be able to understand what shear force is.

Teaching guidelines for activity 5.3

- Guide the learners to put glue in between two blocks of wood and place it on top of a longer block. Ask them why it is important to apply glue on the wooden blocks. Let them hook a spring to the smaller block and pull.
- Ask them to record the reading just before the log starts to move.
- Explain to the learners that shear force is the force that dislodges an object from its resting position.

Assessment

Observation

- Observe how each group discusses their findings. Why does the log show resistance to move? Can they be able to use this observation to explain shear force?

Conversation

- Talk to the learners while discussing their findings. What can they explain about this force just before the block starts to move?
- Are they in a position of explaining what happens to the block while loaded? Ask them to explain to you shear force.
- Can they do so?

5.4 Notch effect

Specific learning outcome

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

Teaching guideline for activity 5.4

- This activity can be done better in groups and outside the classroom.
- Ask the learners to take a plane rubber and draw parallel lines on the rubber. Ensure they hold the rubber at the end and bend it. Let them explain why the parallel lines on the rubber remain parallel. Ensure that they draw equally spaced parallel lines on the rubber.
- Give them a chance to discuss their findings and ask them later to present in class.
- Guide them to cut a V- shape from the top of the rubber. Let them observe and draw the lines on the notch. Observe keenly and note how the lines concentrate at the notch. Ask them to explain what causes this observation.
- Ask them to smoothen the v-shaped end of the notch and bend the block. Let them observe the patterns of the lines to tell the distribution of stress.
- You could use a piece of wood instead of a rubber as a way of improvising.

Assessment

Observation

- Let the learners observe the lines that they drew on the rubber block.
- They can also observe the new lines formed on the rubber block. Observe the lines too.
- How different are the observations after the notch is smoothened round?

Conversation

- As the learners are discussing their findings, are they in a position to explain what causes the lines to concentrate at the notch? Are they able to explain what will happen if they used a rigid structure in place of a rubber? What is the difference between the two?
- Can the learners be able to explain what observation they would make if they used a rigid structure in place of the rubber?

Product

- A material will always break easily at the notch. Check the lines at the notch.
- How can the notch effect be minimised?

Note that firewood intended for domestic use is easily broken as stress due to the applied force is concentrated at the notch.

5.5 Struts and ties

Specific learning outcome

By the end of this section, the learner should be able to explain what struts and ties are.

Teaching guideline for activity 5.5

- Ask them to do activity 5.5 in the learner's book.
- Ask learners to use the wooden timber, nails and hammer to make a right-angled triangle.
- Let them hold the structure up and hang an object from the base line.
- Ask them to suggest to the members of the groups the tie and struts on their structure.
- Are they able to explain the pieces that are under stress and which ones are not?
- Guide them in doing a meaningful research from reference books on ties and struts.
- Take them through example 5.2. Use other similar examples familiar to the learner's.

Assessment

Observation

- Observe how each group discusses their findings. Are they able to answer questions asked in each activity? Can they identify ties and struts from the structure they have formed?

Conversation

- Talk to the learners while discussing their findings.
- Can they explain what ties and struts are?
- What are their functions in a structure?
- Guide the learners through example 5.2 in the learner's book. As you guide them through the example, ensure that the learners are contributing rather than solving it on your own.

Product

- Test if the learners can identify struts and ties with ease.
- Did they understand the example?

Mention to the learners that girders are examples of pieces of a supporting material.

5.6 Shapes and strengths of structures

Specific learning outcome

By the end of this section, the learner should be able to explain the different strengths of shapes of structures.

Teaching guidelines for activities 5.6 and 5.7

Activity 5.6

- Ask learners to make a square using the drinking straw and pins.
- Let them support the structure on one corner and place a load on each of the remaining corners. Let them observe what happens to the structure and explain the observation.
- Ask them to put a diagonal piece of straw BD, let them place the load at one of the corners again. Let them explain what happens this time.
- Ask them to tell if they can notice any difference in the structure. What difference can they note on the shape?
- Can they be able to explain what causes this observation?

Activity 5.7

- This activity requires group work. It is aimed at enhancing the creative skills of the learners as well as encouraging teamwork. You are only required to facilitate them to obtain results.
- Ask the learners to use the locally available materials to make structures of different shapes. Let them evaluate the strength of each shape they have made. Remember to caution them on safety while using the materials.
- Allow them to discuss on their own groups the various findings before they present them in class.
- Let them brainstorm about the different structures that have different strengths. Ask them to state some areas where shapes of structures influence their strengths?
- Allow a member of each group to present their findings in class. Guide them where necessary. Emphasise to them the key points in the activity.
- With all the contributions given during discussions, guide them on how to refine their reports.
- Ask them to name and describe all the structures that they know.
- Give them some questions from exercise 5.2 to do as an assignment.

Assessment

Observation

- Observe the learners as they carry out the activity. Is everyone in the group participating? Ask them to observe what happens at each stage. Encourage them to make notes.
- Observe as they do the activity. Are they able to make the structures? Ask them to improvise by using locally available materials.
- Look at their designs to investigate strength of different structures. Observe how each group discusses its findings. Can they explain why different shapes make different structures to have different strengths? How accurate is their presentation?
- Ask learners to observe many of the structures around the school and deduce the mechanical properties of each.

Conversation

- Ask them to contribute and participate in the group work.

  After the activity, hold a discussion with learners to emphasise the following.
- When supporting a structure, some pieces in it are under tensional force and are called ties. Whereas the ones under compression force are called struts.
- When you put a diagonal on a square or rectangular structure, you form two triangles, which are stronger than the square and rectangle.
- Discuss the structures observed. Do they have beams, struts or ties? How do they contribute to the strength of the structure?

Product

- Structures are used in supporting of roofs, water tanks, and bridges among others.

  How does the shape of a structure affect its strength? Explain to the learners.

  Can the learners use purely local materials to make the structures?
- Can they name the types of structures like the dome-shaped, Triangular, T and L-shape? Note that a structure is a composition of pieces of materials joined together and collectively performing a task of supporting a load. The triangular structure is the strongest of all.
- Discuss with the learners some of the applications of mechanical properties of structures. How is the structure of the bridge compared to the work it does? Let them name all the types of bridges as you briefly discuss each of them.

- Encourage all the learners to name a structure and say how its shape contributes to its strength and function. Ensure that they can state at least five applications of mechanical properties of structures.
- Mark the work done by the learners from exercise 5.2. Revise with them where necessary.

Answers to numerical questions

Exercise 5.1

3. 1000 N
4. (a) 26.12 N (b) 1.679 kg

Topic 6 Motion and momentum

(Student's book, pages 177 – 216)

Background information/Prior knowledge

The fifth topic is about static equilibrium of an object, how to apply vectors in static equilibrium to determine the quantities being asked, how structures are constructed to counter the applied force, kinematics of the objects, momentum and energy of objects. The Newton's equations of motion form the basis of mechanics. The learners need to understand these concepts, as they will help them in solving problems involving motion and momentum. Solve everyday problems involving motion e.g. the movement of locomotives. These two topics will enlighten the learners on solving problems related to energy and momentum. The concepts that were taught in the lower classes will form a foundation for this topic. This topic may appear unfamiliar to some learners but it touches on daily interactions with structures for example, tables, stools, bridges among others.

Subtopics

Subtopic no.	Name of subtopic
6.1	Linear motion
6.2	Linear momentum and impulse
6.3	Newton's laws of motion

Suggested teaching /learning activities

6.1 Linear motion

Specific learning outcome

By the end of this section, the learner should be able to explain what kinematics of objects is and determine the quantities associated with them.

Teaching guidelines for activities 6.1, 6.2 and 6.3

Activity 6.1

- Learners can carry out this activity on an individual basis.
- Let them throw a tennis ball perpendicularly towards a wall. Ask them to catch the ball as it bounces back.
- Ask them to measure and record the distance and the displacement covered by the ball.
- Give them an opportunity to discuss and note the difference between the two and how each is measured. Are they able to come up with logical conclusion?
- Encourage them to read widely about this concept.

Assessment

Observation

- Observe the learners as they find the distance and in turn displacement of the ball.

Conversation

- Ask the learners to discuss the difference between distance and displacement. Discuss the distances they measured.

Is there a difference? Which one?

Are they able to note the difference between distance and displacement?

Product

- Let the learners define distance and displacement. Are they able to write their SI units?

Note that distance is the length covered by a moving object between two points. On the other hand, displacement is distance in a specified direction. It is a vector quantity.

Both quantities are measured in metres.

Activity 6.2

- This activity should be done in pairs. The activity has been set in form of a question.
- Ask the learners to read the activity and familiarise themselves with it.
- Allow them to discuss the questions given in the activity in steps one after the other. Encourage them to attempt working out the questions on a piece of paper.

- Let them write down the formula for calculating speed. Ask one learner to try working out the speed as asked in step 1. Encourage the learner to explain the formula used and the method of calculating speed.
- Ask them to discuss examples 6.1 and 6.2 in the student's book in pairs under your guidance.

Assessment

Observation

- Observe the learners as they write down the formula for finding speed. Are they able to write down the correct formula? Can they be able to use the formula to solve the questions asked?
- Observe as they do the calculations. Are they able to calculate the speed at which the car and bicycle travelled? Which one of the two was moving faster? Can they state the SI unit of speed?

Conversation

- Emphasise to them on the inclusion of SI units in answers, for example, 20 m/s indicates a speed of 20. Mention to them that speed is the distance covered by an object in a unit time.
- Guide them through the examples given. Are they able to apply the formulae to solve these examples? Guide those who may be having difficulties in answering the questions or using the formulae. At this point, it is necessary that you offer individual assistance.

