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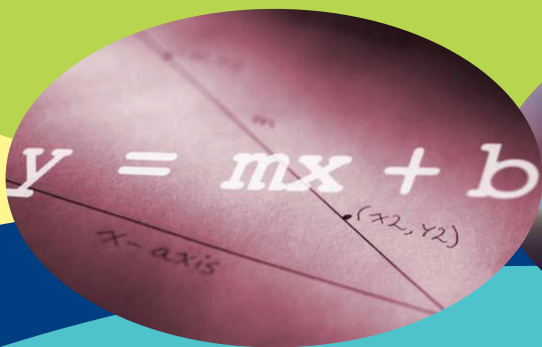

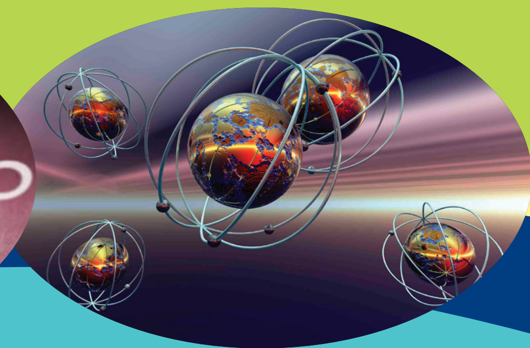

Uganda Advanced Certificate of Education

TEACHING SYLLABI FOR

Physics
Mathematics

VOLUME 2

2013

THE REPUBLIC OF UGANDA
Ministry of Education and Sports

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The National Curriculum Development Centre (NCDC) would like to thank everyone who worked tirelessly towards the production of the Advance Level (UACE) Curriculum Teaching Syllabi.

Special thanks go to the Ministry of Education and Sports for supporting the work. NCDC would also like to thank the following for their professional input: Secondary Schools, Universities, National Teachers' Colleges, Uganda National Examinations Board (UNEB), Directorate of Educational Standards (DES), Secondary Science and Mathematics Teachers' Programme (SESEMAT), Technical and Business Institutions, Religious Organisations, Professional Organisations, retired and practising Teachers.

Last but not least, NCDC would like to thank all those who worked behind the scenes to finalise the documents.

NCDC takes full responsibility for any errors and omissions in the documents and welcomes suggestions to address them.

FOREWORD

For a long time teachers have been using Uganda National Examinations Board (UNEB) syllabi to plan their teaching schemes. This approach has rendered the curriculum to be largely driven by examination.

Working with relevant subject panels, NCDC has produced the Teaching Syllabi for all the Advanced Level subjects. The subject content in the syllabi has been clarified using appropriate specific objectives. It should be noted that the content in the syllabi has remained largely the same except in a few subjects where it has been updated by removing obsolete and/or irrelevant material. Suitable teaching / learning strategies have been suggested to the teacher and other users.

Teachers will find the syllabi useful in planning the teaching / learning processes. The content therein will go a long way in enhancing the learners' educational experiences and guide the teachers towards successful delivery of meaningful learning experiences.

The teaching / learning strategies suggested in the Syllabi are just a guide to the teacher but are not meant to substitute the rich professional approaches that the teacher may opt to use to deliver knowledge, and to develop understandings, skills, values and attitudes.

Connie Kateeba

DIRECTOR

National Curriculum Development Centre

General Introduction

This book contains Teaching Syllabi for the following principal subjects:

1. Physics
2. Mathematics

The syllabi have been reviewed to remove outdated and/or irrelevant content.

Purpose of the Teaching Syllabi

It is envisaged that the teaching syllabi will help teachers to cover the syllabi content adequately up to appropriate depth. The design of these syllabi is to emphasise the teaching approaches to be used for each sub-topic/sub-unit to achieve the general objectives of the syllabus. The periods allocated for each topic should also guide teachers to make effective plans so that they can complete the syllabus within the recommended period.

Further guidance has been given to enable the teacher develop the learners' knowledge, skills, understandings, attitudes and values by highlighting the general and specific objectives.

Application of Science/Mathematics to daily life is a key feature for all the sub-topics/sub-units in the syllabus. It is important to note that teachers make the learners appreciate the relevance and benefits of studying these subjects at Advanced Level.

The teaching syllabi contain features which the practicing teacher should find very useful during scheming, preparation of lessons, actual teaching, assessment of learners and self evaluation. It also helps the teacher to break down the content and identify the main points in every sub-topic/sub-unit.

The guidance given is not meant to replace your resourcefulness but has been provided as a supplement to your efforts.

For every subtopic sub-topic/sub-unit, the following have been provided:

Suggested Teaching and Learning Strategies

The recommended methods should all be based on experiments and experimental-investigative approaches where students can participate individually or in groups. A list of the necessary **teaching / learning resources** has also been suggested. Where possible, some of the apparatus should be improvised.

Notes

Where applicable, these have been provided to further clarify the scope and depth for each sub-topic/sub-unit.

Applications

Where possible, a number of practical applications for each sub-topic/sub-unit have been mentioned. These are just examples. You are encouraged to expose the learners to as many applications as possible. Use local examples mainly.

Broad Aims of Education in Uganda

i) To promote understanding and appreciation of the value of national unity, patriotism and cultural heritage, with due consideration of internal relations and beneficial inter-dependence.

ii) To inculcate moral, ethical and spiritual values in the individual and to develop self-discipline, integrity, tolerance and human fellowship.

iii) To inculcate a sense of service, duty and leadership for participation in civic, social and national affairs through group activities in educational institutions and the community.

iv) To promote scientific, technical and cultural knowledge, skills and attitudes needed to promote development.

v) To eradicate illiteracy and to equip the individual with basic skills and knowledge to exploit the environment for self-development as well as national development, for better health, nutrition and family life and for continued learning.

vi) To contribute to the building of an integrated, self-sustaining and independent national economy.

Aims and Objectives of Secondary Education in Uganda

i) Instilling and promoting national unity and an understanding of social and civic responsibilities.

ii) Promoting an appreciation and understanding of the cultural heritage of Uganda including languages.

iii) Imparting and promoting a sense of self-discipline, ethical and spiritual values, personal responsibility and initiative.

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

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

vi) Enabling individuals to develop basic scientific, technological, agricultural and commercial skills required for self-development.

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

viii) Laying the foundation for further education.

ix) Enabling the individual to apply acquired skills in solving the problems of their community.

x) Instilling positive attitudes towards productive work.

Uganda Advanced Certificate of Education

Physics

TEACHING SYLLABUS

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Introduction

This Physics Teaching Syllabus is meant to aid teachers handling Physics at Uganda Advanced Certificate of Education (UACE). It is designed to build on and also include the Physics Syllabus at Uganda Certificate of Education (UCE). Knowledge beyond that required for UCE is not expected unless specifically mentioned in topics in the UACE syllabus.

The syllabus is divided into seven broad units. Each unit is divided into several sub-units which are arranged in a sequence that presents terms, concepts and procedures which should be learned before those that build on, extend or apply the knowledge gained.

Purpose of the Teaching Syllabus

This teaching syllabus will help teachers to cover the syllabus content adequately up to appropriate depth. The design of this syllabus is to emphasise the teaching approaches to be used for each sub-unit to achieve the General Objectives. The periods allocated for each unit should also guide teachers to make effective plans so that they can complete the syllabus within the recommended period.

Further guidance has been given to enable the teacher develop the learners' knowledge, skills, understandings, attitudes and values by specifying the general and specific objectives.

Application of Physics to daily life is a key feature for all the sub-units in the syllabus. It is important to note that teachers make the learners appreciate the relevance and benefits of studying Physics at Advanced Level.

The Teaching Syllabus contains features which the practicing teacher should find very useful during scheming, preparation of lessons, actual teaching, assessment of learners and self evaluation. It also helps the teacher to break down the content and identify the main points in every sub-unit.

The guidance given is not meant to replace your resourcefulness but has been provided as a supplement to your efforts.

Aims of Teaching Physics

i) Enabling the learners to know:
   - the basic principles and concepts of Physics.
   - how theories and models are used to explain concepts in Physics.
   - the resources available to facilitate discovery about unfamiliar principles and concepts in Physics.

- the use of knowledge of the principles and concepts of Physics in everyday life situations.

ii) Making the learners aware of the effects of scientific discoveries and knowledge on everyday life through some applications of Physics.

iii) Enabling learners to;
- develop an experimental attitude by performing experiments in schools.
- familiarise themselves with and practice scientific methods.
- develop the necessary skills to design and carry out practical investigations based on the knowledge of Physics.

iv) Preparing the learners for further studies in Physics and related fields.

v) Enabling the learners to appreciate the applicability of Physics in other disciplines.

vi) Enabling the learners to develop;
- an initiative for inventiveness.
- skills for practical investigation and exploration.
- capacity to design models and analytical schemes for use in problem-solving schemes.

General Objectives

The learners should be able to;

i) recognise problems that can be dealt with using methods, concepts, principles, models and theories of Physics.

ii) recognise the use of, and manipulate apparatus and equipment common in a Physics laboratory.

iii) design and carry out practical investigations and experiments, describe and explain the procedures used as well as their effectiveness and limitations.

iv) handle all practical work with the accuracy required to obtain the desired results.

v) define terms related to various concepts in Physics and explain their relationship to materials and phenomena in the environment.

vi) discuss the use and effectiveness of theories or models in explaining physical phenomena as well as events in the laboratory and in the environment.

Target

This teaching syllabus is aimed at enriching the teaching strategies employed by qualified Physics teachers in schools. It is also aimed at helping the teacher to present the concepts to the learner in a logical and simple way.

The learner is expected to have adequate prior knowledge on the basic concepts of Physics.

Scope and Depth

The syllabus has been divided into **seven** broad units, namely:

1. Light
2. Mechanics
3. Waves
4. Thermal Properties of Matter
5. A. Electrostatics and Current Electricity
   B. Electronic Devices
6. Electromagnetism
7. Atomic and Nuclear Physics

Teaching Sequence

SENIOR FIVE

Unit	Sub-Unit
1. Light (64 periods)	1.1. Reflection of Light at a Plane Surface
	1.2 Reflection of Light at Curved Surfaces
	1.3. Refraction of Light at a Plane Surface
	1.4 Refraction of Light through Triangular Prisms
	1.5. Refraction of Light through a Thin Lens
	1.6. Optical Instruments
2. Mechanics (108 periods)	2.1. Physical Quantities and their Units
	2.2. Kinematics
	2.3. Newton's Laws of Motion
	2.4. Solid Friction
	2.5. Work, Energy and Power
	2.6. Statics
	2.7. Fluid Flow
	2.8. Mechanical Properties of Matter
	2.9. Surface Tension
	2.10. Uniform Motion in a Circle
	2.11. Gravitation
	2.12. Simple Harmonic Motion
3. Waves (76 periods)	3.1. Basic Properties of Waves
	3.2. Wave Theory
	3.3. Interference of Waves

	3.4. Diffraction of Waves
	3.5. Stationary Waves
	3.6. Resonance
	3.7. Sound
	3.8. Polarisation of Waves
4. Thermal Properties of Matter (32 periods)	4.1. Thermometry
	4.2. Specific Heat
	4.3. Change of State

SENIOR SIX

Unit	**Sub-Unit**
4. Thermal Properties of Matter (cont'd) (64 periods)	4.4. Gas Laws
	4.5. Kinetic Theory of Gases
	4.6. Vapours
	4.7. Thermodynamics
	4.8. Transfer of Heat
	4.9. Survey of Energy
5A. Electrostatics and Current Electricity (46 periods)	5.1. Electrostatics
	5.2. Electric Field
	5.3. Capacitors
	5.4. Current Electricity
5B. Electronic devices (10 periods)	5.5. Cathode Ray Oscilloscope
	5.6. Transistors
6. Electromagnetism (64 periods)	6.1. Magnetism in Matter
	6.2. Magnetic Effect of an Electric Current
	6.3. Force on a Current Carrying Conductor
	6.4. Electromagnetic Induction
	6.5. A.C. Circuits
7. Atomic and Nuclear Physics (56 periods)	7.1. Charged Particles
	7.2. Quantum Theory
	7.3. Nuclear Physics
	7.4. Radioactivity

Time Allocation

The allocation of periods for each unit and for each term assumes that there will be twelve (12) weeks of effective teaching available per term for two years except for the first term of Senior Five and the third term of Senior Six. It is also recommended that there will be six (6) periods, each of 40 minutes of teaching per week for Physics theory and three (3) periods of laboratory practical work per week on the school timetable.

How to Use the Syllabus

The Physics Teaching Syllabus is aimed at providing the teacher with guidance required to teach Physics in Advanced Level classes. It is not meant to substitute the creativity of the classroom teacher. The Physics Teaching Syllabus has the following features:

a) **General Objective(s)**
This is a statement of the general learning outcome(s) expected of a learner at the end of the unit.

b) **Unit**
A unit consists of a number of sub–units around the same theme.

c) **Number of periods per unit**
The number of periods suggested for each unit is only to be used as a guide to enable the teacher cover the work adequately.

d) **Sub-Units**
Under each sub-unit there is a matrix which contains content on the sub-unit with the accompanying specific objectives.

e) **Specific objectives**
These clarify the content and scope. The teacher should use the objectives to plan the teaching strategies suitable for the lesson. Specific objectives also guide in evaluation at the end of the learning process.

f) **Content**
Items in the content column have been simply listed but should be handled together with the specific objectives of the sub-unit.

g) **Suggested Teaching and Learning Strategies**
The recommended methods should all be based on experiments and experimental-investigative approaches where students can participate individually or in groups. A list of the necessary **teaching / learning resources** has also been suggested. Where possible, some of the apparatus should be improvised.

h) **Notes**
These further clarify the scope and depth for each sub-unit.

i) Applications

Where possible, a number of practical applications for each sub-unit have been mentioned. These are just examples. You are encouraged to expose the learners to as many applications as possible. Use local examples mainly.

Assessment

a) Continuous Assessment

It is recommended that the teacher carries out continuous assessment basing on each unit. The questions in the assessment should reflect acquisition of the following testable competences:

i) *Knowledge*

Assess the learner on;

- knowledge of terminology.
- knowledge of specific facts.
- familiarity with experiments suggested in the syllabus.
- knowledge of common principles and generalisation identified in the syllabus.

ii) *Comprehension*

Assess the learner's ability to;

- explain standard phenomena from laws and models and to describe standard experiments met with before.
- translate between various forms of information presentation.
- use standard methods to solve familiar numerical types of problems.
- draw conclusions from experiments of a straight forward type.

iii) *Application and higher abilities*

Assess the learner's ability to;

- analyse presented information.
- synthesise ideas from presented analyses.
- apply laws and generalisations already learnt to new situations.
- devise experiments to test hypotheses and statements of models.
- exercise evaluative judgment on suitability and results of scientific procedures.

iv) *Practical abilities*

The written tests will demand knowledge of, and familiarity with experiments in Physics relevant at this level. The practical component of the examination will further test acquisition of the following abilities:

- application of knowledge to practical situations.
- manipulation of the apparatus and performing experiments.
- making and recording observations accurately.
- presentation of data in an appropriate form.
- appropriate manipulation of data
- drawing conclusions from observations made.
- assessing suitability of procedure, experiment and observations made in support of the conclusion.

The suggested assessment items under each unit are just exemplar. The teacher should explore a wide range of approaches.

b) Summative Assessment

Uganda National Examinations Board (UNEB) will administer a Physics (Principal Subject) examination at the end of Senior Six.

Examination Format

There will be ***three*** papers as outlined below:

Paper 1 (2 ½ hours)

The paper will consist of three sections: A, B and C. Ten questions will be set as follows:

Section A. Four questions from unit 2 of the syllabus.
Section B. Three questions from unit 4 of the syllabus.
Section C. Three questions from units 5B and 7 of the syllabus

Candidates will be required to attempt a total of ***five*** questions including at least one but not more than two from each section. Each question carries twenty marks. *(Total: 100 marks)*

Paper 2 (2 ½ hours)

The paper will consist of four sections: A, B, C and D. Ten questions will be set as follows:

Section A. Two questions from unit 1 of the syllabus
Section B. Two questions from unit 3 of the syllabus
Section C. Three questions from unit 6 of the syllabus
Section D. Three questions from unit 5A of the syllabus

Candidates will be required to attempt a total of five questions including at least one question from each of the sections A, B, C and D. The fifth question should be selected from either section C or D. Each question carries twenty marks. (*Total: 100 marks*)

Paper 3 (3 ¼ hours)
Three questions will be set. Candidates will be required to attempt question 1 and one other question. (*Total: 67 marks)*

Note: SI units and SI nomenclature will be used in all question papers.

Unit 1: Light

Duration: 64 Periods

This unit describes light propagation in terms of rays. The major concern in this unit is the geometrical properties of light and its applications.

General Unit Objectives

By the end of this unit, the learner should be able to:

- explain the formation of images by plane and curved surfaces.
- explain the behaviour of optical devices and instruments.
- determine properties of optical devices and instruments.

Sub-Unit 1: Reflection of Light at a Plane Surface

This sub-unit deals with light rays and how they behave when they strike plane surfaces.

Specific Objectives	Content
The learner should be able to: • verify: -the rectilinear propagation of light. -the reversibility of light.	• Propagation of light • Reversibility of light
• state the laws of reflection of light.	• Laws of reflection of light
• verify the laws of reflection of light.	• Verification of the laws of reflection of light
• distinguish between regular and diffuse reflection of light.	• Regular and irregular reflections
• describe applications of regular and irregular reflection.	• Applications of regular and irregular reflection
• derive the relationship between; - angle of deviation and glancing angle for a single plane mirror and for two plane mirrors at an angle to each other. - angle of rotation of a plane mirror and angle of rotation of the reflected ray.	• Deviation of light at: - a plane mirror - mirrors inclined at an angle to each other (include periscope and kaleidoscope) • Rotating a mirror keeping the direction of incident ray constant
• describe the mode of operation of a sextant and optical lever mirror galvanometer.	• Principle of the sextant and optical lever mirror galvanometer
• explain the formation of the image in a plane mirror using a ray diagram.	• Images in a plane mirror
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Demonstrate rectilinear propagation, reversibility of light and the laws of reflection of light.
- Demonstrate applications of regular and irregular reflections using a ray box or a torch.
- Brainstorm on use of two plane mirrors at an angle to each other and the properties of images in plane mirrors.
- Discuss the periscope and kaleidoscope (their design and mode of operation).

Note

- Include periscope, kaleidoscope and light beam galvanometer

Teaching/ Learning Resources

- Optical and drawing pins
- Plane mirrors
- Ray box
- Plain paper
- Mathematical set
- Soft board

Applications

- Dressing mirrors
- Periscope as used in submarines
- Light beam galvanometer

Assessment

- Practical exercise on the relationship between angle of rotation of a plane mirror and angle of rotation of the reflected ray, and the relationship between angle of deviation and glancing angle
- Project on making a periscope
- Describing the application of plane mirrors
- Description of images in plane mirrors
- Solving numerical problems

Sub-Unit 2: Reflection of Light at Curved Surfaces

In this sub-unit, you will deal with the behaviour of light rays when they are incident on curved surfaces.

Specific Objectives	Content
The learner should be able to:	
• identify different types of curved mirrors.	• Types of curved mirrors
• define the optical properties of curved mirrors.	• Optical properties of curved mirrors
• draw a ray diagram to show the formation of a caustic surface.	• Caustic surfaces
• explain advantages of parabolic mirrors over concave mirrors.	• Parabolic mirrors
• derive the relationship ***r = 2f*** for spherical mirrors.	• Relationship between ***r*** and ***f***
• construct ray diagrams on scale to form images using standard rays.	• Formation of images by curved mirrors
• describe images formed by curved mirrors.	• Images in curved mirrors
• define linear magnification.	• Linear magnification
• derive expressions for linear magnification in curved mirrors.	• Expressions for linear magnification
• derive the formula $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$ (for concave and convex mirrors).	• The mirror equation $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$ (for both point and finite objects)
• measure the focal length of convex and concave mirrors.	• Experiments to measure the focal length of concave and convex mirrors
• describe applications of curved mirrors (including parabolic mirrors).	• Applications of curved mirrors
• define spherical aberration.	• Spherical aberration
• explain the occurrence of spherical aberration.	• Occurrence of spherical aberration
• describe how spherical aberration can be minimised in curved mirrors.	• Minimisation of spherical aberration
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Demonstrate different types of curved mirrors, optical properties of curved mirrors, advantages of parabolic mirrors over concave mirrors.
- Measure the focal length of a concave mirror using different methods.
- Use guided discovery on construction of ray diagrams.
- Discussion of terms and derivations of expressions involved.

Notes

- Simple qualitative consideration, including experimental demonstration of spherical aberration and chromatic aberration.
- Spherical aberration only in relation to a point source on the axis of a large aperture mirror.
- Derivation of $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$ for both point and finite objects.
- Illuminated object, no-parallax methods should be used.
- Learners should draw accurate ray diagrams.
- Correct use of any of the two sign conventions.

Teaching/ Learning Resources

- Concave and convex mirrors and holders
- Optical pins/bulbs
- Wire gauze
- White screen

Applications

- Solar concentrator
- Car headlamp reflector
- Reflecting telescopes
- Driving mirrors
- Shaving/dressing mirror
- Torch reflector

Assessment

- Project work on constructing a solar concentrator
- Exercise on definition of terms and derivations of expressions
- Performance of experiments to determine the focal length of a curved mirror
- Solving numerical problems

Sub-Unit 3: Refraction of Light at Plane Surfaces

When a light ray moves from one medium to another of different optical density, it changes speed and in most cases it changes direction as well.

Specific Objectives	Content
The learner should be able to: • state the laws of refraction of light. • verify the laws of refraction of light. • define absolute and relative refractive indices. • explain refraction of light in terms of velocities of light in adjacent media.	• Laws of refraction of light: - Snell's law - verification - refractive index • Cause of refraction
• determine refractive index of glass using a parallel-sided or semi-circular glass block.	• Determination of refractive index
• derive the expressions - $_1n_2 = \frac{1}{_2n_1}$ - $_1n_3 = {_1n_2} \times {_2n_3}$ - ***nsin i = constant*** for media with parallel boundaries in contact.	• Media with parallel boundaries in contact
• derive an expression for the refractive index of; - a small quantity of a transparent liquid in a concave mirror. - a transparent medium with parallel boundaries by measuring real and apparent depth.	• Refractive index of a small quantity of a transparent liquid; - in a concave mirror - using real and apparent depth
• measure the refractive index of a transparent liquid; - using a concave mirror. - using real and apparent depth method.	• Measurement of refractive index of a transparent liquid using; - a concave mirror - real and apparent depth method
• carry out experiments that lead to the understanding of the concept of critical angle.	• Critical angle
• define critical angle . • derive the expression $\frac{1}{n} = \sin C$.	• Concept of the critical angle • Total internal reflection

Specific Objectives	Content
	- The relation $\frac{1}{n} = \sin C$
• define total internal reflection.	• Definition
• explain the occurrence of total internal reflection.	• Explanation of occurrence of total internal reflection
• explain the appearance of images in thick plane mirrors.	• Thick plane mirrors
• explain how a mirage is formed	• Mirage
• measure refractive index of a transparent liquid using air cell method.	• Air cell
• describe some applications of refraction of light and total internal reflection.	• Applications of refraction of light and total internal reflection
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Involve learners in hands-on activities to:
  - verify laws of refraction using glass block or semi-circular glass.
  - determine refractive index of glass using glass block.
  - determine refractive index of transparent liquid using an air cell, the no parallax method with concave mirror and the real and apparent depth method.
  - explain the appearance of images formed in thick plane mirrors.

Notes

- Emphasise the difference between:
  - reflection and refraction including their proper spellings.
  - statement of the laws of reflection and refraction.
  - critical angle and total internal reflection.
  - effects and applications of total internal reflection.
- Revise trigonometric ratios.
- Discuss likely sources of errors.

Teaching / Learning Resources

- Rectangular glass block/semi-circular glass block
- Transparent liquid such as water
- Air cell
- Concave mirror
- Optical pins

- Thick plane mirrors

Applications of Total Internal Reflection

- Optical fibres (used in communication and endoscopes)
- Totally internally reflecting prisms (like in prism binoculars, telescopes)
- Bicycle reflectors/bridge reflectors
- Effects of total internal reflection in:
  - the mirage
  - the fish's eye view
  - atmospheric refraction

Assessment

- Exercise on definition of terms, derivations of expression and calculations involved
- Describing experiments relating to refraction at a plane surface
- Explaining applications and effects of total internal reflection

Sub-Unit 4: Refraction of Light through Triangular Prisms

The total deviation suffered by a ray of light as it enters and leaves the glass prism is the sum of the angles of deviation of the ray at the two refracting surfaces. This concept is used in the spectrometer in analysing light.

Specific Objectives	**Content**
The learner should be able to:	
• measure the refracting angle of a triangular prism.	• Refracting angle
• derive the expressions - $d = (i_1 - r_1) + (i_2 - r_2)$ - $n = \dfrac{\sin\left(\dfrac{A+D}{2}\right)}{\sin\left(\dfrac{A}{2}\right)}$	• Deviation of Monochromatic light through a triangular prism • Minimum deviation
• measure angle of minimum deviation.	• Measuring angle of minimum deviation
• describe the structure and action of the spectrometer.	• Spectrometer • Grazing incidence and grazing emergence

Specific Objectives	Content
• derive an expression for the limiting angle of a prism.	• Limiting angle of prism
• derive the expression ***d = (n-1)A .***	• Deviation by thin prisms
• explain the dispersion of white light by glass prisms.	• Dispersion of white light by prisms
• describe applications of glass prisms.	• Applications of prisms (prism binoculars and periscope)
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Practical measurement of A and D using a spectrometer should be emphasised.
- Guide learners in the derivation of the expressions for:
  - n in terms of A and D
  - d in terms of n and A

Teaching/Learning Resources

- Glass prisms
- Spectrometer
- Optical and drawing pins

Applications

- Spectrometer in the analysis of the spectrum of white light
- Prism binoculars
- Prism periscopes

Assessment

- Derivation and use of expressions in solving numerical problems.
- Explanation of the phenomenon of dispersion.

Suggested Activity

By using a finger to 'block' the nozzle of a hose pipe, water comes out in small jets. If done against a green background (such as a shrub) in the presence of sunlight, the learners will observe a rainbow. Learners should be guided to explain why the rainbow forms.

Sub-Unit 5: Refraction through a Thin Lens

The effect that a lens has on a beam of light depends on its shape (concave or convex) and the extent of its curvature (thickness).