Product

- Ensure that the learners are able to state the formula for speed and calculate questions related to speed.
- Can they calculate average speed? Ensure that they can also state average speed.

Note that speed is expressed as distance moved in a unit time. It is measured in m/s. Similarly, average speed is expressed as total distance travelled over the total time taken.

What about uniform speed? Let the learners give their answers.

Activity 6.3

- Retain the pairs used in activity 6.2. This is for continuity and better understanding of the concept at hand.

- Ask one learner to move some distance in one direction as the other one records the time taken to cover the distance. Let him/her move the same distance but now in the opposite direction. Let the time taken be recorded.
- Ask them to carry out activity 6.3.
- Let them hold a discussion and use the data they have collected to find the velocity. Are they able to explain what velocity is? How are they using their data to determine velocity? Explain to them that velocity is speed in a specified direction. Mention to them that it is the displacement of an object in a given direction in a unit time.
- Ensure that the learners can fully describe a given motion by asking each one of them to do so. By so doing, the learners' confidence is enhanced. Use this opportunity to guide the slow learner without necessarily compromising on the needs of the gifted learners.
- Guide them as you explain the term velocity. Emphasise to them that quantities such as distance and speed only have magnitude. They are thus referred to as scalar quantities. Velocity and displacement have both magnitude and direction. They are called vector quantities.
- Discuss example 6.3. Ask three learners to work it on the board .Review the working to emphasise on key areas .Guide those who may be having difficulties in answering the questions or using the formulae. Motivate them more by asking them many questions during a question and answer session, which is another way of showing them that you, do recognise them.
- Ask them to do questions in exercise 6.1 in the learners' book.

Assessment

Observation

- Observe as the learners carry out the activity.
- Be keen to see how they work out the solutions on the board. Are they able to substitute properly?
- Observe them while working out solutions to exercise 6.1.Do they look confident?

Conversation

- Encourage the discussion between those who have already understood the concepts and those with difficulties. This will help the learners embrace peer teaching. Are they able to apply the formulae to solve this example?
- Listen to their description of certain quantities. Ensure that they have grasped the correct description.

Product

- Review the definition of speed and distance after which you define velocity and displacement .Ensure that they are able to differentiate the quantities. Note that most learners always confuse the calculation of uniform speed, uniform velocity. Average speed, average velocity etc. You are highly advised to give extra exercises for practice.
- Mark their work. Correct them accordingly.

Teaching guidelines for activity 6.4

- This activity shall be done in groups. In this activity, the different groups should determine acceleration. You may choose to retain the previous groups.
- Ask them to carry out activity 6.4. Ensure that they increase the angle of inclination to enable the trolley to start moving down the runway. Ask them to record the time i.e. from just when it starts moving start the ticker-timer.
- Let them observe the separation distance of the dots on the tape? Are they able to explain what leads to the change in the separation distance between them?
- Ask them to discuss their findings.

Assessment

Observation

- Observe the learners as they do the activity. Engage them with probing questions as they do. Are they able to answer questions related to the concept?
- Observe the trolley rolling down the runway. Guide them accordingly.

Conversation

- Encourage them to brainstorm amongst themselves. Listen to the learners as they discuss. Are they able to come up with the units of acceleration? How well are they able to explain it?
- Allow them to discuss in groups. Are they able to explain how the tape will look like if the speed of the trolley was reduced with time? Are they able to explain the name given to the rate of change of velocity with time? What is the SI unit of this quantity?
- Ask the learners to copy example 6.4 in their exercise books and discuss it in their groups. Ensure they are doing a constructive discussion. Are they able to use the relevant formula to calculate acceleration? Let them compare their solution to the working in the book.

- Guide them through and engage them with probing questions. How well do they understand the concept?

Teaching guidelines for activity 6.5

- Let the learners carry out this activity in pairs. Review the aspect of acceleration. Explain to them that it is the rate of change of velocity of a body with time .Re-introduce the equation for acceleration.
- Give out a question on acceleration and ask them to brainstorm and solve.
- Ask them to use their algebraic knowledge to make V the subject of the formula in the given equation. Ensure that they master the first equation of motion by answering several questions.
- Let them use the expression given to derive the second equation of motion. Guide them through and offer individual assistance to others in need.
- Ask them to use the first and the second equations of motion to derive the third equation of motion. Are they able to derive this equation in the right format?
- Let them discuss some of the examples in which these equations are applied.
- Emphasise to them that they should master this equations as they are important in mechanics and will need to remember them to solve equations of motion.
- Ask volunteers to write the equations on board in turns after which you clarify where necessary.
- Guide them through examples 6.5, 6.6 and 6.7. Ensure that they are able to substitute in the equations.
- Let them attempt questions in exercise 6.2 in the learner's book.

Assessment

Observation

- Observe as the learners derive the three equations of motion basing on their knowledge of algebra and substitution. How well can they do the substitution to get the equations in the right format?

Conversation

- Guide them through the derivation of the three equations of motion. Note that the 3rd equation is always not easy for the learners to grasp. Ensure that they do so by asking them to work out many questions. Listen to the learners as they discuss. Are they able to give expressions that lead to solving the equations? How well can they explain the equations?

- Give them an opportunity to discuss and use the equations they have derived to discuss examples 6.5 to 6.7. How well are they able to apply the equations? Can they do the correct substitutions in the right equation?
- Ensure that they have mastered them.

Product

- Mark work done in exercise 6.2 and guide them where possible. This exercise will give you the opportunity to evaluate how much the learners have understood so that you can guide them in the areas that they may be having difficulties.
- More questions should be assigned to them for further practice.

Teaching guidelines for activity 6.6

- To accomplish this activity, remind the learners on the requirements of drawing a graph. Labeling of axes is key when drawing a graph and so are the points to be plotted among others.
- Ask them to discuss and sketch distance-time graphs for two bodies: one at rest and the other moving at a constant velocity. Are they able to sketch well-labeled graphs?
- Let them present the graphs they have drawn to the class and interpret them. Are they able to interpret the graphs?
- Can the learners be able to analyse graphs of bodies whose speed is increasing or decreasing with time? Are they able to explain what the gradient in each case represents?

Assessment

Observation

- Observe them as they draw the graphs and as they present them in class.
- Have a glance at group graphs. Ensure that they are well drawn.
- Are they exhibiting teamwork, critical thinking and cooperation?

Conversation

- Let the learners copy the question in example 6.8 in their exercise books. Give them an opportunity to discuss and solve the question without referring to the book. After they are done let them compare their work with the worked solution in the learner's book.
    1. Have they followed the instructions in answering the question?
    2. How well have they solved the question?

- You may guide those who may be having difficulties and then advise them to review the example later so that they may be able to follow.
- Ensure that the learners can draw and interpret the graphs accordingly. Let them explain what the gradient of the graph represents.
- Discuss example 6.8 with the learners for better understanding of the concepts. Ensure that they participate in the discussion by asking questions at random.

Product

- Ensure that they have drawn straight-line graphs for a body with uniform velocity. Otherwise, ask them to repeat the activity.

Teaching guidelines for activities 6.7 and 6.8

Activity 6.7

- This activity will concentrate on displacement – time graphs. It is important to review the previous activity on distance – time graphs. This will form a basis on which advanced concepts will be built.
- Organise the learners in convenient groups of mixed abilities.
- Ask them to sketch and analyse different displacement - time graphs for bodies under different circumstances. Let them describe the motion of the objects under motion. Again, ask them to sketch and analyse different displacement - time graphs. What can they note about the graphs?
- Let the groups present their findings to the class. Are they able to explain the shape of the graphs? Ask them to compare their graphs.
- Mention to them that the graphs for a body moving with a constant velocity are a straight line in the positive quadrant. However, the same body moving with the same velocity but in an opposite direction will exhibit a straight-line graph but in the negative quadrant. See Figure 6.13 (a) and (b).

Activity 6.8

- Let the learners work in groups of three. Review the previous lessons.
- Ask the learners to draw and interpret speed – time graphs for a body at rest.
- Let the learners discuss example 6.9 as you guide them through. Ensure that they label the axes and plot as required. Ask them to do the same for a body moving with uniform and non-uniform speed. Let them do the same for another body whose speed is increasing.
- Ask them to compare and analyse the graphs in class.

- Take them through example 6.9 to enable them grasp the concept. Emphasise to them that such calculations must bear the SI units of the quantities involved, for example acceleration (m/s^2), velocity (m/s) etc

Assessment

Observation

- Observe them work in groups. Look at their graphs and guide them where necessary. Are the graphs accurately drawn on graph papers? Have they made all the requirements?
- Be observant when they are presenting and comparing their graphs.
  Are the shapes of the graphs the same?
  Are they willing to see what others have drawn?
- Develop interest in watching them solve an example on the chalkboard.

Conversation

- Ask the learners some probing questions while reviewing the previous content. This is meant to create a link between the concepts.
- Listen to them as they discuss in their groups before presentation to the whole class.
  Are they able to use scientific terms to explain the different graphs drawn?
- As they present their work in a class discussion, does their language depict mastery of the concepts?
- How good is their analysis of the graphs?
- Ask them to compare their graphs.

Product

- Check the graphs the learners have drawn.
  How well have they been presented? Are they able to draw the different graphs correctly?
  Can they interpret the different graphs correctly?
- Can they note the difference between displacement - time graphs and speed - time graphs?
- What is your assessment of their understanding of the examples given on board?