Specific Objectives	Content
The learner should be able to:	
• identify types of lenses.	• Types of lenses
• define the terms principal focus, principal axis, optical centre, focal length.	• Optical properties of lenses
• define the power of a lens.	• Power of a lens
• draw accurate ray diagrams to show formation of images by a lens.	• Formation of images by lenses
• describe the images formed by lenses	• Images in lenses
• calculate linear magnification of images.	• Linear magnification of images
• derive the formula $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$ for a thin lens (convex and concave).	• Thin lens formula (for point and finite objects)
• define conjugate foci.	• Conjugate foci
• derive the expression $l^2 - d^2 = 4df$.	• Displacement of a lens keeping object and screen fixed
• measure the focal length of a convex lens using displacement method.	• Measurement of focal length of a convex lens using displacement method
• derive Newton's relation **xy = f²**	• Newton's relation
• derive the expressions - $\frac{1}{f} = (n-1)\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$.	• Relationship between focal length of a lens and refractive index
- $\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}$.	• Thin lenses in contact

Specific Objectives	Content
• measure focal length and radius of curvature of a lens (concave and convex). • measure the radius of curvature of a thin convex lens. • define spherical and chromatic aberrations. • explain the occurrence of spherical and chromatic aberrations in lenses. • describe methods of minimising chromatic and spherical aberrations. • solve numerical problems.	• Determination of focal length and radius of curvature of a lens • Radius of curvature of a thin convex lens • Chromatic and spherical aberration • Explanation of occurrence of spherical and chromatic aberrations • Methods of minimising chromatic and spherical aberrations • Numerical problems

Suggested Teaching and Learning Strategies

- Involve learners in hands-on activities to:
  - determine nature and position of the images formed by lenses at different positions of the object.
  - verify the lens formula.
  - measure the focal length and radius of curvature (consider the displacement method too).
- Use guided discovery on accurate drawing of ray diagrams to show formation of images by lenses and derivation of expression involved.

Notes

- Simple qualitative consideration, including experimental demonstration of spherical aberration and chromatic aberration.
- Spherical aberration only in relation to a point source on the axis of a large aperture lens.
- $P = \frac{1}{f} Dioptres$, with f in metres.
- Derivation of $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ for point and finite objects.
- Use of no parallax, illuminated object or ray boxes.
- Discuss **Boy's** method.
- Emphasise the correct use of the sign convention.
- Use of thin lenses should be emphasised.

Teaching/Learning Resources

- Concave and convex lenses
- White screen
- Illuminated wire gauze
- Optical pins

Applications

- Optical instruments such as hand lens, microscope, telescope, lens camera and projection lantern
- Spectacles to correct eye defects

Assessment

Exercise on:

- definitions of terms involved, derivations of expressions and explanations of concepts
- description of experiments.
- numerical calculations involved.

Sub-Unit 6: Optical Instruments

The apparent size of an object depends on the size of the image at the retina and hence the angle subtended at the eye by the object. Therefore, the purpose of an optical instrument is to increase the visual angle.

Specific Objectives	Content
The learner should be able to:	
• define the terms near point, far point and accommodation.	• Near point, far point and accommodation
• define visual angle.	• Visual angle
• explain the relationship between visual angle and apparent size of objects.	• Relationship between visual angle and apparent size of objects
• define magnifying power of an optical instrument.	• Magnifying power of an optical instrument
• describe the structure and action of a simple microscope.	• The simple microscope
• derive the expression $\boldsymbol{M} = \frac{D}{f} - 1$ for a simple microscope.	• The expression $\boldsymbol{M} = \frac{D}{f} - 1$
• explain why an image formed by a	• Images formed by a simple

Specific Objectives	Content
simple lens microscope is free of chromatic aberration.	microscope
• describe the structure and action of a compound microscope in normal adjustment.	• Compound microscope (essential features only)
• derive the expression for the angular magnification of a compound microscope: - in normal adjustment. - when the final image is at infinity.	• Angular magnification in a compound microscope • Refracting telescopes • Expressions for magnifying power
• describe the structure and action of astronomical and Galileo's telescopes in normal adjustment and with the final image at the near point.	• Astronomical and Galileo's telescopes
• derive the expressions - M⍰ = $\frac{f_o}{f_e}$ - $M = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$ for the astronomical and Galileo's telescopes.	• The expression $M = \frac{diameter \quad of \quad objective}{diameter \quad of \quad eye - ring}$
• describe the action of astronomical and Galileo's telescopes.	• Reflecting telescopes
• define the eye-ring and explain its significance.	• The eye ring (consider normal adjustment only)
• derive the expression $M = \frac{diameter \quad of \quad objective}{diameter \quad of \quad eye - ring}$	
• describe the structure and action of Cassegrain, Coude⍰ and Newtonian reflecting telescopes.	
• compare the use of refracting and reflecting telescopes.	• Comparing the use of refracting and reflecting telescopes
• describe the action of prism binoculars, a projection lantern and a simple lens camera.	• Prism binoculars, projection lantern and simple lens camera
• describe a terrestrial method of	

Specific Objectives	Content
measuring the speed of light. • solve numerical problems.	• Measuring the speed of light • Numerical problems

Suggested Teaching and Learning Strategies

- Use guided discovery to:
  - draw accurate ray diagrams.
  - derive expressions of angular magnification.
- Demonstrate to the learners the use of optical instruments.
- Discuss methods of obtaining erect images in an astronomical telescope.
- Use two lenses to view distant objects in the neighbourhood.
  Precaution: the learner must not point the telescope at the sun.

Notes

- Ignore treatment involving achromatic or other compound eyepieces and objectives.
- $M = \left(\frac{D}{f_e} - 1\right)\left(\frac{v-1}{f_o}\right)$ for a compound microscope included.
- Only essential optical features of the telescopes are required
- For eye-ring, consider normal adjustment only.
- Emphasise ray diagrams showing how light passes through the different parts of an optical instrument.

Teaching/Learning Resources

Microscope, telescope, prism binoculars, lens camera, projector, lenses (convex and concave of different focal lengths) and hand lenses.

Applications

- Telescopes are used in the development of optical astronomy.
- Microscopes are used for viewing and studying tiny micro-organisms like malaria parasites.
- Lens camera is used in photography.
- Projector for casting images on screens.
- Hand lenses for magnifying objects.

Assessment

Exercises on:

1. derivation and use of expressions in solving mathematical problems.
2. describing use of the various optical instruments.

Unit 2: Mechanics

Duration: 108 Periods

Mechanics is a branch of Physics concerned with the behaviour of physical bodies when subjected to forces or displacements and the subsequent effects of the bodies on their environment.

General Unit Objectives

By the end of this unit, the learner should be able to:

- measure physical quantities accurately and express them to required number of significant figures.
- explain behaviour of objects in terms of their motion and forces acting on them.
- explain the state of fluids and equilibrium of systems.

Sub-Unit 1: Physical Quantities and their Units

A physical quantity is a property that can be quantified by measurement such as mass, time, and length.

Specific Objectives	Content
The learner should be able to: • use the basic measuring instruments. • state the basic (fundamental) physical quantities. • state the basic SI units. • define derived quantities. • define dimensions of physical quantities. • derive the dimensions of physical quantities. • check the consistency of equations using dimensions. • define scalar and vector quantities and mention examples of each. • add and subtract vectors using component method. • find the resolved components of a vector in two perpendicular directions. • solve numerical problems.	• Measuring instruments • Physical quantities • Fundamental • SI units • Derived quantities • Dimensions of physical quantities: - definition - derivation • Use of dimensions (**Not** to derive equations) • Scalar and vector quantities • Addition and subtraction of vectors • Resolution of vectors in two perpendicular directions • Numerical problems

Suggested Teaching and Learning Strategies

- Practically measure quantities using the measuring instruments.
- Practically estimate the value of a fraction of the smallest division.
- Demonstrate the use of vectors in day to day life experiences.

Notes

- Measuring instruments include:
  - Vernier calipers
  - Micrometer screw gauge
  - Meter rule
  - Measuring cylinder
  - Circular scales
  - Stop watches and clocks
  - Ammeters and voltmeters
  - Thermometers
- Emphasise the techniques of reading the scales accurately and proper recording.
- Express measured values to appropriate number of decimal places.
- Use of dimensions to derive equations is **not** required.
- Emphasise correct symbolic use of vector signs.
- It is useful to have knowledge of solutions to triangles; sine and cosine rules.

Teaching/Learning Resources

- Different types of measuring instruments

Applications

- Tailoring
- Carpentry and joinery
- Building
- Industry

Assessment

- Project for making a metre rule, a protractor, a measuring cylinder, a vernier scale (use locally available materials)
- Correct notation for units
- Exercise on measuring using vernier calipers and a micrometer screw gauge
- Exercise on definition of terms and derivation of expressions involved

Sub-Unit 2: Kinematics

Kinematics is the branch of Physics which deals with the motion of bodies (objects) and systems (group of objects) without consideration of the forces that cause the motion.

Specific Objectives	Content
The learner should be able to:	
• define displacement, speed, velocity and acceleration.	• Motion in a straight line • Displacement, speed, velocity and acceleration
• distinguish between speed and velocity.	• Distinction between speed and velocity
• define uniform velocity and uniform acceleration.	• Uniform velocity
• derive the equations of uniformly accelerated motion in a straight line.	• Equations of uniformity
• define uniform acceleration.	• Uniform acceleration
• draw and interpret different motion graphs.	• Motion graphs
• determine distance travelled and acceleration from a velocity-time graph.	• Distance travelled and acceleration • Free fall
• define acceleration due to gravity.	• Acceleration due to gravity
• measure acceleration due to gravity using different methods.	• Measurement of acceleration due to gravity
• define time of flight and range.	• Projectiles (Projectile motion on an inclined plane is beyond the scope)
• calculate time of flight, maximum height and range.	• Time of flight, maximum height and range (range along a horizontal plane only)
• describe applications of projectile motion.	• Applications of projectile motion
• calculate relative velocity and closest distance of approach.	• Relative velocity and closest distance of approach (Only simple cases for relative velocity and closest distance of approach should be considered)
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Practical determination of acceleration due to gravity using the free fall methods.
- Demonstration of the projectile motion by throwing an object.
- Learner-based graphical methods.

Notes

- Real life examples should be used in solving problems using the equations of motion.
- Drawing of graphs should be a learner-based activity.
- Emphasise graphing techniques including use of workable scales.
- Use free fall methods.
- Simple cases only for projectile motion.
- Range along a horizontal plane only.
- Use vector approach and the analytical methods.
- Only simple cases for relative velocity and closest distance of approach should be considered.
- Knowledge of trigonometrical identities and of resolution of vectors is essential.
- Elementary differentiation and integration is necessary.
- Knowledge of cross and dot vector products is not required.
- Projectile motion on an inclined plane is beyond the scope.

Teaching/Learning Resources

- Ball
- Stop watch/stop clock
- Tape measure
- Trolleys
- Graph paper
- Ticker timer

Applications

Playing football (especially free kicks), military (artillery section), navigation (air and marine), speedometer, javelin, short put, speed guard, crossing roads and overtaking.

Assessment

- Drawing of velocity-time graphs and displacement-time graphs using information practically obtained by the learners
- Interpretation of graphs

- Calculations on projectiles, linear motion, relative velocity and distance of closest
- approach
- Definitions and derivations of equations of uniformly accelerated motion
- Experimental determination of acceleration due to gravity

Sub-Unit 3: Newton's Laws of Motion

These laws describe the relationship between the forces acting on a body and the subsequent motion caused by the forces.

Specific Objectives	Content
The learner should be able to:	
• define mass and inertia.	• Mass and inertia
• define linear momentum and state its units.	• Linear momentum units
• state the principle of conservation of momentum.	• Principle of conservation of momentum (cases of oblique collisions are not required)
• describe some applications of momentum.	• Applications of principle of conservation of momentum (treatment requiring use of coefficient of restitution is outside the scope of the syllabus)
• state Newton's laws of motion.	• Newton's laws of motion
• derive the relation ***F = ma.***	• Resultant force, ***F = ma***
• calculate resultant force in a physical situation .	• Concept of a Newton Resultant Force
• define impulse.	• Concept of impulse
• state and verify the law of conservation of momentum for collisions along a straight line.	• Law of conservation of momentum
• distinguish between elastic and inelastic collisions.	• Elastic and inelastic collisions
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Discuss Newton's laws of motion
- Demonstration of inertia using a paper card, a coin and an empty bottle.
- Demonstration of Newton's third law using colliding bodies.
- Guided discovery on derivation of ***F= Ma.***

Notes

- Concept of gravitational mass and inertial mass should be clarified.
- Cases of oblique collisions are not required.
- Relationship between impulse and change in momentum is essential.
- Verify the law of conservation of momentum for collisions along a straight line using Newton's Third law.
- Treatment requiring use of coefficient of restitution is outside the scope of the syllabus.

Teaching/Learning Resources

- Trolleys, balls of the same size, coins, paper cards, empty bottles, ticker timer

Applications

- Pool table game, table tennis, firing a bullet from a gun, rockets, seat belts, traffic accident scenes

Assessment

- Learners should design and carry out an experiment to verify the principle of conservation of linear momentum.
- Definition of terms, derivation of expressions involved and related calculations.

Sub-Unit 4: Solid Friction

Solid friction deals with forces opposing the relative sliding motion between two solid surfaces in contact.

Specific Objectives	Content
The learner should be able to:	
• define friction.	• Solid friction
• investigate the factors that affect solid friction between surfaces.	• Factors that affect solid friction
• state the laws of solid friction.	• Static and kinetic friction
• measure coefficients of static and kinetic friction.	• Coefficients of static and kinetic friction
• explain the laws of friction.	• Laws of friction • Explanation of laws of solid friction (Molecular theory explanation of solid friction required)
• describe some applications of solid	• Applications of solid friction

Specific Objectives	Content
friction. • solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Discuss the applications of solid friction in daily life.
- Practically
  - investigate of frictional forces using a wooden block, a pulley, masses and a scale pan.
  - determinate of the coefficient of limiting friction using an inclined plank and a block.
- Discuss methods of increasing and reducing friction (limiting and kinetic).