Teaching guidelines for activity 6.9

- By now, the learners have familiarized themselves with graph drawing. This activity is about velocity- time graphs. Let them brainstorm about velocity – time graphs.

Ensure that all can draw by guiding them.

- Ask them to draw a gradient for their graph. Ask them what the gradient of the graph represents.
- Allow them to exercise step 3 of the activity fully first on their own. Let them compare their results with those of other groups before they present their work to the class.
- Ask the learners to discuss examples 6.10 and 6.11

Assessment

Observation

- Observe the learners as they are discussing. Are they able to explain the graphs correctly? Can they differentiate the different graphs?
- Observe them draw the graphs as you move around guiding them where possible.
- Observe as they do their presentation on the blackboard.

Conversation

- Listen to the learners as they answer the questions you pose to them.
- Encourage the learners to discuss the examples 6.10 and 6.11. Are they able to explain every step of the example? Are they able to discuss constructively?

Product

- Ask the learners to work out exercise 6.2 individually in their books. Mark their work. From the way the learners are presenting their answers gauge how well they have mastered concepts. If there are, many learners with challenges organise for a remedial lesson.
- You may also encourage them to do more research on the different types of graphs covered.

6. 2 Linear momentum and impulse

Specific learning outcome

By the end of this section, the learner should be able to explain linear momentum and solve equations involving linear momentum.

Teaching guidelines for activity 6.10

- The aim of this activity is to illustrate linear momentum. Ask them to use a hammer to hit a nail into a wooden block.

- Ensure they use varied amount of forces as they hit the nail and observe the penetration distance of the nail. What can they note?
- Give them an opportunity to discuss their findings and use their conclusion to explain what linear momentum is. Are they able to differentiate between impulse and momentum?

Assessment

Observation

- What is the effect of hitting the nail with a big force and hitting the nail with a smaller force? Can they explain the impact of the two forces on the nail?

Conversation

- Ask the learners to discuss example 6.12. How well can they discuss the examples? Are they able to explain every step of the example?
- Choose the learners at random from the class to present examples 6.13 and 6.14 to the class. This helps build communication skills and leadership skills among the learners.
- Explain to them the terms linear momentum and impulse.

Product

- The mass of the hammer and the rate at which it is hitting the nail will determine the depth of the nail in the wood.

Specific learning outcome

By the end of this section, the learner should be able to state Newton's laws of motion and use them to solve problems.

Teaching guidelines for activity 6.11

- Activity 6.11 aims at demonstrating the force of inertia using a coin and cardboard. It is also intended to make the learners think critically.
- Ask the learners to put a coin on the cardboard on top of a table.
- Ensure they pull the cardboard slowly and then abruptly each time noting what happens to the coin. Ask them to record their observations each time.
- Discuss with them their observations. Clarify for better understanding.

- Ask the learners to name other areas in daily life where inertia is exhibited, for example passengers in a moving vehicle tend to fall forward when the vehicle suddenly stops. This is because when the vehicle is halted the passengers are still in a state of continuous uniform motion. This is due to inertia.
- Ask the learners to work out exercise 6.4 in the learner's book.

Assessment

Observation

- Observe the learners as they pull the cardboard.
- Together with the learners, observe what happens to the coin. Where does it fall? Why?

Conversation

- Are they able to explain what happens to the coin and why they make that observation?
- Allow them to discuss their observations before making class presentations. Are they able to explain what causes the observations they have made? How can they relate these observations to the importance of safety belts in vehicles?
- Engage the learners in a question and answer session by asking them probing questions. For example, why do vehicles have seat belts?

Product

- Explain to the learners that every object always strives to maintain its state of rest or motion. This is from Newton's First Law of Motion which states that," *a body remains in its state of rest or motion in a straight line unless acted upon by an external force"*.
- Mark their work in class and guide them accordingly by reviewing some of the questions. Does their working show mastery of content?
- Let them do more exercises on the same concept to master it.

Teaching guidelines for activity 6.12

- This activity is meant to demonstrate Newton's second law of motion using trolleys of different masses and springs. In the absence of spiral springs, instruct the learners to improvise with rubber bands.
- Review the previous activity and gauge how much of the first law of motion has been grasped. Ask them some probing questions related to the second law.
- Ask the learners to form groups in readiness for activity 6.12. Ensure that each group has all the requisite materials including a spacious working area. Advise them to read the activity first before doing it.

- Let them carry out the activity and record their observations. As they release the trolleys, they should be keen to note that the trolleys move at different velocities.
- Discuss with them the observations made. Ensure that they come up with a relationship between the mass of a trolley, the force applied on it and its acceleration.
- Ask the learners to discuss examples 6.15 to 6.17. Let them copy example 6.17 in their exercise books and try to solve it individually without referring to the book. After they are done let them compare their answers with the solution of the example. Have they managed to solve it correctly? Note: This requires high level discipline on the part of the learner so as to avoid copying directly from the book.
- Ask them to attempt doing questions in exercise 6.5.

Assessment

Observation

- Observe the rate at which the trolleys are moving. Let the learners observe too. Why the observations?

Conversation

- Are they able to state which trolley accelerates faster? Are they able to explain Newton's second law of motion using momentum? How well can they discuss the examples? Are they able to explain every step of the example?
- Discuss with them the graph in example 6.17 .Does it verify Newton's second law of motion?

Product

- Let the learners do exercise 6.4. Mark their work. Do their answers depict mastery of the concepts learnt?
- Explain to them that under Newton's second law of motion, F = *ma.*

Teaching guidelines for activity 6.13

- This activity shall demonstrate action and reaction forces. Explain to the learners that these forces are common in our daily lives.
- Organise the learners in convenient groups. Let them carry out activity 6.13.
- Ask them to explain what happens when they tie an inflated balloon on a trolley and allow air to come out of the trolley. Are they able to explain which direction the trolley moves and why it moves in that direction?
- Let them discuss and relate their observation to Newton's third law of motion. Can they be able to state the law correctly?
- Ask them to attempt related questions from the Unit Test 6 in the learner's book.

Assessment

Observation

- Observe the balloon set loose in the air. Why is this necessary?
- Observe all the steps and particularly step 6. What do you observe?

Conversation

- Ask the learners questions as they answer. Explain why the trolley behaves in that manner. Let them appreciate the presence of forces that are opposing each other.
- Discuss with them why a person jumping from a boat experiences a pull on his legs. Let them understand that the forward action of jumping is met with an opposing backward force as the boat moves in the opposite direction to this force. Ask them to name and explain other real life experiences.

Product

- The forces acting on a body are always equal and in opposite directions. Hence, Newton is Third Law of Motion; for every action there is an equal and opposite reaction.
- Mark the learner's work done from the Unit Test 6 in the learner's book. force of zero.

Answers to numerical questions

Exercise 6.1

2. (a) 8.3 m/s 30 km/h
3. (a) 2.2 hrs or 2 hr 12 min
   (b) 5.45 km/hr
4. (i) 15 m/s (ii) 20 m/s (iii) 35 m/s
   (b) 22.5 m/s

Exercise 6.2

2. (a) 5 m/s^2 b) 250 m
3. 1 m/s^2 b) 400 m
4. (a) (i) 5 s (ii) 25 m
5. (b) 0.129 m/s^2
6. (a) (i) 30 m/s (ii) 108 km/h
   (b) 2700 m
7. (a) 1.8 m (b) 90 m
8. 3 s
9. (a) 125 m (b) 5 s
10. (a) 7.67 s (b) 4.51 s

Exercise 6.3

3. (b) 1 m/s^2, 400 m
4. (a) 3 m/s^2 (b) 3 m/s^2 (c) 600 m
5. (a) at = 1, s
   at = 2, s = 20 m
   (b) at = 3, s = 45 m
   at = 4, s = 80 m
   (c) g = 9.34 m/s^2
7. (a) 508 m (b) 52 m/s
   (c) 2.6 m/s^2

Exercise 6.5

3. (a) 3.48 Ns (b) 139.2 N
4. (a) 3 m (b) 26.25 N
5. (a) 2.25 Ns or 2.25 kg/m/s
6. 0.08 kg or 80 g
7. 1.5 m/s

Topic Test 6

2 30 m/s 3. 190 m 4 8.3 mls
5 (a) 5.0 m/s^2 (b) 40 m
8 (i) 2.0 m/s^2 (ii) 15 s
(iii) 1210 m (iv) 290
9. (a) 2.5 m/s, 4m/s
   (b) 0.25 m/s^2 (c) 3.2 s

11. (b) (i) 31×10^{-3} s
    (ii) 6.045 Ns

UNIT 5

Thermal energy

(Student's book pages 209-246)

Topics in the unit

Topic 1: Thermal energy

Learn about	Key inquiry Questions
Learners should investigate using appropriate equipment, the specific heat capacity of a substance. They should understand latent heat, specific latent heat capacity They should understand the rise in temperature of a body in terms of an increase in its internal energy (random thermal energy), define the terms heat capacity and specific heat capacity, latent heat and specific latent heat capacity, and apply the relationship thermal energy = mass ×specific heat capacity ×change in temperature to new situations or to solve related problems. They should work in groups to design practical investigations to determine the heat capacity, specific heat capacity, latent heat and specific latent heat capacity of a substance.	1. How can we determine the heat capacity and latent heat of a substance? 2. Why the internal energy of a substance changes? 3. How could we use knowledge of heat quantity to explain the factors that affect the boiling point and melting point?