Notes

- Molecular theory explanation of solid friction required.
- Mention applications of friction in daily life.

Teaching/Learning Resources

- Wooden blocks, pulleys, scale pans, plank or metre rule, beam balance and masses.

Applications

- Walking
- Lighting a match stick or firestone
- Applying brakes in a vehicle or bicycle
- Grinding
- Peeling
- Cutting

Assessment

- Learners should carry out an experiment to investigate the types of solid friction and determine the coefficient of solid friction (static and dynamic).
- Exercise on description of experiments to investigate the factors that affect solid friction between surfaces in contact.
- Exercise on stating and explaining the laws of friction, ways of reducing solid friction and its applications.

Sub-Unit 5: Work, Energy and Power

The application of a force on an object may result in motion of the object in the direction of the force through a specified distance in a given time. The energy supplied is used to do the work. The faster the work is done the more power is expended.

Specific Objectives	Content
The learner should be able to:	
• define work and energy.	• Work and energy (work as a product of force and distance moved in direction of force and as a transfer of energy) • Concept of work and energy
• calculate work done from a force-distance graph.	• Work done from a force-distance graph
• state the work-energy theorem.	• Work-energy theorem
• mention different types of energy.	• Types of energy
• derive the expressions - ***K.E.*** = $\frac{1}{2}mv^2$ - ***P.E. = mgh***	• Expressions for types of mechanical energy (kinetic energy due to explosive forces **not** required.)
• describe different energy transformations in different situations.	• Transformation of energy
• state the principle of conservation of energy.	• Conservation of energy
• define conservative and non-conservative fields and forces and mention examples of them.	• Conservative and non conservative fields and forces
• define power.	• Concept of power
• derive the expression ***P = F. V.***	• Formulae for power
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Discuss the different forms of energy with the class.
- Prove the principle of conservation of energy using mechanical energy.
- Determine work and power practically by one running through a measured distance for a known time.
- Projects by learners for energy transformations.
- Mention many practical examples.

- Take field trips to power generating stations.
- Discuss how the law of conservation of energy applies to a body in free fall.

Notes

- O level knowledge of this sub-unit is essential.
- Proof of the principle of conservation of energy using mechanical energy is required.
- Kinetic energy due to explosive forces is **not** required.
- Work as a product of force and distance moved in the direction of a force and as a transfer of energy.
- Ample calculations should be given.

Teaching/Learning Resources

- Stop clock/stop watch, tape measure, bicycle dynamo, torch bulb, wires, electric motor, weights (loads), a model system engine, aluminium foil (to form a concave reflector).

Applications

- Production of electricity
- Windmills
- Engine
- Motors
- Loud speakers
- Solar energy
- Bicycle dynamo
- Bio mass and bio gas

Assessment

- Project for any energy transformation such as a model steam engine to lift a load, solar water heater and a solar concentrator
- Descriptions of energy converters
- Exercise on definitions, calculation and derivations involved

Sub-Unit 6: Statics

Statics is a branch of mechanics concerned with the action of forces on a stationary body in equilibrium.

Specific Objectives	Content
The learner should be able to:	
• calculate the resultant of parallel forces.	• Parallel forces - resultant of parallel forces and couples
• define moment of force.	• Moment of a force
• state the principle of moments.	• Principle of moments
• describe applications of principle of moments.	• Applications of principle of moments
• define a couple.	• Couple
• define the torque.	• Torque (τ)
• calculate the work done by a couple.	• Work done by a couple
• describe applications of couples.	• Applications of a couple
• define centre of gravity.	• Centre of gravity (Mathematical treatment of centre of mass is beyond the scope of the syllabus)
• locate the centre of gravity of objects including a lamina of uniform thickness.	• Concept of centre of gravity • Centre of gravity of objects
• describe applications of knowledge of centre of gravity.	• Practical applications of knowledge of centre of gravity
• state the conditions for a rigid body to be in equilibrium under action of a number of coplanar forces.	• Coplanar forces equilibrium of forces and triangle of forces (Treatment of forces in different planes **not** required)
• define density and relative density.	• Fluids in static equilibrium
• measure the densities and relative densities of different materials.	• Density and relative density • Measurement of density and relative density
• define pressure.	
• derive the expression $P = h\rho g$ for pressure at a point in a fluid.	• Pressure • Expression for pressure in fluids of uniform density
• describe applications of pressure in fluids.	• Applications of pressure in fluids
• state Archimedes' principle.	• Archimedes' Principle
• verify Archimedes' principle.	• Verification of Archimedes'

Specific Objectives	Content
	principle
• state the law of floatation.	• Law of floatation
• describe applications of Archimedes' principle.	• Applications of Archimedes' principle
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Emphasise a learner-based practical approach.
- Use different approaches to measure density.
- Demonstration of couples and coplanar forces.
- Practical verification of Archimedes Principle and law of floatation.
- Field trips to sites to observe hydraulic lifters.
- Guided discovery to derivation of expressions, description of principles and applications.
- Use of animations and video clips where applicable.

Notes

- Mathematical treatment of centre of mass is beyond the scope of the syllabus.
- Knowledge on solutions of triangles and resolution of forces is useful.
- Experimental determination of relative density of solids and liquids using various methods should be emphasised.
- Treatment of forces in different planes is **not** required.
- Mathematical treatment of the law of floatation is required.
- Use examples based on daily experience such as see-saw, beam balance, lever balance, ruler, timber and/or iron bars.
- $W = \tau \theta$
- Significance of knowledge of centre of gravity.
- The relationship between force and pressure in fluids should be brought out.
- Archimedes' Principle should be experimentally verified.
- Demonstration of coplanar forces in equilibrium is necessary.

Teaching/Learning Resources

- Seesaw, beam balance, lever balance, ruler, knife edge, plumb-line, retort stand, thread and some solid objects

Applications

- Seesaw, beam balance (weighing scale) stability in vehicles, steering wheel, water tap turning, opening doors and windows

Assessment

- Practically determining relative density of solids and liquids, verifying Archimedes' Principle and determining the centre of gravity of both regular and irregular objects.
- Project work to make a lever balance and a seesaw and use the seesaw to classify members in the class with similar masses.
- Experimental verification of the law of floatation.
- Exercise on description of application of pressure in fluids the principle of moments, definitions of terms involved, derivation of relevant expressions and calculations

Sub-Unit 7: Fluid Flow

Fluid flow is a branch of fluid mechanics that deals with fluids (gases and liquids) in motion. It is subdivided into:

- Aerodynamics (study of air and other gases in motion).
- Hydrodynamics (study of liquids in motion).

Specific Objectives	Content
The learner should be able to:	
• define streamlines, streamline flow and turbulent flow.	• Streamline and turbulent flow
• derive the expression $A_1v_1 = A_2v_2$ for an incompressible fluid.	• Equation of continuity
• derive Bernoulli's equation $p + \frac{1}{2}\rho v^2 + \rho gh = \textbf{\textit{constant.}}$	• Bernoulli's Principle - Derivation
• state Bernoulli's principle.	• Statement of Bernoulli's Principle
• describe applications of Bernoulli's Principle.	• Applications of Bernoulli's Principle
• describe experiments to measure fluid velocity.	• Measurement of fluid velocity
• explain the design of aerodynamic shapes.	• Design of aerodynamic shapes
• define viscosity.	• Viscosity
• describe the effects of viscosity on an object moving in a fluid.	• Effect of viscosity on motion in a fluid
• define the terms velocity gradient and coefficient of viscosity.	• Velocity gradient and coefficient of viscosity
• derive Stokes' formula.	• Stokes' formula
	• Poisseuille's formula

Specific Objectives	Content
• derive the formula, $\frac{V}{t}=\frac{\pi p a^4}{8\eta l}$ • measure coefficient of viscosity of a liquid. • explain effect of temperature on viscosity of liquids and gases using molecular theory. • solve numerical problems.	• Coefficient of viscosity of a liquid • Effect of temperature on viscosity of liquids and gases • Numerical problems

Suggested Teaching and Learning Strategies

- Demonstrate the following:
  - streamline and turbulent flow (may be done using digital technology).
  - Bernoulli's Principle by blowing a stream of air above a piece of paper.
  - determination of coefficient of viscosity (may be done using digital technology or web animations).
  - the effect of temperature on viscosity of liquids.
  - determination of the coefficient of viscosity.
  - the effect of temperature on viscosity of liquids.

Notes

- Applications should cover aerofoils and sprays among others.

Teaching/Learning Resources

- Paper to demonstrate the aerofoil lift
- Capillary and delivery tubes
- Funnel and a light ball to demonstrate Bernoulli's Principle

Applications

- Bunsen burner, filter pump, aerofoil lift in aircrafts, suction effect, sprays, ventri-meter, domestic water installation, spinning ball, carburetor for petrol engines and fuel injector for diesel engines

Assessment

- Demonstration on the coefficient of viscosity.
- Describing an experiment to distinguish between laminar flow and turbulent flow.
- Derivation of Stoke's Formula, Bernoulli's Principle, equation of continuity and Poisseuilli's Formula.

- Definitions of terms used and explanation of temperature effects on viscosity in liquids and gases using the molecular theory.

Sub-Unit 8: Mechanical Properties of Matter

This sub-unit deals with solids and how they react to forces which stretch them. It also deals with molecular forces and molecular behaviour of solids and the idea of dislocations.

Specific Objectives	Content
The learner should be able to:	
• investigate the behaviour of a wire/spring under stress to bring out the concept of Hooke's law.	• Stress-strain curves for a stretched wire/spring (Include necking, work hardening)
• state Hooke's law.	• Hooke's law
• explain the special features of a stress-strain curve.	• Features of a stress- strain curve for a ductile material
• define and investigate ductility, brittleness, stiffness and strength of materials.	• Investigate ductility, brittleness, stiffness and strength
• define stress, strain and Young's Modulus.	• Stress, strain and Young's Modulus (Ignore bulk modulus and shear rigidity)
• measure stress, strain and Young's Modulus.	• Measurement of stress, strain and Young's Modulus
• derive an expression for the work done during an extension or compression process of an elastic material.	• Work done during an extension or compression process (area under a stress –strain curve) • Elastic potential energy
• describe applications of deformation of solids.	• Applications
• Solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Practically determine Young's Modulus and verify Hooke's law.
- Demonstrate elasticity using a rubber cord.
- Graphical representation and calculation of total work done in stretching an elastic material.
- Verify Hooke's law, practically, using various materials.

Notes

- Ignore shear (rigidity stress) and bulk modulus.
- Necking (breaking stress), work hardening, proportional limit, elastic limit, yield point and breaking point included.
- Emphasis should also be put on experimental determination of Young's Modulus.
- Comparison of behaviour of brittle, ductile and elastic materials and their applications.

Teaching/Learning Resources

- Spiral spring
- Rubber cord
- Retort stand
- Catapult
- Masses
- Meter rule
- Two thin and identical wires
- Micrometer screw gauge
- A glass rod

Applications

- Spring balance
- Catapult
- Sliding a carpet by moving a rack
- Force meter (as used in gyms)
- Selection of materials to use in construction and in manufacturing industries

Assessment

- Project of making a weighing scale using a spring or rubber.
- Graphical interpretation of results obtained from the experiment to verify Hooke's law.
- Exercise on definitions of terms, explanations of special features of a stress-strain curve and derivation of expressions involved.

Sub-Unit 9: Surface Tension

This sub-unit deals with the effects that suggest that the surface of a liquid behaves as a stretched elastic skin that is, it is in a state of tension. For example, a steel needle will float if it is gently placed on the surface of water contained in a bowl despite its greater density.

Specific Objectives	Content
The learner should be able to:	
• define surface tension.	• Surface tension
• explain surface tension in terms of molecular theory.	• Molecular theory
• explain some common surface tension phenomena.	• Common surface tension phenomena
• derive an expression for the excess pressure inside a spherical bubble.	• Pressure difference across a spherical surface
• define angle of contact.	• Angle of contact
• derive the expression $h = \frac{2\gamma \cos\theta}{\rho g r}$	
• explain the phenomenon of capillary rise.	• Capillary rise • Explanation of capillary rise
• measure surface tension.	• Measurement of surface tension
• explain the factors that affect surface tension.	• Factors that affect surface tension
• describe some effects and applications of surface tension.	• Effects of surface tension and applications of surface tension
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Practically demonstrate factors affecting surface tension and to measure surface tension and measurement of angle of contact.
- Guided discovery to derivation of the expression of excess pressure inside a spherical bubble and $h = \frac{2\gamma \cos\theta}{r\rho g}$.
- Measure surface tension and explain the factors affecting surface tension should be emphasised.
- Demonstrate different methods to measure surface tension.
- Demonstrate factors that affect surface tension.

Notes

- Emphasise simple phenomena, including angle of contact, capillary rise, and pressure difference across a spherical surface.
- The following are included:
  - cohesion and adhesion
  - liquid drop
  - tensional balance

Teaching/Learning Resources

- Capillary tubes
- Liquids such as water, oil
- Trough (basin or dish)
- Detergents
- Wire frames
- Thread
- Protractor

Applications

- Soldering: a good joint is formed only if the molten solder (a tin-lead alloy) melts and spreads over the metal involved
- Motion of insects on water surface
- Painting and spraying where the paint must not form drops but remain a layer once spread-out
- Lubrication of machines (surface tension assists oils to adhere to axles and bearings)
- Applied in umbrellas and other water proof objects
- Bubble machine
- Use of detergents in washing dirty items

Assessment

- The description for measuring the angle of contact and experiments to measure surface tension.
- Definitions of terms, derivation of expressions and calculations involved.