Knowledge and Understanding	Skills	Attitudes
Understand thermal physics, heat capacity of a substance, carry out energy calculation. Understand the rise in temperature of a body in terms of an increase in its internal energy	Investigate using appropriate equipment, the specific heat capacity of a substance. Design practical investigations to determine the heat capacity, specific heat capacity, latent heat and specific latent heat capacity of a substance. Apply the relationship, thermal energy = mass ×specific heat capacity ×change in temperature to new situations Derive the mathematical expression of the thermal energy.	Develop conceptual thinking about thermal energy.

Contribution to the student's competences

1. Communication and cooperation: These skills are acquired as learners discuss with one another and express themselves while collaboratively doing the activities in the unit and making presentations to the rest of the class. Communication and personal confidence improves as they answer questions in class and making explanations.
2. Creativity and critical thinking: These competences are enhanced as learners carry out experiments and activities, measure quantities accurately in analysing data and drawing logical conclusions besides solving the problems provided in the exercises.

Links to other subjects

1. Mathematics: The learners will come across so many activities they will require the knowledge they learned in Mathematics to solve the questions. When working on questions involving specific heat capacity of substances they will need to do substitution in the formulae using the knowledge they learned in algebra.
2. Chemistry: The learners will be dealing with heat emitted from substances. They will need to have the knowledge from Chemistry on chemical energy released or absorbed by substances when they are heated or cooled.

Cross-cutting issues addressed in the topic

1. Environment & Sustainability
   The unit has many activities on heating solids, liquids and gases to observe the effect of heat on these states of matter. The activities provide the teacher with the opportunity to sensitise the learners on the importance of choosing environmental

friendly sources of heat (non-polluting) and to avoid the use of solids and gases which when heated emit gases that pollute the environment.

2. Peace and values
   The unit provides numerous pair and group activities that require learners to work together. This will enhance peaceful co-existence and teamwork among them. They will learn to appreciate each other.

Attention to special needs

- This topic provides numerous activities and exercises of varying levels of difficulty to cater for learners of different learning abilities i.e. the average, gifted and slow learners. You should ensure that all learners including those with physical and mental challenges participate in one way or another in the tasks they are able to do in the activities. Refer to the introduction part of this Teacher's Guide for more information.

Topic 7 Thermal energy

(Student's book, pages 218-253)

Background information and /or prior learning

Learners in their daily lives observe or do tasks involving heating substances and change of state. This topic will help them understand what exactly happens inside the particles of the substances when being heated and during the change of state. Make use the learner's prior knowledge and experiences on heating substances while introducing and explaining the concepts in this unit for learners to understand them with ease. Therefore, teach the concepts by following the known to unknown approach.

Subtopics

Subtopic No.	Name of subtopic
7.1	Heat capacity and specific heat capacity
7.2	Methods of determining specific heat capacity
7.3	Latent heat and specific latent heat of fusion
7.4	Latent heat and specific latent heat of vaporisation
7.5	Applications of specific heat capacity
7.6	Internal energy of a system
7.7	The processes of melting and solidification

Suggested teaching/learning activities

6.1 Heat capacity and specific heat capacity

Definition of specific heat capacity

Specific learning outcome

By the end of this section, learners should be able to define specific heat capacity and solve related problems.

Teaching guidelines to activities 7.1 and 7.2

Activity 7.1

- Activity 7.1 aims to show that the heat required to create a change in the temperature of a substance depends on the mass of the substance.
- Briefly review the topic on the effect of heat on substances. Organise the learners in groups of mixed abilities.
- Ask them to do activity 7.1. Ensure that the learners heat different masses of water as they observe the time taken to heat each amount of water. Encourage them to record the observations, which include the visible changes in temperature.
- Ensure that they are following the instructions given.
- Guide them to observe safety measures while heating water. This is to prevent them from being burnt.
- Ask the students to do exercise 7.1 in the learner's book.

Activity 7.2

- Retain the groups used in activity 7.1 for continuity of learning. Review activity 7.1 to help the learners recall some key concepts.
- Ask the learners to repeat step 2 of activity 7.1. Let them heat the same amount of water but each time supplying different amounts of heat. As they heat, they should observe and record the change in temperature.
- Introduce the term heat capacity. Define and discuss its equation by taking the learners through examples 7.1 and 7.2. Emphasise the inclusion of SI units in the working of examples and final answers.
- Let them do question I from exercise 7.1 as class work. This encourages the learners to do more research as well as self-evaluation.
- Let the learners attempt questions from exercise 7.2 in the learner's book after a discussion on specific heat capacity.

Assessment

Observation

- Observe the groups as they are doing the activities and discussing their answers. Are they able to relate mass and change in temperature? Can they define heat capacity?
- In their observations ensure that the learners note the time taken to cause a change in temperature. What does it depend on? Can they be able to explain what causes this observation?

- Let them observe the temperature changes in activity 7.2. Does the temperature change depend on the amount of heat supplied? What is the effect of changing the amount of heat supplied to a substance on its temperature?
- Observe the final temperatures.

Conversation

- Talk to the learners by asking them while discussing their findings. Are they able to explain heat capacity of a substance? Can they define the key words?
- Lead the learners through example 7.1 on the chalkboard. Keep on involving the learners so that they are able to follow up the working of the example. Select the learners randomly to lead the others in discussing examples 7.2 to 7.5. This helps to enhance peer education. It will also help them develop their oral skills as they discuss.
- Ask the learners some probing questions as they are presenting on the chalkboard to the rest of the class. Can they derive the expression, logically?

Product

- Explain the terms heat capacity. Read and mark the answers given by the learners to questions in exercises 7.1. Are they able to write their answers in a scientific language?
- Use this exercise to gauge how much the learners have understood. You can encourage pear teaching among the learners during their free time.
- Explain the term specific heat capacity and other key terms. Mark the answers given by the learners on exercise 7.2.

Teaching guidelines for activity 7.3

- Let the learners organise themselves in groups in preparation for doing activity 7.3. Ensure that the learners put equal amounts of cooking oil and water in different tests tubes. Ask them to put the test tubes in a water bath after inserting thermometers.
- Instruct them to observe any changes in the liquid and thermometer. Record the changes accordingly. Guide them to conclude from their observations.

Assessment

Observation

- Observe the changes in temperature that the learners have recorded. What causes the difference in temperature?

Conversation

- Discuss with the learners their results. Are they the same? If not why?

Ask them questions as you use their results to work out the specific heat capacity of the substances. Are they able to note that the two have different heat capacity?

- Explain to them that solids require more heat energy to melt than liquids and gases to change state. Hence, their specific heat capacities are also higher.
- Mention that the variation is in the acquisition of temperature.

Product

- Solids have the highest specific heat capacities whereas gases have the lowest.

7.2 Methods of determining specific heat capacity

Specific learning outcome

By the end of this section, learners should be able to solve problems related to specific heat capacity.

Teaching guidelines for activity 7.4

- The activity aims to demonstrate how to determine the specific heat capacity of a solid by using electricity. It can be best done in groups for ease of sharing materials.
- Guide the learners through the activity for them to record the temperature, voltage, current and the time it takes to heat the solid object. Advice them to always remember to record the initial temperature and current values.
- Explain to them that the energy supplied to the substance is used in bringing about change in temperature in the solid.
- Allow them to discuss and come up with the formula for the specific heat capacity of the solid.

Assessment

Observation

- Observe the learners as they do the activities. Are they able to do each step in the activity and eventually determine the specific heat capacity of solids using the electrical method?
- Observe them as they start and read the stopwatches. Can they take the readings? What about other variables?

- Observe the readings on the stopwatch.
- Let them write what they observe. Are they able to note down all the variables? How much current was passed through the solid?

Conversation

- In the discussion of the results for Activity 7.4, guide the learners in the derivation of the expression for the specific heat capacity of a solid using electrical method as where V and I are the voltage and current readings of the of the source respectively. t is the heating time, m is the mass of the solid and $\Delta\boldsymbol{\theta}$ is the change in temperature.
- Guide them through examples 7.6 and 7.7 in the learner's book.
- Explain to them where the energy supplied goes. Tell them that such energy is responsible for the rise in temperature of the substances. Are they able to explain what happens to the energy supplied?

Product

- Explain to the learners that in such a system,

Electrical energy used = Heat energy gained by the metal cylinder

This means that no energy is lost.

Teaching guidelines for activity 7.5

- Organise the learners in groups. Ensure that all the materials required are available .You may choose to use a straw in place of a stirrer.
- Talk about the safety precautions while carrying out the activity to prevent injuries.
- Ensure that the learners take a container of a known specific heat capacity and measure its mass. Ask them to also take the mass of the container + water.
- Ask them to record the temperature of the cold water in which the hot solid will be transferred.
- Let them observe and record the temperature of the solid in the water bath when the water boils. Discuss with them the observations made.
- Encourage them to compare results with other groups.
- Ask them the significance of stirring the mixture of the hot solid and the cold water.
- Guide them to calculate the specific heat capacity of the water. Let them explain what happens to the heat in the hot solid when it is put in the cold water?
- Ask them to use the data they have collected from the activity to calculate the specific heat capacity of water.
- Discuss with them the possible assumptions in the activity.

- Guide them through example 7.8. Involve all the learners by giving them responsibilities while working it out on the board.
- Select some related questions from exercise 7.3 and ask the learners to do them in their books. They can work them in groups to encourage them to embrace peer teaching. Give them more questions as an assignment.

Assessment

Observation

- Observe the learners as they do the activity. Are they able to do each step in the activity and eventually determine the specific heat capacity of water through the method of mixtures?
- Observe them record their findings. What happens when a hot solid is lowered into cold water? Why is it necessary that the water container be lagged?