Sub-Unit 10: Uniform Motion in a Circle

This sub-unit deals with motion of objects in circular paths or moving in a curve about some point such as a bicycle or car turning round corners or racing cars going round circular tracks.

Specific Objectives	Content
The learner should be able to: • define angular velocity. • derive the expression **$v = \omega r$.** • define centripetal and centrifugal forces.	• Angular velocity • Expression for angular velocity • Acceleration and force in circular motion • The expression

Specific Objectives	Content
• derive the expression $a = \frac{v^2}{r} = \omega^2 r$	$a = \frac{v^2}{r} = \omega^2 r$
• explain the equilibrium of forces in circular motion.	• Motion of a bicycle rider, car around a circular track • Forces in a circular track
• identify the forces acting on a car moving round a circular track.	
• explain the conditions for skidding by a car or a cyclist moving round a circular track.	• Conditions for skidding
• identify the forces acting on a car moving on a banked circular track.	• Banked tracks (with or without friction)
• explain the advantage of banking a track for racing cars.	• Advantage of banking
• derive the expression $\tan\theta = \frac{v^2}{rg}$ for a conical pendulum.	• The conical pendulum
• describe some other applications of circular motion.	• Applications of circular motion • Motion of rigid bodies (simple treatment) • Moment of inertia
• define moment of inertia.	• Rotational kinetic energy
• derive the expression for rotational kinetic energy of a rigid body about an axis.	• Distinction between rotational kinetic energy and translational kinetic energy
• distinguish between rotational kinetic energy and translational kinetic energy.	• Numerical problems
• solve numerical problems.	

Suggested Teaching and Learning Strategies

- Practical whirl of an object to demonstrate motion in a circle either vertical or horizontal.
- Guided discovery to derive the expression $a = \frac{v^2}{r} = w^2 r$; $v = wr$ and $\tan\theta = \frac{v^2}{rg}$.
- Practically demonstrate the action of centrifuges.

Notes

- Use practical examples such as a bicycle rider, an object on a string whirled either vertically or horizontally.
- Simple treatment of banked tracks (with or without friction).
- Distinguish between centripetal and centrifugal forces.
- Introduce the radian measure.
- The following are included: a cycle rider, car moving on a circular track and motion in a vertical circle.
- Simple treatment of banked tracks (with and without friction).
- Simple treatment of rigid bodies.
- Rotational kinetic energy and moment of inertia should be emphasised.

Teaching / Learning Resources

- A string
- A pendulum bob
- Marbles
- Toy cars (model car)
- Ply wood/cardboard

Applications

- Banked tracks for racing cars
- Bicycles and cars turning round corners
- Ice skaters, ballet dancers, acrobats and drivers use the principle of angular momentum
- The earth and other planets moving around the sun
- Satellites moving round planets
- Roller coaster
- Rotor
- Looping the loop at an amusement park
- Centrifuge is used for training astronauts and in laboratories for separating liquids

Assessment

- Derivation of the expressions, definition of terms and calculations involved.
- Learners should demonstrate centripetal force using water in a bucket and whirled in a vertical plane without any water pouring out.

Sub-Unit 11: Gravitation

In gravitation you will deal with the motion of planets around the sun, communication satellites placed round the earth and moon satellites. It also discusses gravitational potential energy and its application to the escape velocity from planets.

Specific Objectives	Content
The learner should be able to:	
• state Kepler's laws.	• Kepler's laws
• state Newton's law of gravitation.	• Newton's law of gravitation
• define gravitational field intensity.	• Gravitational field intensity
• describe the principle of laboratory determination of the gravitational constant, **G.**	• Laboratory determination of the gravitational constant, **G**
• derive the dimensions of **G.**	• Dimensions of **G**
• derive Kepler's third law using Newton's law of gravitation.	• Derivation of Kepler's third law
• derive expressions for masses of sun and earth.	• Masses of the earth and moon
• explain the variation of **g** with latitude.	• Variation of acceleration due to gravity, **g,** with latitude
• explain weightlessness in a satellite.	• Weightlessness in a satellite
• derive expressions for **g** above and below the earth's surface.	• Variation of acceleration due to gravity, g, with distance from the centre of the earth
	• Orbits round the earth
• define parking orbit.	• Parking orbits
• derive an expression for the period of a satellite in a parking orbit.	• Expression for the period of a satellite in a parking orbit
• define gravitational potential and velocity of escape.	• Concepts of gravitational potential and velocity of escape
• derive expressions for: - Gravitational potential and velocity of escape. - Kinetic energy, potential energy and total energy of a satellite in the earth's orbit.	• Mechanical energy of a satellite, total energy in an orbit

Specific Objectives	Content
• explain the effect of friction on orbits of satellites. • describe applications of communication satellites. • solve numerical problems.	• Effect of friction on orbits of satellites • Communication satellites • Numerical problems

Suggested Teaching and Learning Strategies

- Guided discovery on:
  - derivations of Kepler's third law from Newton's law of gravitation
  - dimensions of **G.**
  - expressions of the mass of the sun and the earth.
  - **g** above and below the earth's surface.
  - expression for the period of a satellite in a parking orbit, gravitational potential of a satellite.
  - relationship between potential energy, kinetic energy and total energy of a satellite in the earth's orbit.

Notes

- All cases should be supported by adequate examples and problems.
- Kepler's laws, Newton's law of gravitation and relation between G and g should be clearly brought out.
- Give a similarity between gravitational potential and electric potential (Analogy between gravity and electricity).

Teaching / Learning Resources

- Web animations and video clips
- Atlas

Applications

- Motion of planets around the sun, the moon, the earth and satellites around the earth.

Assessment

- Statement of Newton's law of gravitation
- Derivation of Kepler's third law
- Description of the laboratory determination of the gravitational constant
- Related calculations and derivations of related formulae
- Sketching variation of g with distance from the centre of the earth

Sub-Unit 12: Simple Harmonic Motion

This is one of the types of vibrations in day to day life. It is important because all other vibrations can be treated as if they are composed of simple harmonic vibrations. It is the way in which the acceleration of a body depends on its displacement and is directed towards the equilibrium position.

Specific Objectives	Content
The learner should be able to:	
• define simple harmonic motion (SHM).	• Simple harmonic motion, (SHM)
• derive the expressions for acceleration, velocity and displacement in SHM.	• Expressions for acceleration, velocity and displacement in SHM
• draw sketch graphs to show - variation of displacement, velocity, acceleration and with time - acceleration and force with displacement.	• Graphical representation of SHM
• verify that the resulting motion of a system, when slightly displaced, is SHM.	• Examples of SHM: - simple pendulum - floating cylinder - liquid in a U-tube - mass at the end of a vertical spring or a horizontal spring on a smooth surface - mass at the end of a vertical string - mass between two coupled springs on a smooth horizontal surface - mass at the end of two coupled vertical springs - mass at the end of two parallel vertical springs of the same spring constant.
• derive expressions for period, **T,** in each of the cases above.	• Expressions for period in SHM
• determine acceleration due to gravity, **g**, using • a simple pendulum. • a loaded helical spring/rubber band.	• Determination of acceleration due to gravity, **g** using SHM methods

Specific Objectives	Content
• derive expressions for kinetic energy, potential energy and total energy in SHM.	• Energy in SHM
• draw sketch graphs for kinetic energy, potential energy and total energy in SHM.	• Graphical representation of energy in SHM
• describe the interchange of energy in SHM.	• Interchange of energy in SHM
• describe situations where SHM is applied.	• Applications of SHM
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Practical approach demonstrating examples of SHM.
- Experimental determination of **g** using SHM method.
- Guided discovery on derivations involved.
- Bring out relationship between SHM and circular motion, that is, use of motion of a body moving in a circle to derive the defining equation and other related equations.
- Verification of motions of the following being SHM when slightly displaced:
  - simple pendulum.
  - floating cylinder.
  - liquid in a U-tube.
  - mass at the end of a vertical and horizontal spring on a smooth surface.
  - mass between two coupled springs on a smooth horizontal surface.
  - mass at the end of two coupled vertical springs.
  - mass at the end of two parallel vertical springs.
- An experimental approach should be emphasised.
- Discuss limitations.
- Discuss the principle of conservation of energy in SHM.
- Emphasise the significance of the negative sign in the expressions for acceleration in SHM.

Notes

- Ignore the compound pendulum.
- Graphical representation of SHM is required.
- Total energy in SHM and applications are required.
- Treatment restricted to springs of the same spring constant.
- Treatment for elastic strings only for cases where a mass hangs at the end of the string(s).

Teaching/Learning Resources

- Pendulum bob
- Slotted masses
- Spiral springs
- U-tubes
- Cylinder
- Stop clock/stop watch
- Rubber bands
- Ruler
- Wire ring and a bead
- Watch glass and marble

Applications

- Shock absorbers in cars.
- Stop clocks/measuring instruments such as voltmeters, ammeters, galvanometers.
- Swings

Assessment

- Practical exercise on determination of acceleration due to gravity using SHM
- Identification of a simple harmonic motion
- Definitions of terms, derivation of expressions, calculations and practical applications of SHM

Unit 3: Waves

Duration: 76 Periods

This unit deals with the transfer of energy by vibration of particles of the medium.

General Unit Objectives

By the end of this unit, the learner should be able to:

- relate the different wave properties and use them to explain the different wave behaviour (reflection, refraction, interference and diffraction).
- explain formation of stationary waves on stretched strings/in pipes and link them to the characteristics of sound.
- explain the occurrence of resonance, beats, Doppler effect and polarisation

Sub-Unit 1: Basic Properties of Waves

In this sub-unit, you will deal with classification and general properties of waves.

Specific Objectives	Content
The learner should be able to:	
• define a wave.	• Concept of a wave
• define the terms amplitude, displacement, wavelength, frequency and phase.	• Terminology used in waves
• derive the expression $T = \frac{1}{f}$	• Relationship between period and frequency
• derive the expression $v = f\lambda$	• Relationship between wavelength, frequency and velocity
• explain what is meant by transverse and longitudinal waves.	• Transverse and longitudinal waves
• mention examples of transverse and longitudinal waves.	• Examples of transverse and longitudinal waves
• define a progressive wave.	• Progressive waves
• explain progressive wave motion.	• Progressive wave motion
• state the characteristics of a progressive wave.	• Characteristics
• mention examples of progressive waves.	• Examples of progressive waves
• explain phases of vibration.	• Phase of vibrations

Specific Objectives	Content
• derive the expression $y = a \sin 2\pi \left(\frac{t}{T} \pm \frac{x}{\lambda} \right)$	• Progressive wave equation
• explain the significance of ± in the progressive wave equation.	• Superimposing two progressive waves
• determine the equation of resultant of two superimposed progressive waves.	• Resultant equation of two superimposed progressive waves
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Use regular sinusoidal oscillations to introduce wave properties.
- Demonstrate practically the concept of a wave.
- Phase of vibration using double beam oscillator.
- Transverse and longitudinal waves using rope and slinky springs.
- Phase of vibrations using two pendulum bobs with independent fixed points.
- Wave fronts, rays, frequency, crest/rough by use of ripple tank experiment or water in a pond.
- Use a rope with 'particles' (like plastic cups) of different colours tied at regular intervals to demonstrate wave motion on water.
- Demonstrate wave properties using ripple tank experiments.

Notes

- Classification of waves as transverse and longitudinal, mechanical and electromagnetic waves.
- Progressive waves and phase of vibrations (the SHM concept should be used).
- Statement of the principle of super position of waves.
- Derivation of the resultant form of superposed progressive wave i.e. $y = 2a \cos \omega t \sin \omega t$ hence $y = A \sin \omega t$.
- Brief overview of trigonometric identities is essential.

Teaching/Learning Resources

- Two pendulum bobs
- Ropes
- Slinky springs
- Ripple tank/water pond
- Double beam oscillator

Application

- The concept of superposition is used in amplification of sound (amplifiers) and in radio wave broadcasting (FM and AM).
- Mobile phones
- Musical instruments

Assessment

- Give learners an exercise on the entire sub-unit with specific focus on progressive wave and general wave equations.
- Definition of terms, derivation of expressions and calculations involved.

Sub-Unit 2: Wave Theory

In this sub-unit, you will deal with the behaviour of waves including reflection, refraction, wave fronts, optical path and Huygens' Principle.

Specific Objectives	Content
The learner should be able to:	
• define a wave front, ray and optical path	• Wavefront, ray and optical path
• demonstrate circular and straight wavefronts.	• Types of wavefronts
• demonstrate the reflection and refraction of waves.	• Reflection and refraction of waves
• draw reflected and refracted wavefronts.	• Patterns of reflected and refracted waves
• describe applications of reflection and refraction of waves.	• Applications of reflection and refraction of waves
• state Huygens' postulate.	• Huygens' postulate
• explain Huygens' construction of wavefronts.	• Construction of new wave fronts
• apply Huygens' construction to reflection and refraction of light.	• Application of Huygens' postulate on construction of reflected and refracted of light
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Demonstrate using the ripple tank experiment, the concept of:
  - circular and straight wave fronts.
  - refraction and reflection of waves.

Notes

- Proof of $n = \frac{c}{v}$ is included.
- Use large and clear ray diagrams.

Teaching/Learning Resources

- Ripple tank and accessories
- Glass slab (for reducing water depth)

Applications

- Determination of refractive index of a material
- In radar systems
- 'SONAR' (Sound Navigation and Ranging) for bats and submarines.

Assessment

- Definition of terms, derivation of expressions and calculations involved.
- Linking geometrical and physical optics.

Sub-Unit 3: Interference of Waves

Interference as one of the properties of waves deals with the superposition of waves.