Conversation

- Discuss with them some of the assumptions made in the activity. Are they able to clearly state the assumptions they have made in the experiment to get the results?
- Discuss with the learners the results obtained. Allow them to fully participate. Discuss the solution of example 7.8.
- Discuss with the learners some of the measures that have been undertaken to ensure that accurate results are obtained. For instance, the container is covered with cotton wool to minimise heat loss. The system is placed in a wooden container, which further minimises heat loss.

Product

- Guide the learners to calculate the specific heat capacity of water using the method of mixtures.
- Guide them in calculating the specific heat capacity of water. The value for specific heat capacity of water is 4200J/kgK.

Teaching guidelines for activity 7.6

- This activity aims at enlightening the learners on how to determine specific heat capacity of a liquid using the electrical method. Organise the learners in convenient groups.
- Ensure that all the requisite materials are available for use. Ask the learners to set up the apparatus as shown in Fig. 7.5.

- Ensure that the learners follow and complete the steps in activity 7.6 as they record the various variables required.
- Explain to them that the cardboard lid, cotton wool, wooden container aluminium foil etc are meant to minimize heat loss in the system.
- Explain that the observations for all the variables i.e. temperature, current, time, voltage etc should be recorded immediately after observation.
- Discuss the safety measures undertaken in this activity.
- Guide them through example 7.9 in the learner's book.
- Explain to them that different liquids have different specific heat capacities. Encourage them to name a few.
- Conclude by guiding them to calculate the specific heat capacity of the liquid used by incorporating the results obtained.
- Ask them to do the related questions in exercise 7.3.

Assessment

Observation

- Observe the learners as they do the activity. Are they able to collect the right data that will help them calculate the specific heat capacity of the liquid by electrical method?
- Look at their data. Compare with many others. Are they able to collect the right data? Is there some form of consistency in the data?

Conversation

- Ask the learners some probing questions to test their understanding.
- Guide them in discussing the results obtained by the learners. Are the results showing some consistency?
- Choose the learners at random to lead the others in discussing example 7.9 on the chalkboard. This will instil leadership skills in the learners. Ask the others to contribute to the discussion.
- Discuss with them some of the assumptions made in the activity. For example,

Energy is not lost to the outside environment.

Are they able to state clearly the assumptions that have been made in the activity?

Product

- Conclude the activity by mentioning that the heat lost by the hot solid is gained by the container and the water,

i.e. Heat lost by the hot solid = Heat gained by the container and the water

Remember no heat is lost to the outside environment.

- Are they able to use the data they have collected to come up with the formula of calculating the specific capacity of liquids by the electrical method?

7.3 Latent heat and specific latent heat of fusion

Specific learning outcome

By the end of this section, the learner should be able to differentiate between latent heat and specific latent heat of fusion and solve problems involving them.

Teaching guidelines for activities 7.7 and 7.8

Activity 7.7

- This is another activity in which the learners are trained in designing and carrying out investigations. Before the learners do the activity, introduce them to latent heat of fusion and its definition as discussed.
- Advice them to be careful not to be burnt while doing the activity. You should also caution them against breaking glasses (beaker) and thermometer.
- The molecules of a solid are kept in fixed positions by strong molecular forces of attraction. Latent heat of fusion is the energy needed to break these forces for the solid to melt. Most learners may have observed ice cream or a plastic melting. Make use of their prior experience to introduce the concepts of latent heat of fusion.
- Let the learners design an experiment to determine the latent heat of fusion by electrical method. They can do this by modifying activity7.6.You can also give room for creativity for the learners to design a better experiment.
- Ensure that they can write a logical procedure that they will follow in the activity. Emphasise to them to follow their written procedure.
- Guide them to use a relevant formula and the data they have collected to determine the specific latent heat of fusion of ice. Ask them to compare their results.
- Ask them to write a report for their investigation. Let them present their findings in class.
- Guide the learners through example 7.10. Let all of them participate by answering questions as you discuss the problem with them.
- Ask them to attempt selected questions from exercise 7.4 in the learner's book.

Activity 7.8

- To do this activity the learners should be in mixed ability groups. Ensure that all the materials required for the activity are available.
- Ask them to follow the procedure in activity 7.8 and record mass, temperature, current and time readings accurately.
- Give them an opportunity to use the relevant equations and formulas to determine the latent heat of fusion by the method of mixtures. Are they able to get a value that is close to the exact value?
- Allow each group to present the results of the activities to the rest of the class. Are they able to write the formula? Has each group found the same value? How different the values of the learners compared to the actual value?
- Ask the learners to do questions from exercise 7.4 in the learner's book.

Assessment

Observation

- Look at the procedure and/ or design of the learners in activity 7.7.
- Observe the learners as they do the activities. Are they able to do each step in the activities and eventually determine the specific latent heat of fusion of ice using the electrical method and by the method of mixtures?
- Remind them to be observant at every step and record them immediately. In activity 7.8 for example, the learners should be keen every time they add a piece of dry ice to avoid spillage. At the same time, they ought to observe and take reading of the temperature.

Conversation

- Ask the learners some questions as they do the activities. Can they explain what they are doing in each step?
- Discuss and explain to them the determination of the specific latent heat of fusion. Can they explain how to determine the specific latent heat of fusion of a solid?
- Can the learners be able to explain some of the errors that they may have caused their values to differ from the exact value?
- Let the different groups use the data they have collected to discuss the value of specific latent heat of fusion of ice.

Product

- Ensure that the learners can define key words like latent heat of fusion, specific latent heat of fusion etc.

- Read and mark the answers for questions done from exercise 7.4. Are their answers correct?
- Revise with them accordingly. Ensure that they have understood and mastered the formula for calculating specific heat capacity of ice.

7.4 Latent heat and specific latent heat of vaporization

Specific learning outcome

By the end of this section, the learner should be able to differentiate between latent heat and specific latent heat of vaporisation and solve problems involving them.

Teaching guidelines for activity 7.9

- Define for the learners the term specific latent heat of vaporisation of water. Encourage them to get the difference between this term and specific latent heat of fusion.
- Explain to them that molecular forces of attraction more closely hold the molecules of a liquid together than those of gases. However, liquids are able to move freely. Explain to them that latent heat of vaporisation is the energy needed to break these forces for the liquid to change into gaseous state.
- Ask them to follow all the instructions as they are in the activity.
- The learners must have observed water boiling. Make use of this prior experience to introduce the concepts of latent heat of vaporisation.
- Review the concept of latent heat of fusion and its definition as discussed in the learner's book before the learners do the activity. Note that they had already covered this.
- Ask them to read the ammeter after connection .Let them take the ammeter readings after closing the switch.
- Ensure that the learners collect the readings for mass, temperature, current and time as they do the activity. Are they able to record the data accurately? Assist those who may have challenges in setting up the apparatus.
- Allow them to discuss in their groups as they use the relevant formula to work out specific latent heat of vaporisation. Can they explain how they can use the data to determine the latent heat of vaporisation of water? Can they explain what happens to the energy supplied?
- Guide them to take and record the readings for mass, temperature, current and time accurately.

- Ask them to answer all the questions given in the activity and derive the formulae required
- Ask them to present the results of the activity to the rest of the class. Ask them to name any assumptions and errors in the activity.
- Guide the learners through example 7.11. Let them participate by working sections of a similar question on the chalkboard or answering questions.
- Ask the learners to do some questions in Exercise 7.4.

Assessment

Observation

- Observe the learners as they do the activity. Are they able to do each step in the activity and eventually determine the specific latent heat of vaporisation of water using electrical method?
- Observe them take readings. Are they doing it correctly?

Conversation

- Can the learners explain how to determine the specific latent heat of vaporisation of water? Can they explain what they are doing in each step?
- Guide them through examples 7.12 and 7.13. You may choose learners at random to explain the different steps in solving the examples. This will help them master the concepts. Ensure that the learners are able to work out a similar problem on the board.
- Discuss in details how best to take readings of given nature.
- Ask them to work out questions from exercise 7.4. Attend to those with challenges in understanding the same.

Product

- Mark the answers given by learners. Use their answers to evaluate how much they have understood the concepts thought. You may organise remedial classes to teach them in the areas that they may be having difficulties. You can also encourage the learners to have peer discussions.
- Recapitulate by asking them to define the terms.
- Give more questions as an assignment.

7.5 Applications of specific heat capacity

Specific learning outcome

By the end of this section, the learners should be able to explain applications of specific heat capacity in our daily lives.

Teaching guidelines to activity 7.10

- This activity aims at inculcating a reading culture in the learners. Ensure that all the requisite materials are available. Resource persons should be sort for and arrangements to avail themselves done in advance. Encourage the learners to ask the resource persons as many questions as possible. They should also show that they know their environment besides being disciplined. You should discourage chorus answers from the learners.
- Let the learners use the reference materials and the Internet to do more research on the applications of specific heat capacity. Ask them to note them for future reference. Are they able to do a constructive research and make notes on the applications? How well can they present their findings?
- Give learners time to present their findings to the rest of the class. Are they doing constructive discussions?

Assessment

Observation

- Observe the groups presenting their findings. Do they demonstrate understanding of the applications of specific heat capacity?

Conversation

- Ask the learners some questions as they as they present their findings. Are they able to explain the applications of specific heat capacity?
- Let them read the applications of specific heat capacity written down by the learners from their findings. Are the applications correct?

Product

- Enlist some of the applications as written in the learner's book page 233. Explain as you mention examples where necessary.

7.6 Internal energy of a system

Specific learning outcome

By the end of this section, the learner should be able to explain internal energy, derive its expression and solve related problems.