Specific Objectives	Content
By the end of this sub-unit, the learner should be able to:	
• define interference.	• Concept of interference
• define coherent sources and path difference.	• Coherent sources and path difference
• state the factors that determine the energy of a wave.	• Energy of a wave
• explain the terms division of amplitude and wavefront .	• Division of amplitude and wavefronts
• define constructive and destructive interference.	• Constructive and destructive interference
• state the conditions for constructive and destructive interference to occur.	• Conditions for constructive and destructive interference to occur
• explain the principle of Young's double slit experiment.	• Principle of Young's double slit experiment

Specific Objectives	Content
• derive the expression $\Delta y = \frac{\lambda D}{a}$ • explain the appearance of fringes. • describe Young's double slit experiment for measuring: - wavelength. - slit separation. - fringe separation. • Explain the occurrence of interference in thin films, thin wedges, Lloyd's mirror, Fresnel's bi-prism and Newton's rings. • derive the mathematical expressions for the fringe separation in each of the above cases. • mention applications of interference. • solve numerical problems.	• Separation of fringes • Appearance of fringes • Young's double slit experiment • Thin films, thin wedges, Lloyd's mirror, Fresnel's bi-prism and Newton's rings • Mathematical expressions for the fringe separation in each of the above • Applications of interference • Numerical problems

Suggested Teaching and Learning Strategies

- Use ripple tank to demonstrate the interference of water waves either using two spherical or a straight dippers and a barrier with two slits.
- Use guided discovery on interference of sound from coherent source and a microphone connected to a CRO.
- Explain change of phase.
- Demonstrate other cases where interference occurs.
- State the conditions for the occurrence of constructive and destructive interference.
- Describe Young's double slit experiment for measuring wavelength, slit separation and fringe separation.
- Explain the occurrence of interference in thin films, air wedge film, Lloyds mirror, Fresnel's bi-prism and Newton's rings and derivation of mathematical expressions for fringe separation in each case.
- Mention applications of interference in daily life.

Notes

- Only qualitative treatment of interference in thin films.
- The following are included:
    - path difference

- energy of a wave

Teaching/Learning Resources

- Ripple tank for interference of water waves.
- Two loud speakers, microphone and CRO for interference of sound waves.
- Narrow double slit with source of light for interference of light waves
- Travelling microscope
- Glass slides
- Convex lens and glass sheet for Newton's ring experiment

Applications

- Measurement of wavelength
- Used in radio-wave broadcast especially in placement of transmitters
- Determination of flatness of surfaces

Assessment

- Observation of patterns using a set up of a narrow double slit and Newton ring experiment
- Explanation of causes of interference in each of the cases studied
- Derivations of expressions involved

Sub-Unit 4: Diffraction of Waves

Diffraction as a property of waves deals with the spreading of waves as they pass round an obstacle.

Specific Objectives	Content
The learner should be able to:	
• define diffraction of waves.	• Concept of diffraction
• explain diffraction of waves.	• Explanation of diffraction
• describe the dependence of diffraction on wavelength.	• Dependence of diffraction on wavelength
• use the expression ***d sin θ = nλ***	• Diffraction equation (Derivation of ***d sin θ = nλ*** not required)
• describe the appearance of diffraction images in single slit, double slit diffraction and plane transmission grating.	• Single slit and double slit diffraction and plane transmission grating
• describe the effect of number of slits per unit length on appearance of	• Effect of number of slits per unit length • Applications of diffraction

Specific Objectives	Content
fringes. • mention some applications of diffraction of waves. • solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Measure wave length of light using a spectrometer.
- Demonstrate use of diffraction gratings.
- Discuss terms and derive expressions involved.
- Demonstrate diffraction of waves.
- Discuss how Huygens' theory is used to explain diffraction.

Notes

- Derivation of $d \sin \theta = n\lambda$ is **not** required.

Teaching/Learning Resources

- Spectrometer
- Travelling microscope
- Gratings

Applications

- Measurement of wavelength of light
- Used in radio telescope (Detail **not** required.)

Assessment

- Exercises on definitions of terms, description of experiments and calculations
- Explanation of diffraction

Sub-Unit 5: Stationary Waves

This sub-unit deals with superposition (overlapping or meeting) of two waves travelling in opposite directions. The two waves should have the same wavelength and frequency, and should have nearly equal amplitude.

Specific Objectives	Content
The learner should be able to: • define a stationary wave. • explain how a stationary wave is	• Concept of stationary waves • Formation of stationary waves

Specific Objectives	Content
formed. • state the characteristics of a stationary wave. • derive a stationary wave equation. • mention examples of stationary waves. • demonstrate the factors affecting the pitch of a note from a stretched string. • derive the expression **v =** $\sqrt{\frac{T}{\mu}}$.	• Characteristics of stationary waves • Stationary wave equation • Examples of stationary waves • Stationary waves on stretched strings • Factors affecting the pitch of a note from a stretched string • The expression **v =** $\sqrt{\frac{T}{\mu}}$
• define end-correction in pipes. • derive expressions for various frequencies when a stretched string or a pipe is sounded. • explain the relative advantages and disadvantages of open and closed pipes. • describe an experiment to determine the frequency of a stretched string. • describe an experiment to determine the speed of sound in air using a resonance tube and Kundit's tube. • describe applications of stationary waves in pipes and strings. • solve numerical problems.	• Stationary waves in pipes • End-correction • Harmonics in strings and pipes • Relative advantages and disadvantages of open and closed pipes • Determination of frequency of a stretched string • Use of resonance tube and Kundit's tube to determine speed of sound in air • Applications of stationary waves in pipes and strings • Numerical problems

Suggested Teaching and Learning Strategies

- Use resonance tube to demonstrate resonance.
- Use sonometer to demonstrate variation of frequency of a string.
- Demonstrate stationary wave in string of sonometer using signal generator.
- Use Kundt's tube and a loud speaker of known frequency to determine velocity of sound in a gas. (The same idea can be used in liquids while using iron filings instead of dust particles).
- Determine the speed of sound in air using resonance tubes.

Notes

- Include determination of frequency of sound waves.
- TV and Radio reception waves are some of the examples of stationary waves.
- Also cover stationary waves on stretched strings, pipes and rods and factors affecting pitch.
- Harmonics in strings and pipes are included.

Teaching/Learning Resources

- Resonance tubes (burette)
- Signal generator and vibrator
- Sonometer
- Tube, dust particles, loudspeaker
- Metre rule

Applications

- Construction and design of musical instruments
- Determination of velocity of sound in gases/liquids/strings or rods
- Used in comparison of velocity of sound in different gases

Assessment

- Carrying out an activity on the sonometer and on resonance tubes to determine velocity of sound in air
- Project on making a sonometer and any other stringed musical instruments
- Definitions of terms, derivation of expressions, description of experiments and calculations

Sub-Unit 6: Resonance

If a system with some degree of damping is forced to remain oscillating, some periodic external force must be applied. In this sub-unit,, you will deal with forced and natural frequency of an oscillating system.

Specific Objectives	Content
The learner should be able to:	
• define free and damped oscillation	• Free and damped oscillations
• sketch graphs to show free and damped oscillations (under damped, critically damped and over damped	• Sketch graphs of free and damped oscillations
• describe applications of free and damped oscillations.	• Applications of free and damped oscillations
• explain the causes of damping.	• Causes of damping

Specific Objectives	Content
• define forced oscillations. • define resonance. • describe applications of resonance. • explain resonance in strings and pipes. • derive a relationship between length of air column or length of string and frequency. • solve numerical problems.	• Forced oscillations • Resonance • Applications of resonance • Resonance in strings and pipes • Relationship between length of air column or length of string • Numerical problems

Suggested Teaching and Learning Strategies

- Explain that resonance is an example of interference.
- Demonstrate free, damped and forced oscillations using mechanical and electrical oscillations (use of graphs is necessary).
- Demonstrate resonance in strings and pipes.
- Discuss causes of damping.

Teaching/Learning Resources

- Resonance tube
- Tuning forks
- Coupled pendula
- Water
- Empty bottles

Applications

- Tuning of radios
- Construction of bridges and houses with limited amplitude of vibration
- Making of damped doors and car suspensions (shock absorbers)
- Construction of moving coil meters like galvanometers, voltmeters, ammeters and speedometers

Assessment

- Listing other areas where damping and resonance is applicable in daily life
- Tuning instruments such as stringed instruments using concept of resonance
- Definitions of terms, derivation of expressions, description of experiments and calculations

Sub-Unit 7: Sound

These sub-unit deals with longitudinal waves produced due to vibrations of particles in a medium.

Specific Objectives	Content
The learner should be able to:	
• define sound.	• Concept of sound
• describe how sound is produced.	• Production of sound
• explain how sound is propagated in different media.	• Propagation of sound
• define tone, fundamental note, overtones, harmonics, octaves.	• Tone, fundamental note, overtones, harmonics and octaves
• mention the effect of overtones on quality of sound.	• Significance of overtones
• explain the factors that affect the speed of sound in air.	• Factors that affect speed of sound in air
• define beats.	• Beats
• Explain how beats are formed.	• Formation of beats
• derive the expression for beat frequency $\Delta f = f_2 - f_1$.	• Beat frequency
• give applications of beats	• Applications of beats
• define Doppler effect.	• Concept of Doppler effect
• explain Doppler effect.	• Explanation of Doppler effect
• mention examples of Doppler effect.	• Examples of Doppler effect
• derive expressions for apparent frequency in various relative motion situations.	• Apparent frequency
• describe applications of Doppler effect.	• Applications of Doppler effect
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Demonstrate:
  - fundamental note and overtones using a resonance tube.
  - how beats are produced using tuning forks of different frequency.

Teaching/Learning Resources

- Tuning forks
- Resonance tube

- Stringed instruments
- Water

Applications

- Beats are used in tuning musical instruments
- Doppler effect used in radar checks, speed trap, determination of speed of planets, measurement of temperature of plasmas

Assessment

- Making and tuning stringed instruments basing on the knowledge of beats
- Definitions of terms, derivation of expressions, description of experiments and calculations

Sub-Unit 8: Polarisation of Waves

In this sub-unit, you will deal with waves oscillating only in specific planes.

Specific Objectives	Content
The learner should be able to:	
• define polarisation.	• Concept of polarisation
• distinguish a plane polarised wave from a non plane polarised wave.	• Distinction between plane polarised and non plane polarised light
• explain polarisation of light.	• Polarisation of light
• define a Polaroid.	• Polaroid
• describe the production of polarised light.	• Production of polarised light by: - using a polaroid - reflection - double refraction - selective absorption - scattering
• state Brewster's law.	• Brewster's law
• describe applications of polarisation.	• Applications of polarisation
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Demonstrate:
  - polarisation of light using a polaroid.
  - polarisation by reflection, double refraction, selective absorption and scattering.

Notes

- Ignore details of the Nicol prisms
- Examples of applications of polarisation include:
  - photo-elasticity
  - reducing glare
  - dipole aerial

Teaching/Learning Resources

- Polaroid
- Glass slabs
- Water and milk drops

Applications

- Reducing glare by sunglasses
- Photo-elasticity (Stress Analysis)
- Photography
- Determining concentration of solutions (Saccharimetry)

Assessment

- Exercises on definitions of terms, derivation of expressions, description of experiments and calculations.

Unit 4: Thermal Properties of Matter

Duration: 96 Periods

This unit deals with temperature and its measurement, quantity of heat and modes of heat transfer.

General Unit Objectives

By the end of this unit, the learner should be able to:

- describe the setting up of temperature scales and mode of operation of different types of thermometers.
- determine thermal properties of substances and use them to describe the behaviour of solids and fluids.
- use kinetic theory to relate thermodynamic variables.
- explain changes of state of matter.

Sub-Unit 1: Thermometry

Thermometry is about thermometric properties, temperature scales and different thermometers and their comparison.

Specific Objectives	Content
The learner should be able to:	
• define a thermometric property.	• Thermometric properties
• mention suitable thermometric quantities.	• Thermometric quantities
• list the different types of thermometers.	• Types of thermometers
• describe the steps involved in setting up a temperature scale.	• Temperature scales
• define upper fixed point, lower fixed point, and fundamental interval.	• Fixed points on a thermometer
• define the absolute temperature scale.	• The absolute zero
• convert temperatures from the Celsius scale to the absolute temperature scale and vice versa.	• Conversion of temperature from one scale to another
• describe measurement of temperature using different types of thermometers.	• Working of different types of thermometers - liquid-in-glass - constant volume gas

Specific Objectives	Content
	thermometers - electrical resistance thermometers - thermoelectric - pyrometers (optical and total radiation) - Semi-conductor (digital) thermometers - Radiation pyrometers
• compare temperatures measured using different types of thermometers.	• Comparison of temperatures measured using different thermometers
• state the advantages and disadvantages of different types of thermometers.	• Advantages and disadvantages of different types of thermometers
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Guide learners to improvise an air thermometer.

Notes

- Conversion to Fahrenheit scale should be discussed.

Teaching/Learning Resources

- Different types of thermometers including: liquid-in-glass thermometer and digital thermometer.
- Charts of the various types of thermometers (such as optical pyrometer).

Applications

- Measurement of temperature.

Assessment

Exercises on:

- conversion of temperature from one scale to another
- comparison of different types of thermometers
- definitions of terms, derivation of expressions, description of experiments and calculations

Sub-Unit 2: Specific Heat

Materials differ from one another in the amount of heat needed to cause a given rise in temperature. This quantity depends on material of the body, mass and change in temperature of the body.

Specific Objectives	Content
The learner should be able to:	
• define heat capacity and specific heat capacity.	• Heat capacity and specific heat capacity
• state the units of heat capacity and specific heat capacity.	• Units of heat
• measure specific heat capacity using different methods.	• Measurement of specific heat capacity by - method of mixtures - electrical method - continuous flow method
• state the advantages and disadvantages of different methods of measuring S.H.C.	• Comparison of the different methods of measuring S.H.C.
• discuss the causes of heat leakage in calorimetric experiments.	• Heat leakages
• state Newton's law of cooling.	• Newton's law of cooling
• state the factors that affect the rate of cooling.	• Factors that affect the rate of cooling
• verify Newton's law of cooling.	• Verification of Newton's law
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Practical approach to measure specific heat capacity of both solids and liquids and verification of Newton's law of cooling
- Demonstration of factors affecting the rate of cooling

Notes

- Include accurate determination of the specific heat capacity of water.
- Treat a temperature fall (negative change in temperature) as an absolute value.
- Restrict to cases where there is measurable temperature change.

Teaching/Learning Resources

- Calorimeter
- Thermometer
- Stirrer
- Lagging material
- Beam balance
- Solids and liquids
- Stop clock
- Heat source

Applications

- The use of water in cooling systems because of its high specific heat capacity for example, in car radiators.

Assessment

Exercises on:

- definitions of terms, derivation of expressions, description of experiments and calculations.
- comparison of the different methods of measuring specific heat capacity.

Sub-Unit 3: Change of State

A body absorbs heat (in melting, boiling and sublimation) and gives out heat (in freezing or condensation) without causing a change in temperature. This sub-unit deals with latent (hidden or dormant) heat of vaporisation and fusion.

Specific Objectives	Content
The learner should be able to:	
• explain (using molecular theory) melting, boiling, evaporation and cooling by evaporation.	• Melting, boiling and evaporation
• define specific latent heat of fusion and specific latent heat evaporation.	• Latent heat
• measure specific latent heat (fusion and evaporation) using the method of mixtures and the electrical method.	• Measurement of latent heat
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Practical measurement of specific latent heat.
- Emphasise the difference between latent heat and specific heat capacities.
- Discuss real life examples.
- Explain the behaviour of gases in terms of behaviour of molecules.

Teaching/Learning Resources

- Steam trap
- Calorimeter
- Weighing scale
- Thermometer
- Lagging and heat shield
- Stirrer

Applications

- Latent heat of fusion of water is applied in:
    - picnic coolers.
    - preventing frost damage to plants.
    - cooling off after swimming.
- Distillation
- Drying crops

Assessment

- Definitions of terms, derivation of expressions, description of experiments and calculations
- Explanation of change of state using kinetic theory

Sub-Unit 4: Gas Laws

The behaviour of gases is explained in terms of volume, pressure and temperature. Kinetic theory assumes the existence of atoms and molecules in large numbers and applies the laws of mechanics using simple averaging.

Specific Objectives	Content
The learner should be able to: • state the gas laws. • verify the gas laws. • Sketch the graphical	• Gas laws - Boyle's, Charles' and Pressure laws - Verification • Graphical representation of the gas laws

Specific Objectives	Content
representation of the laws. • derive the equation of state PV = n R T. • define pressure and volume coefficients of expansion αv and αp. • prove that αv = αp. • solve numerical problems.	• Equation of state • Pressure and volume coefficients of expansion • Proof of equality of αv and αp • Numerical problems

Suggested Teaching and Learning Strategies

- Hands-on activities to verify and sketch graphical representation of the gas laws
- Guided discovery on derivation of the equation of state, definitions of terms used and solving related mathematical problems
- Graphical representation of the gas laws
- Discussing real life examples
- Explain the behaviour of gases in terms of behaviour of molecules.

Teaching/Learning Resources

- Thermometers
- Glass tube sealed at one end
- Volume and mm scales
- Plastic syringes
- Bourdon pressure gauge (if available)
- Glass flask
- Source of heat
- Water bath
- Oil

Applications

- Preserving beverages
- Ignition systems of cars
- Investigation of the behaviour of carbon dioxide

Assessment

Exercises on:

- describing experiments to verify gas laws
- definition of terms, derivation of expressions and calculations involved
- explanation of behaviour of gases in terms of behaviour of molecules

Sub-Unit 5: Kinetic Theory of Gases

Kinetic theory assumes the existence of atoms and molecules in large numbers and applies the laws of mechanics using simple averaging techniques.

Specific Objectives	Content
The learner should be able to: • describe Brownian motion.	• Brownian motion (Calculations on Brownian motion are not required)
• explain what is meant by kinetic theory of gases.	• Kinetic theory of gases
• explain why a gas exerts pressure.	• Pressure exerted by molecules in an ideal gas
• derive the expressions - $P = \frac{1}{3}\rho\overline{c^2}$. - $\frac{1}{2}m\overline{c^2}$ = $\frac{3}{2}$ ***KT.*** stating the assumptions made	• The expressions $P = \frac{1}{3}\rho\overline{c^2}$ and $\frac{1}{2}m\overline{c^2}$ = $\frac{3}{2}$ ***KT*** (At least four assumptions required)
• State: - Avogadro's law. - Dalton's law of partial pressures. - Grahams law of diffusion.	• Avogadro's law, Dalton's law of partial pressures and Graham's law of diffusion
• deduce Avogadro's law, Boyles's law, Charles' law, Pressure law, Graham' s law of diffusion and Dalton's law of partial pressures from the expression $\frac{1}{2}m\overline{c^2}$ = $\frac{3}{2}$ ***KT*** **.**	• The importance of the equation $\frac{1}{2}m\overline{c^2}$ = $\frac{3}{2}$ ***KT***
• explain behaviour of a real gas. • distinguish between real and ideal gases. • write down Van der Waal's equation:	• Real gases - behaviour • Distinction between real and ideal gases • Van der Waal's equation for real gases

Specific Objectives	Content
$$\left(p+\frac{a}{v^2}\right)(v-b)=RT \; .$$	
• state the significance of constants a and b in Van der Waal's equation.	• Significance of constants **a** and **b** in Van der Waal's equation
• sketch a volume-pressure graph for a real gas.	• Variation of volume with pressure for a real gas
• account for the difference between the ideal and real gas equations.	• Explanation of the difference between the behaviour of real and ideal gases
• define critical temperature.	• Critical temperature
• state the significance of critical temperature.	• Significance of critical temperature
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- The concept of 'root mean square' should be clarified and its proper notation emphasised. Use numbers to clarify it.
- Demonstrate Brownian motion using;
    - smoke cell experiment.
    - pollen grains on water.
    - dust particles in air.
- Explain Brownian motion in terms of kinetic theory.

Notes

- Calculations on Brownian motion are not required.
- At least four assumptions on kinetic theory required.

Teaching/Learning Resources

- Smoke cell
- Microscope
- Strong light source

Assessment

Exercises on:

- observation of the random motion of gas molecules
- explanation of kinetic theory of gases
- explanation of Brownian motion in terms of kinetic theory of gases
- explanation on why a gas exerts pressure

- definition of terms, derivation of expressions and calculations involved

Sub-Unit 6: Vapours

A gas is a substance in the gaseous phase above its critical temperature while vapour is a substance in the gaseous phase but below its critical temperature. If the vapour is in a closed vessel above the liquid, it exerts a pressure on the liquid. At dynamic equilibrium this will be saturated vapour pressure (SVP), otherwise it is unsaturated.

Specific Objectives	Content
The learner should be able to: • distinguish between a gas and a vapour. • distinguish between saturated and unsaturated vapour. • explain the occurrence of a saturated vapour using kinetic theory. • define saturated vapour pressure (SVP). • describe experiments to investigate the variation of SVP of water with temperature. • explain the relationship between boiling, SVP and external pressure. • define boiling point. • describe processes that involve use of vapours and SVP. • solve numerical problems.	• Vapours and gases • • Saturated and unsaturated vapours • Explanation using kinetic theory • Saturated vapour pressure (SVP) • Variation of SVP with temperature • • Linkage between boiling, SVP and external pressure • Boiling point • Applications • • Numerical problems

Suggested Teaching and Learning Strategies

- Hands-on activities to demonstrate saturated and unsaturated vapours.
- Discussion of definitions, derivations of expressions and calculations involved.
- A gas cannot be compressed into a liquid without cooling.
- Sketch SVP – temperature graph.
- Use of P – V and P – T graphs to show the behaviour of saturated and unsaturated vapours.

Note

- A gas is a vapour above the critical temperature.

Teaching/Learning Resources

- Test tubes
- Ether
- Syringe and needle
- Source of heat
- Water bath
- Apparatus for the dynamic method of the determination of SVP

Applications

- Vapour recovery units used to manage greenhouse gas emission
- Refrigerator
- Pressure cooker
- Ventilation

Effects

- Formation of dew (below critical temperature)
- Boiling (when SVP = external pressure)

Assessment

- Explaining difference(s) between gases and vapours and saturated and unsaturated vapours.
- Explanation of phenomena such as boiling in relation to SVP and external pressure.
- Definition of terms, derivation of expressions and calculations involved

Sub-Unit 7: Thermodynamics

The heat supplied to a gas raises its internal energy and enables it to expand and hence does external work. The internal energy consists of the kinetic energy due to the translational rotational and vibrational motion of the molecules all of which depend only on temperature and potential energy due to the intermolecular forces.

Specific Objectives	Content
The learner should be able to:	
• define internal energy of an ideal gas.	• Internal energy
• state the factors on which the internal energy of an ideal gas depend.	• Factors which affect the internal energy of a gas
• define the terms isobaric and isovolumetric processes.	• Isobaric and isovolumetric processes
• derive the expression W = $\int PdV$ and relate it to the area under a P - V graph.	• Work done by an expanding gas
• define the principal specific heat capacities Cp and Cv of an ideal gas.	• Principal specific heat capacities
• show that $\Delta W = n\, C_v\, \Delta T$ and $\Delta W = n\, C_p\, \Delta T$ for isovolumetric and isobaric processes respectively.	• Expressions for work in isovolumetric and isobaric processes using the principal specific heat capacities
• state the first law of thermodynamics	• First law of thermodynamics
• derive the relationship $C_p - C_v = R$.	• Relationship between C_p and C_v
• calculate the ratio $\gamma = \frac{C_p}{C_v}$ for molecules of different atomicity.	• The ratio $\gamma = \frac{C_p}{C_v}$
• define isothermal and adiabatic processes.	• Isothermal and adiabatic changes
• explain what is meant by reversible isothermal and reversible adiabatic processes.	• Reversible isothermal and reversible adiabatic processes.
• state the conditions necessary for the above processes to occur.	• Conditions necessary for reversible adiabatic processes
• derive the expression PV^γ = constant.	• The expression PV^γ = constant

Specific Objectives	Content
• derive expressions for the work done during isothermal and adiabatic processes. • describe processes that involve isothermal and adiabatic changes. • solve numerical problems.	• Work done during isothermal and adiabatic processes • Applications of isothermal and adiabatic processes • Numerical problems

Suggested Teaching and Learning Strategies

- Discussion of concepts, derivations and calculations involved
- Guided discovery on drawing sketch graphs for isobaric, isothermal, isovolumetric and adiabatic processes
- Derivation of expressions and calculations involved
- Discussion on the changes which occur to an expanding or compressed gas
- Explain why Cp is greater than Cv.
- Draw sketch graphs for isothermal, adiabatic, isobaric and isovolumetric processes.
- Knowledge of indices is necessary.

Notes

- Ignore experimental determination of principal specific heat capacities.
- Zeroth law should be mentioned.
- Basic knowledge of integration and indices is essential.

Applications

- Heat engine
- Heat pumps and refrigerators
- Petrol engine cycle
- Diesel engine cycle

Assessment

- Defining reversible isothermal and adiabatic processes
- Drawing graphs of the following processes: isothermal, isovolumetric and adiabatic

Sub-Unit 8: Transfer of Heat

Heat transfer deals with passage of heat energy from one body at higher temperature to another at lower temperature by processes of conduction, convection and radiation.

Specific Objectives	Content
The learner should be able to:	
• explain the mechanism of heat conduction in solids, liquids and gases.	• Heat conduction - Mechanism of heat conduction
• state the factors which determine the rate of heat transfer in a material.	• Rate of heat conduction
• define thermal coefficient conductivity, k.	• Coefficient of thermal conductivity and its measurement
• describe experiments to measure thermal conductivity, k, for solids.	• Measurement of thermal conductivity (for good and bad conductors – principle of one method for each).
• explain the mechanism of convection.	• Convection of heat
• describe how radiation can be detected.	• Radiation of heat
• state properties of good and bad radiators /absorbers.	• Detection (thermopile, bolometer) • Good and bad radiators / absorbers
• define a black body.	• Black body radiation
• describe examples of systems that approximate to a black body.	• Examples of black bodies
• sketch a graph to show variation of relative intensity with wavelength of radiation.	• Energy distribution in the spectrum of black body radiation
• State: - Stefan's law. - Wien's displacement law. - Provost's theory of exchanges.	• Stefan's law ($\frac{P}{A}$ **= δT^4**) • Wien's displacement law (**$\lambda_m T$ = 2.9 x 10^{-3}** *m K)* • Provost's theory of exchanges
• estimate the temperature of the	• Temperature of the sun and other

Specific Objectives	Content
sun and other black bodies.	black bodies
• arrange the components of the electromagnetic spectrum in order of increasing (or decreasing) wavelength (or frequency).	• The electromagnetic spectrum
• state the properties and uses of each of the components in the electromagnetic spectrum.	• Properties and uses of each of the components in the electromagnetic spectrum • Methods of detection
• describe methods of detection of the components of the electromagnetic spectrum.	
• describe systems that use the principles of heat transfer.	• Applications of heat transfer
• describe how cooling corrections are made for both good and bad conductors.	• Cooling correction
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Practical approach to measure thermal conductivity of solid.
- Discussion of definitions, derivations of expressions and calculations involved.
- Draw sketch graphs to show the variation of temperature along a bar (lagged and unlagged).