Teaching guidelines to activities 7.11 and 7.12

Activity 7.11

- This activity requires a lot of creativity and critical thinking. Use plastic tumblers with covers as transparent materials. Ask the learners to shake up marbles in a closed container and observe their movement. Are they able to note down how the marbles are moving in the container?
- Allow them to discuss in groups how this analogy can relate to the flow of energy in a system. Are they able to explain how energy flows in a system?
- Now let them heat some water in a beaker as they record the temperature. Ask them, to explain the energy transformations taking place in the water as it is heated. Are they able to describe the energy transformations as it is heated and as it boils?
- Let then explain the law that governs the energy transformation. Can they state it correctly?
- Discuss after defining the terms, internal energy in a system. Ensure that all participate in trying to define. Encourage them by saying 'Good"," excellent" and explaining where possible.
- Remind the learners to take care of the environment by collecting all the used materials and keeping them in one place.
- Let them discuss examples 7.14 to 7.16 as you guide them through.
- Ask the learners to do questions from exercise 7.5.

Assessment

Observation

- Observe the groups to observe the marbles as they are dropped in the container. What colour can you see?
- Ask them probing questions as the activity is going. Do they demonstrate understanding of internal energy?
- Ask them to make more observations when the container holding the marbles is shaken.

- Let them compare their findings with other groups.
- Gauge their understanding of the concepts from body language and responses. Do they look confidence when answering questions?

Conversation

- Ask them to carry out research on the flow of energy in a system. Let them present their findings in a class discussion and compare their notes with other groups. Are their findings logical? How well can they explain the flow of energy in a system?
- Ask the learners some questions as they present their findings. Are they able to explain the effect of heat gain or loss to the internal energy of a system?
- Discuss with them the concept of energy transformation. Which law governs the energy transformation in this activity?
- Discuss with the learners whether work is done by the environment or to the environment.

Product

- Mark the answers written down by the learners. Are their answers correct? Are the learners able to calculate the change in internal energy due to work done, heat gain or loss?
- Mention to them that the law of conservation of energy still holds in this case. This law states that energy can neither be created nor destroyed but can be converted from one form to another.
- Note that when a system absorbs energy, its energy levels rise. This is taken as positive energy since heat is supplied to the system otherwise when energy is removed the reverse is true.

7.7 The processes of melting and solidification

Specific learning outcome

By the end of this section, the learners should be able to explain melting and solidification of substances and the factors that affect melting point of a substance.

Teaching guidelines for activities 7.13 and 7.14

Activity 7.13

- Review the concept of melting process as learnt in the early years. Engage the learners in a question and answer session to test their memory.

- Organise the learners in mixed ability groups to share the resources available. Outline safety precautions that have to be observed while doing the activity that involves the use of fire from Bunsen burner or otherwise and breakables like glasses.
- Guide the learners to measure the temperature of crushed ice in a beaker using a thermometer. Ensure that as the ice is being heated, temperature and time (at intervals) are being recorded. Let them heat the ice until all of it turns into liquid.
- Ask them to record all the observations starting with the initial temperature of the ice before heating. Their table should be the same as table 7.3 in the learner's book. What can they observe as they heat the ice? Does the temperature increase consistently?
- Let them use the data they recorded to plot and draw a graph of temperature against time on a graph paper. Are they able to choose a suitable scale for their graph? How well have they drawn the graph?
- Ask them to discuss and analyse all sections of the graph as they explain what is happening in each case. Let them explain the shape of the graph and what is happening in each section.
- Ask the learners to do related questions from exercise 7.6.

Activity 7.14

- Organise the learners in groups of mixed abilities.
- Guide the learners to lay a block of ice on two cement blocks and hung weights on the ice using a string as shown in Fig. 7.12. Note that the weights can be substituted by any two but equal masses. The Mathematics knowledge of making masses using arbitrary unit shall be helpful. A wire can be use in place of a string.
- Ask them to observe the ice melting.
- Ask the learners to do related questions from exercise 7.6.

Assessment

Observation

- Observe the learners in groups as they do the activities.
- Move around the classroom observing whatever the learners are doing, for example, drawing graphs.
- Also, observe them as they present their findings. Are they able to note that the pressure by the weights lowers the melting point of ice? Can they collect and record data accurately. Can they draw the graphs asked accurately?
- In activity 7.14, the block of ice will melt faster due to an increase in pressure. This means that the melting point of ice is lowered. What would happen if the melting point were to increase?

Conversation

- Ask the learners some questions to remind them of what they have already learnt. Ask the learners some questions as they do the activities draw the graph and explain the graph through a class presentation. Can they explain each part of the heating and cooling graph?
- Lead the learners in a class discussion to help them fully understand what happens during melting and freezing. Use question and answer method to help them explain the heating and cooling curve for water as depicted in the graph.
- Let each group analyse its results and relate them to the graph drawn.

Product

- Mark the answers written down by the learners. Are their answers correct? Have they written the correct explanations for the heating and cooling curves?
- Listen to their oral answers and correct them where necessary.

Unit Assessment

- Ask the learners to do questions in the unit test 7 given at the end of the topic.
- Mark their work and assess the extent to which they have mastered the concepts learnt in the unit.
- Organise remedial teaching for those who may still be having challenges.

Answers to numerical questions

Exercise 7.1

2 26.67 J/K
3. 20800 J

Exercise 7.2

1 35° C 3 111.11 J/kg K

Exercise 7.3

2 (a) 26000 J (b) 391000 J
5 327.6 s
6 25.93°C or 298.93 K
7. 10.71 kg 8. 630 J/kgK
10. 63.66°C 11. 4 000 J/kg/K

Exercise 7.4

5 840 000 J
6. (a) 882 000 J
(b) 882 s
8. 0.398 kg
9 358.73 s

Topic test 7

6. 33600 J
7. 8.7°C
8. 1 771.43 J/kgK
9. 1 505 400 J
10. 382.5 J/kgK
11. 50.17 J/s
12. 2.24×10^6 J/kg
13. 50 J
14 +1000 J
16. 25.9°C

UNIT 8

Bulk properties of solids and fluids

(Student's book, pages 247 - 290)

Topics in the unit

Topic 8: Bulk properties of solids and fluids

Learn about	Key inquiry Questions
Learners should investigate by performing experiments in groups about the bulk intensive and extensive properties, eg of intensive property of solids to find stress and strain and establish the relationship between stress and strain. They should understand Hook's law; Young's and shear modulus, elasticity of length and shape, bulk modulus and volume elasticity. They should derive the equation of continuity and Bernoulli's equation, and apply them to solving problems regarding the bulk properties of fluids. Include density, specific weight, specific volume, specific gravity, compressible and incompressible fluids, perfect gases, compressibility of perfect gases, standard atmosphere and ideal gas. Learners should design practical investigations using appropriate equipment on viscosity and to derive the equation for the rate of change of shear strain, and the coefficient of viscosity	1. What is meant by Bulk material? 2. How do we need to find bulk density of solid? 3. How can we work out the density, specific weight, specific volume and specific gravity of fluid? 4. Why do fluid have compressible and incompressible property?

Knowledge and Understanding	Skills	Attitudes
Explain the bulk properties of solids and fluids and their application. Understand Hooke's law.	Investigate by performing experiments in groups about the bulk intensive and extensive properties Design practical investigations on viscosity, the rate of change of shear strain, and the coefficient of viscosity Derive the equation of continuity and Bernoulli's equation, and apply them to solving problems	Appreciate the bulks properties for either chemical, mechanical , etc

Contribution to the student's competences

1. **Cooperation:** The activities in this topic are designed in such a manner that it requires learners to work in pairs or groups. Through working as a pair or group, learners will realise that they need each other in order to tackle a particular task given. This will promote cooperation and inter-relationship among the learners.
2. **Communication Skills:** After working in groups, obtaining the results, the learners are required to discuss their findings among themselves and present them to the whole class. This will promote communication skills in learners.

Cross - cutting issues addressed in this topic

1. **Environmental awareness and sustainability:** In this topic, learners have been sensitized on the conservation of the environment. For instance, they are warned against poaching using catapult under the applications of Hooke's law.

Attention to the special needs

As a teacher, you must understand your class and the kind of learners you are dealing with. Never assume that every learner can handle any task given to him or her. Pay attention to physically challenged learners in your class during activities. For instance, those with hand challenges should be asked to observe while the other hold. Those visually impaired too require attention. For more information on how to care for special needs refer to the introduction part of this Teacher's Guide

Topic 8 Bulk properties of solids and fluids

(Student's book pages 256-297)

Background information and / or prior knowledge

- Learners have come across matter in their daily lives and they always interact with matter. In this topic we will explore the states of matter and then look at the kinetic theory of matter. Use the learner's daily experience with interaction with matter to build and help them understand the different concepts in this topic. This should be an interesting topic to the learners as they explain the different concepts they come across in their daily life.

Subtopics

No.	Subtopics
1.1	Matter and its composition
1.2	Introductions to kinetic theory
1.3	Physical properties of matter
1.4	Movement of particles in matter
1.5	Applications of adhesive and cohesive forces
1.6	Surface tension

Suggested teaching/learning activities

8.1 Definition of bulk, intensive and extensive properties

Specific learning outcome

By the end of this section, the learners should be able to explain what intensive and extensive properties of matter are, give examples of each and design an activity to determine some of them

Teaching guidelines to activities 8.1 and 8.2

Activity 8.1

- Some words like bulk, intensive and extensive properties may be unfamiliar to the learners. Explain to them the meaning within the introduction of this section.

- Let the learners discuss with the classmates what bulk, intensive and extensive materials are. Learners may not get it right but it encourages them to look for the right answers.
- Now help them to locate right sites from the relevant reference materials and carry out research on bulk, intensive and extensive properties of matter. Group the students into appropriate groups according to the number of resources available for use.
- Go around and help them to access the internet using the mobile phones provided to them. Caution them against accessing unauthorized sites.
- Ask them to discuss their findings in their groups before presenting them to the class.

Activity 8.2

- In this activity, the learners are required to design their own experiment to determine the extensive and intensive properties of matter. In their investigation, they are supposed to prove that boiling point of a liquid and mass of a substance are intensive properties.

Advise them to be careful as they work with fire. Mishandling of glass could lead to breakages, which can hurt them.

- Provide the learners with the materials required in this activity. Ask them to design and investigate the above subjects.
- Check their designs before allowing them to do the experiments. This is because a wrong procedure will lead to wrong results. Discuss the designs with them to clarify them. Ask them to proceed with the activity record all the observations and analyse them after which they can write a conclusion.
- Discuss with the learners some of the possible errors in the experiment. Ask them to suggest some of the ways they can minimise these errors.
- Let them do questions 1 and 2 from exercise 8.1.

Assessment

Observation

- Observe the learners as they write the designs for and carry out the activities. . Observe if they are able to write down the procedure.
- Move around and look at the set up done by the learners. Find out if they are able to follow the procedure, they have written.
- Observe as the groups record and discuss their results. How are they analyzing the data they have collected? Are they able to differentiate between the extensive and intensive properties?

Conversation

- Talk to the learners as they discuss their results. Are they able to use scientific terms to state the differences between intensive and extensive properties of matter?
- Discuss with them their findings. Ask them questions that will show consistency or inconsistency in the results.
- Guide them to analyse results and reach a conclusion using the data obtained. Are they able to explain what bulk, extensive and intensive properties are?
- Discuss with the learners some examples related to the intensive and extensive properties of matter. Can they give examples of each?

Product

- Check the experiment they have designed. Have they written down the correct procedure that will help them illustrate the intensive and extensive properties of matter? Can they be able to use the data they have collected to differentiate between the two? How well are their experiments structured? Can they accurately record data and analyse it? What conclusion can they make from the experiment?
- Ask the learners to do questions from exercise 8.1, as an assignment .This will help the learners to do more research and learn more to master the concepts.
- Review and explain to them that extensive properties depend on the size of matter in a substance. These include mass, volume, weight etc. On the other hand, intensive properties such as density are because of the ratio between two extensive properties in this case mass and volume. Intensive properties are more concerned about the type of matter present. Examples include melting point, boiling point, oduor, refraction index etc.

Specific learning outcome

By the end of this section, the learners should be able to state and explain bulk properties of solids.

Teaching guidelines to activity 8.3

- This activity is investigative in nature. It is aimed at verifying Hooke's Law. The activity can be best done in groups. Ensure that all the necessary materials are available to the learners.
- Ask them to use the materials provided to set up the activity as shown in Fig.8.1 in the student's book. Let them ensure that the markings on the ruler are on the same side as the point for easy reading.
- Let them record the initial reading of the pointer when no mass is hanged on the spring.

- Let them load the spring with 50 g mass and record the new pointer reading. Explain to them that the difference is the extension produced by a mass of 50 g.
- Ask them to repeat the steps by adding mass to the spring and recording their results in a table such as table 8.1 in the learner's book.
- Move around the class observing what they are doing. Guide those who may be having difficulties.
- Ask them to draw a graph of applied force against extension produced. Ask them leading questions from the graph drawn, for example, how can we get the extension produced by a mass of 250g? Ensure that all the graphs drawn are the same i.e. straight-line graphs. The learners are able to get the extension produced by a different force from the graph.
- Emphasise on the need for them to ensure that they can answer questions in steps 6, 7 and 8 with less difficulties.
- Ask them to discuss their findings before they present their conclusion to the class.
- Guide them through examples in the learner's book. You can also formulate your own questions. Ask the learners to do questions in exercise 8.2.

Assessment

Observation

- Look at the set ups before they start recording results.
- Observe as the groups carry on with the activity and discuss their results. Can they deduce the relationship between extension produced and the force applied?
- Observe to ensure that all the members of a group are actively participating in the activity.
- Look at the graph drawn by the learners. Is it the correct graph? Are they able to get the extension from the graph they have drawn? What does the slope of the graph represent?

Conversation

- Ask them to compare their graphs. What quantity does the slope of the graph represent?
- Talk to the learners as they discuss their results. Are they able to explain the relationship between force and extension? Can they define and explain Hooke's law with ease.
- What can they note about the relationship between the extension of the spring and the force applied? What will happen if they keep adding the masses?

- Guide the learners through the discussion given in the student's book and put more emphasis on the applications of Hooke's law. Take this opportunity to sensitise learners against poaching. Mention to them that this is a social vice that not only deprives the country of revenue but also degrades the ecosystem.
- Lead the learners in discussing example 8.1. Copy examples 8.2 to 8.4 on the board and ask the learners to close their books and attempt working them out. Let them discuss the examples in groups and solve them. Ask them to compare their answers to the ones given in the book. Are they able to solve the examples accurately?

Product

- Mark their answer for the exercise 8.2. Are their answers depicting mastery of Hooke's law concept?
- Emphasise to them that the extension produced in an elastic material like the spring is directly proportional to the extension produced. This conclusion verifies Hooke's Law, which states that, provided the elastic limit is not exceeded, the extension of a spring is directly proportional to the load applied on the spring.
- Mention some of the applications of Hooke's Law. i.e. in the making of spring balances, Spring beds, rubber shoes, catapult for hunting etc.

Teaching guidelines to activity 8.4

- This activity aims to find out the strength of materials. Organise the learners in convenient groups and ensure that the requisite materials are available in the class.
- Ask them to carry out the activity as per the instructions given in the learner's book. Let them clamp cotton threads and steel thread of the same length and thickness as shown in Fig.8.9. Guide them to keep adding masses as they observe what happens to the two threads.
- Does the cotton thread support the same weight as the steel thread? Which one of the two shows strength?

Assessment

Observation

- Observe the learners set up the experiment. Ensure that they are doing the correct thing.
- Look at the complete set ups, and approve before they can start collecting data.
- Are their data in line with the activity?

Conversation

- Discuss with the learners the results of the activity.
- Ask them questions to test their understanding of the concept behind the activity.
- Explain to them that strength is the ability of a material to withstand an external force without breaking.

8.2.3 Stiffness

Teaching guidelines to activity 8.5

- Organise the learners into groups of mixed abilities. This activity can be done outside the classroom to make use of the free space.
- Ask them to design and carry out an investigation on the stiffness of aluminium and steel rods. Ask them to use the locally available aluminium and steel rods to do this activity.
- Check their procedures as you guide and facilitate the activity. Ensure that all the required steps are included in the procedure.
- Let them try to bend the aluminium rod into a curve and note the force with which they bend it.
- Let them try to bend the steel rod again. Ask them to say the one that is easier to bend.

Assessment

Observation

- Observe as you move around offering guidance where necessary.
- Observe them bending the rods.

Conversation

- Engage the learners in oral questions as they do the activity.
- Ask them to try bending the rods. Can they state the one that is easier to bend? Can the learners be able to compare the stiffness of the two materials?

Product

- Check the bent rods.
- Explain to the learners that :

Stiffness is the ability of a material to oppose distortion of its shape or size or both by an applied force.

Teaching guidelines to activities 8.6 and 8.7

Activity 8.6

- This activity has been prepared to demonstrate ductility of a material.
- Ask the learners to be in the same groups as they were in activity 8.5. Let them use a plastic pipe and bend it. Tell them to observe what happens.
- Let them repeat what they did in activity 8.5 and record their findings.
- Ask them some probing questions to ensure that they can differentiate ductility from stiffness.
- Ask them to name some examples of materials that behave like the plastic.
- Let them keep the plastic pipes in a safe store.

Activity 8.7

- Activity 8.7 shall demonstrate the brittleness of a material. Use probing questions like; what is a brittle material? Name some brittle materials in the school compound to test the prior knowledge of the learners.
- Now let them take a piece of chalk and try to bend it. Does the piece of chalk bend? Are they able to explain why the piece of chalk breaks? Are they able to relate the breaking of the chalk to brittleness?
- Allow them to explain their findings. Let them compare the two observations before they present their findings to the class.
- Ask them to clean the working areas after the activity.

Assessment

Observation

- Ask the learners to observe what happens to the pipe. What can they note about the pipe as they bend it, does the plastic pipe deform easily?
- The aluminum rod is easier to bend than the other one.

Conversation

- Ask the learners to explain what is happening in the plastic pipe. Are they able to explain what ductility of the pipe is?
- Ask them to explain why the piece of chalk behaves that way when subjected to a little external force.
- Compared to the piece of chalk, ask the learners to differentiate between ductility and brittleness.

Product

- Explain to them that:

Ductility is the ability of a material to sustain great plastic deformation before fracture. Ductile materials can be reshaped easily as they do not crack or break easily. These materials include copper, iron, nickel etc. This is an important aspect of consideration in metalwork and fabrication.

On the other hand, brittle materials are easy to break. Such materials undergo little or no plastic deformation.

Teaching guidelines to activity 8.8

- This activity aims at enhancing research skills of learners on properties such as stress, strain and Young's modulus.
- Review with them the properties covered early in this section, i.e strength, brittleness, stiffness, etc.
- Guide them to do a research from reference books, resource persons and the internet on stress, strain and Young's modulus.
- In the research ensure they come up with the definitions of the key words and how they are applied.
- They should also research on the mathematical expression for the SI unit of Young's modulus. This calls for the use of their mathematical skills in tackling problems.
- Are they able to explain the significance of the three quantities i.e. strain, stress and Young's modulus?
- Discuss with them examples 8.5, 8.6 and 8.7 in the learner's book.
- Ask the learners to do exercise 8.3.

Assessment

Observation

- Observe the groups as they discuss their findings for the activity. Are they able to investigate each property of the solid stress and strain?
- Observe how they contribute in class. Ensure that every learner is motivated in the class.

Conservation

- Talk to the learners while discussing their findings. Are they able to explain strength, stiffness, ductility, brittleness, and stress and strain?

- After the activities, hold a discussion with the learners to help them understand.
- Strength of a material is the ability of the material to withstand an external force without breaking. The external force puts the material under tension hence the material is said to have tensile strength.
- Stiffness of a material is the ability of a material to oppose distortion of its shape or size or both by an applied force.
- Ductility is the ability of a material to sustain great plastic deformation before fracture.
- Brittleness of a material is the ability of a material to undergo little or no plastic deformation before fracture when an external force is applied.
- Discuss with learners examples 8.5 and 8.6 on the chalkboard.

Product

- .Read the answers they have written for exercise 8.3. Review with them where necessary. Are their answers depicting mastery of concepts such as explaining of strength, stiffness, ductility, brittleness, and stress and strain with ease?

Specific learning outcome

By the end of this section, the learners should be able to explain and determine bulk properties of fluids.

Teaching guidelines to activity 8.9

- This activity should be done in groups. Note that the water can be in a graduated cylinder or beakers. First they should measure:

  Mass of an empty cylinder then

  Mass of cylinder + water.
- Ask the learners to measure the mass of different volumes of water using a beam balance. Encourage them to record their findings in a table such as table 8.2 every time they make an observation.
- Ask them to calculate the ratio of each volume of water to its mass. What can they notice about the ratio?
- Allow them to discuss about their findings? Are they able to relate the ratio to density?
- Guide them through examples 8.9 and 8.10 in the learner's book.

Assessment

Observation

- Observe the learners as they carry out the activity. Observe the groups discussing their findings. Can they identify density as an intensive property of liquids?

Conversation

- Talk to the learners as they are doing the calculations to complete table 8.2. Ensure that the table is correctly filled. Are they able to do the correct calculations?
- Ask the learners to discuss examples 8.9 and 8.10 as they solve them in their exercise books. Are they able to follow the examples with ease? What are some of the challenges they may have during this discussion? You are encouraged to offer individual assistance.
- Ask them to name other intensive properties of matter that they know.

Product

- Explain to the learners that density is an intensive property of matter.

  That Density = Mass /Volume.

  Its SI unit is the kg/m^3.

Teaching guidelines to activity 8.10

- This activity can be done in groups to enable the learners to share the resources available. Let them pour an equal amount of water in one of the measuring cylinders provided and glycerine in the other. See Fig. 8.18 in the learner's book.
- Ensure that they gently release identical ball bearing to fall through a certain height in air, water and glycerine in tall cylinders.
- Let them measure the time taken in each case. Let them be keen on noting the time it takes the ball to fall through each fluid.
- Allow them to discuss their observations and make notes and conclusions on their findings. Ensure that they are able to explain the observations they have made .Is their presentation accurate?
- Discuss with them clarifying where needed be. Define for them the word viscosity.

Teaching guidelines to activity 8.11

- Organise the learners in groups. Ask them to read through activity 8.11 to familiarise with the steps. Allow them to do the activity using the materials provided.

- Let them measure the diameter of the spherical ball given to them using a string and then determine the radius.
- Ask them to fix some rubber bands along the tube at equal intervals and let them drop the small steel ball through the glycerine.
- Ask them to measure the time taken by the ball to move through the equal intervals. Let them also determine the velocity of the ball as it descends into glycerine. Give them time to obtain their own result.
- Allow them to discuss the result they have got. Ask them to calculate the velocity of the ball.
- Are they able to calculate the average velocity? Are they able to use the velocity they obtained to calculate coefficient of viscosity?
- Allow them to discuss their findings.
- Ask the learners to name sources of error in the activity.

After the activities, hold a discussion with the learners and ensure that they understand the following:

- Liquids offer resistance to the movement of objects in them.
- Frictional force in liquids is due to the viscosity. The resistance due to fluids is called viscous drag.
- Terminal velocity is the maximum downward velocity possible for a body falling through a fluid.
- At terminal velocity, U + F = W
- Air resistance is friction due to air. To reduce air resistance, bodies of cars and planes are streamlined.
- Take them through the discussion of Example 7.3 on the chalkboard.
- Ask them to do Exercise 7.4 provided in the student's book.

Assessment

Observation

- Observe as groups discuss their results. Are they able to substitute the results they get in the formula given in order to solve the questions asked?

Conservation

- Define and discuss the key words such as terminal velocity, coefficient of viscosity.
- Can the learners be able to explain what will happen to the time the ball will move through the air, water and glycerine if their temperatures are increased?

- Talk to them while discussing their results. Can they demonstrate how they can obtain each property of the fluid? Can they describe how to determine viscosity of the fluid? What of coefficient of viscosity and terminal velocity?
- What are some of the ways of minimising these errors? Discuss them with the learners.

Product

- Let them write example 8.11 in their exercise books and close the textbooks. Let them discuss the example and solve it in class. Are they able to solve it correctly?
- Choose some questions from exercise 8.4 and ask the quick learners to keep solving them as you guide the slow learners and those who may be having difficulties.
- Give the learners the rest of the questions to do as an assignment.

Specific learning outcome

By the end of this section, the learners should be able to explain streamline and turbulent flow and calculate the rate of flow of fluid.

Teaching guidelines for activity 8.12

- Make a prior arrangement to locate a river or stream near the school and identify the study point, which is safe for the learners.
- Take the learners to the nearby stream or river that you have identified.
- Warn the learners that they must strictly be disciplined to prevent cases of drowning. The areas around streams are usually slippery.
- Let them identify a place where the water is flowing fast and where it flows slowly.
- Ask them to place the floating object on the flowing water at areas where water is moving fast and where it moves slowly. Let them record the time of flow of the floating object from one point to another at those sites (slow and fast sites).
- Guide them so that they may not waste time when doing the activity.
- Allow them to enjoy the vicinity while doing the activity but they must be cautious.
- Let them collect their results and discuss among themselves.
- From the learners' discussions, are they able to explain and differentiate the types of flow? Can they explain that a streamline flow is one where, at a given point each and every molecule of the fluid travels in the same direction and with the same velocity?
- Ask the learners to do exercise 8.5.

Assessment

Observation

- Observe the learners as they carry out the activity. You can also move around and guide them as they record the results.
- Observe the groups discussing their results. Can they differentiate between streamline and turbulent flow?

Conservation

- Talk to the learners as they discuss their findings. Can they derive the equation of the rate of flow of fluid? Guide them through examples 8.12 to 8.14. Allow them to discuss similar examples given to them in class. Are they able to follow through the examples?
- Define the key words like turbulent flow, streamline flow

Product

- Mark their work and guide them accordingly.
- You may create remedial classes to further guide those who may be having difficulties. You can also encourage the learners to embrace peer teaching so that they can learn from those who have understood the concepts.
- Review the whole section with them for better understanding. This section shall usher you into the concept of Bernoulli's equation.

Specific learning outcome

By the end of this section, the learners should be able to derive and use Bernoulli's equation with ease.

Teaching guidelines for activity 8.13

- Ask the learners to open and read the reference books given to them.
- Let them carry out research on Bernoulli's equation. In case you are using electronic devices, group the students into appropriate groups according to the number of devices available for use. Advice them to read widely and do a lot of practice in solving related problems.
- Instruct them to identify the components of Bernoulli's equation. Allow them to discuss their findings in their groups and after that encourage them to present in class.
- Ask them to present how to derive Bernoulli's equation on the chalkboard.

Assessment

Observation

- Observe the groups discussing their findings. Are they able to explain Bernoulli's equation?
- Observe the learners as they derive the Bernoulli's equation on the chalkboard. Are they able to derive Bernoulli's equation step by step?

Conversation

- Engage the learners in question answer session. Ask them questions Talk to them while discussing their findings. Can they explain Bernoulli's equation and derive it? (Note that they may not give 'right' response at this point).
- Guide them through example 8.15 given in the student's book to emphasise how Bernoulli's equation is used.
- Clarify the derivation of the equation as the learners copy the same in their exercise books.

Product

- Read the answers given by the learners from the discussion.
- Ask the learner's to answer questions from exercise 8.6 and unit test 8. Are their answers depicting mastery of concept on Bernoulli's equation and other concepts learnt in this unit?

Answers to numerical questions

Exercise 8.2

4. 8000 N/m

5. 50 N
6. 5 N

Exercise 8.3

2. (a) 79 544.3 N/m^2

   (b) 1 117 322 N/m^2

3. 0.393

4. 14 080 N/m^2

Exercise 8.4

2. $5.31 \times 10^{-7}\ m^3$
4. (b) 0.697 $kgm^{-2}s$

Exercise 8.5

3. (a) 10×10^{-4} m/s
5. 3.19 cm
6. 2.7 m/s

Topic test 8

4. 3.19 cm
5 37 245.22 N/m^2
6. (b) (iii) 2.4 N
7. (a) 4 cm
8. (a) 13 m