Notes

- In thermal conduction, consider only cases of parallel flow.
- Treatment should include:
  - refrigerators
  - water heaters

Teaching/Learning Resources

- Lee's disc
- Copper coil
- Lagging material
- Electrical heating coil
- Thermometers
- Long metal bar with two shallow holes drilled on it

Applications

- Refrigerators
- Car radiator
- Water heaters
- Vacuum flask
- Determination of U-value of materials during construction
- Effect of ocean / sea breeze at beaches
- Ventilation

Assessment

- Definition of terms, derivation of expressions and calculations involved
- Describing behaviour of black bodies

Sub-Unit 9: Survey of Energy

This sub-unit deals with resources, sources, conservation of energy, uses of energy and energy converters. Uganda is endowed with plenty of natural resources which can be harnessed for development.

Specific Objectives	Content
The learner should be able to:	
• explain the concept of energy and energy transfer.	• Concept of energy and energy transfer
• identify different forms and sources of energy.	• Forms of energy
• mention different sources and resources of energy.	• Energy sources and resources
• differentiate between primary and secondary sources of energy.	• Primary and secondary sources of energy
• differentiate between renewable and non-renewable energy resources.	• Renewable and non-renewable energy resources
• describe energy conservation techniques.	• Conservation of energy
• describe the different types of energy converters.	• Energy converters
• describe different ways of energy use.	• Energy use
• determine energy losses in different energy converters.	• Energy degradation

Suggested Teaching and Learning Strategies

- Use the discussion method to handle the following:
  - forms and sources of energy
  - energy transfer
  - renewable and non-renewable energy resources.
  - energy converters and conservation techniques.
- Discuss the sustainable use of energy resources.
- Discuss the degradation of other forms of energy into thermal energy.

Notes

- This sub-unit should be treated qualitatively.

Teaching/Learning Resources

- Energy saving bulbs
- Energy saving stoves
- Solar panel

Applications

- Use of energy saving bulbs and stoves
- Solar panel for heating and lighting
- Biogas and biomass energy for heating and lighting

Assessment

- Differentiating between primary and secondary energy source and between renewable and non-renewable energy
- Describing energy conservation techniques, different types of energy converters and uses of energy
- Determine energy losses in different energy converters.

Unit 5A: Electrostatics and Current Electricity

Duration: 46 Periods

This unit deals with:

- the production and behaviour of static electric charges.
- the behaviour of electric current in electric circuits and the principle of measurement of resistance and potential difference.

General Unit Objectives

By the end of this unit, the learner should be able to;

- describe the production and behaviour of static electric charges.
- explain the behaviour of electric current in electric circuits.
- explain the principle of measurement of resistance and potential difference.

Sub-Unit 1: Electrostatics

This sub-unit deals with small quantities of electric charges; their production and behaviour in electric fields.

Specific Objectives	Content
The learner should be able to:	
• explain charging by friction.	• Charging by friction
• describe the nature of charges in conductors and insulators.	• Types of charges
• explain charging by electrostatic induction.	• Charging by induction
• investigate the distribution of charge on a conductor and inside a hollow metal container.	• Distribution of charge
• explain corona discharge.	• Pointed conductors: Corona discharge
• describe the structure and principle of operation of a Van de Graff generator.	• Van de Graff generator
• explain the principle of operation of a lightning conductor.	• Lightning conductor
• describe and explain applications of electrostatics.	• Applications of electrostatic

Suggested Teaching and Learning Strategies

- Practical approach to:
  - charging by rubbing and by induction.
  - the action of the Van de Graaff generator.
  - the distribution of charge on a conductor (by proof plane).

Note

- Experimental verification of the law of force between electric charges is **not** required.

Teaching/Learning Resources

- Van de Graaff generator
- Gold leaf electroscope
- Ebonite and glass rods
- Proof plane
- Silk and fur (animal hair and wool)
- Pith balls
- Polythene and cellulose, acetate (Perspex)

Applications

- Dust extraction during cleaning
- Paint spraying
- Electrostatic screening/shielding
- Installation of lightning conductors
- Photocopying and fingerprints

Assessment

- Project to:
  - design a gold leaf electroscope using locally available materials.
  - use a hollow metal can, gold leaf electroscope and a charged sphere to study deflections on gold leaf.

Sub-Unit 2: Electric Field

In this sub-unit you will deal with the properties of static charges in an electric field.

Specific Objectives	Content
The learner should be able to: • define electric field and electric field lines. • sketch electric field pattern: - due to a point charge - between point charges - between a point charge and a charged plate - between two charged plates - due to a charged sphere - due to a charged flat metal plate • state Coulomb's law of electrostatics. • calculate the resultant force on a point charge due to a number of point charges. • define electric field intensity. • calculate electric field intensity at a point due to a number of point charges. • sketch a graph showing the variation of intensity with distance: - from a point charge. - from the centre of a charged metal sphere. • derive an expression for the energy stored in an electric field. • define electric potential. • derive an expression of potential at a point due to a point charge. • sketch a graph showing variation of potential with distance: - from a point charge. - from the centre of a charged	• Concept of electric field and electric field lines • Electric field patterns (Arrangement of point charges should be of a simple geometry) • Coulomb's law of electrostatics • Force between point charges • Electric field intensity - Concept of electric field intensity • Electric field intensity at a point due to a number of point charges • Variation of intensity with distance • Energy in an electric field • Electric potential • Potential at a point due to a point charge • Variation of potential with distance • Potential difference • Relationship between electric intensity and electric potential

Specific Objectives	Content
metal sphere. • define potential difference. • derive a relationship between electric intensity and electric potential. • derive an expression for the electric potential energy. • define the electron volt. • solve numerical problems.	• Electric potential energy • The electron volt • Numerical problems

Suggested Teaching and Learning Strategies

- Discuss definitions, derivations of expressions and calculations involved.
- Demonstrate Coulomb's law and the effect of a charged body near charged electroscope.

Notes

- Handle electric field intensity quantitatively.
- Emphasise graphical illustrations.
- Vector approach is recommended when dealing with calculations involving electric field intensity.
- Treat Coulomb's Law (force between point charges) of electrostatics.
- Relate the unit of electric potential to the volt.
- Bring out the concept of test charge clearly.
- Arrangement of point charges should be of a simple geometry.
- Derive the expression $W = QV$.
- Use the following expressions to calculate electric intensity: $E = \frac{F}{Q}$,

  $E = -\frac{dV}{dx}$.
- Use of the gold leaf electroscope as an electrostatic voltmeter

Teaching/Learning Resources

- Gold leaf electroscope and charging materials and objects.

Applications

- Same as those mentioned in electrostatics.

Assessment

- Definitions, derivations of expressions and calculations involved
- Sketching graphs of potential and electric field intensity

Sub-Unit 3: Capacitors

This sub-unit deals with devices that store charges in electronic devices.

Specific Objectives	Content
The learner should be able to:	
• define capacitance.	• Concept of capacitance
• define the Farad.	• Unit of capacitance
• investigate the charging and discharging processes of a capacitor.	• Charging and discharging a capacitor
• explain the charging and discharging processes of a capacitor.	• Explanation of the charging and discharging processes
• investigate the factors which affect the capacitance of a parallel plate capacitor.	• Parallel-plate capacitor
• define a dielectric and dielectric constant.	• The effect of an insulator between the capacitor plates
• explain the action of a dielectric using molecular theory.	• Action of a dielectric
• measure the dielectric constant of a material.	• Dielectric constant
• compare capacitances.	• Comparison of capacitances (e.g. by a ballistic galvanometer or by a calibrated electroscope)
• derive expressions for the effective capacitance of capacitors in series and in parallel.	• Arrangement of capacitors in series and parallel
• derive expressions for the energy stored in a charged capacitor.	• Energy stored in a charged capacitor
• account for the energy loss when two isolated charged capacitors are connected in parallel.	• Energy loss in connected capacitors
• describe applications of capacitors.	• Applications of capacitors
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Practical approach to:
  - measure capacitance using a ballistic galvanometer.

- practically charge and discharge a capacitor using a red switch circuit.
- experimentally determine the factors affecting the capacitance of a parallel plate capacitor.

- Demonstrate using a circuit board the arrangement and application of capacitors.
- Study trips to electronic workshops are recommended.

Notes

- Knowledge of formulae for the capacitance of standard types of capacitors in terms of their dimensions not required.
- Experiments limited to low voltages only e.g. dry cells as source of Emf.
- Use of the expression C = $\frac{\varepsilon A}{d}$ is important.
- Use of ballistic galvanometer and calibrated electroscope to compare capacitances is essential.

Teaching/Learning Resources

- Ballistic galvanometer
- Gold leaf electroscope
- Reed switch
- Cells
- Capacitors
- Dielectric

Applications

- Used in electronic devices such as radios and calculators for storage of charge
- Smoothing p.d.
- Prevention of sparking in a.c. circuits

Assessment

- Exercise on definitions, derivations of expressions and calculations involved
- Explain working of a capacitor in electronic devices.

Sub-Unit 4: Current Electricity

This sub-unit deals with the flow of large quantity of charge through a conductor under applied p.d.

Specific Objectives	Content
The learner should be able to:	
• define the Coulomb.	• The Coulomb
• define electric current.	• Charge - Unit of charge - Concept of current electricity
• explain the concept of potential difference.	• Potential difference
• explain the significance of potential difference.	• Significance of potential difference
• define the volt.	• The Volt
• define Emf.	• Electromotive force (Emf)
• define resistance.	• Resistance
• define the Ohm.	• The Ohm
• state Ohm's law.	• Ohm's law
• verify Ohm's law.	• Verification of Ohm's law
• sketch current - voltage (I-V) characteristics for Ohmic and non-Ohmic conductors.	• Ohmic and non-Ohmic conductors (include thermionic devices, ionised gases and non linear devices)
• identify the factors which determine the resistance of a metallic conductor.	• Factors determining resistanc
• explain the effect of each of the factors above on resistance of a conductor.	• Effect of each of the factors above on resistance of a conductor
• define resistivity.	• Resistivity
• define temperature coefficient of resistance.	• Temperature coefficient of resistance (t.c.r)
• explain the heating effect of current.	• Heating effect of a current
• derive expressions for effective resistance of resistors in series and in parallel.	• Arrangement of resistors in a circuit
• define internal resistance.	• Internal resistance
• explain the cause of internal resistance.	• Cause of internal resistance
• measure internal resistance of a cell.	• Measurement of internal resistance

Specific Objectives	Content
• derive expressions for energy and power in an Ohmic resistor. • derive a condition for maximum power output in an Ohmic resistor. • sketch graphs for variation of efficiency, power output and terminal potential difference (p.d.) with load resistance.	• Energy and power in an Ohmic circuit element • Maximum power output in an Ohmic resistor. • Variation of efficiency, power output and terminal p.d. with load resistance
• state Kirchhoff's laws of electricity. • solve circuit problems using Kirchhoff's laws.	• Kirchhoff's laws • Circuit problems using Kirchhoff's laws
• explain the action of a potential divider.	• Potential divider.
• demonstrate proper use of ammeters and voltmeters in a circuit.	• Use of ammeters and voltmeters in a circuit
• calculate a suitable resistance which can be used to convert a milliammeter into an ammeter and a voltmeter.	• Shunts and multipliers
• explain the principle of operation of a slide wire potentiometer.	• The slide wire potentiometer
• carry out experiments using a slide wire potentiometer to : - compare emfs. - measure internal resistance of a cell. - measure current. - calibrate an ammeter and a voltmeter. - measure resistance. - compare resistances. - measure thermoelectric emfs.	• Slide wire potentiometer experiments
• compare the use of the slide wire. potentiometer with the use of a moving coil instrument.	• Comparison of a slide wire with a moving coil instrument
• derive the condition for balance using a Wheatstone bridge.	• Wheatstone bridge (Calculation of end-correction not required)
• derive the condition for balance of a slide wire meter bridge.	• Slide wire meter bridge
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Practical approach to:
    - verification of Ohms law.
    - investigate behaviour of Ohmic and non-Ohmic conductors (such as thermionic devices, ionised gases, linear and non-linear resistors).
    - determine resistivity.
    - measure temperature coefficient.
    - determine emf and internal resistance of a cell using a potentiometer.
    - calibrate ammeter and voltmeter.
    - measure resistance using a meter bridge.
    - investigate Kirchoff's laws.
- Explain why the Wheatstone bridge is not suitable for comparing very small or very big resistances or resistances which are not of the same order.
- Brainstorm to bring out sources of emf.

Notes

- Modifications of the Wheatstone network for finding battery resistance, galvanometer resistance or resistance of an electrolyte are **not** required.
- The following equations may be useful:

- $W = QV$
- $I = \frac{Q}{t}$

- Ensure Kirchoff's loops are in the same direction.
- Emphasise the use of potential divider rule in solving problems.
- Always check the current conductivity at junctions and contacts.
- Calculation of end-correction is **not** required.

Teaching/Learning Resources

- Cells
- Resistors
- Rheostats
- Ammeters
- Voltmeters
- Galvanometers
- Potentiometers
- Metre Bridge
- Cell holders and connecting wires
- Standard Resistors
- Resistance box

Applications

- Measuring resistances in electrical circuits and appliances
- Potential dividers used in electronic devices
- Potentiometers are used in radios and record players as volume and tone controls

Assessment

- Measurement of values of given resistors either on a potentiometer or on a metre bridge
- Calibration of voltmeters and ammeters
- Modification of galvanometers to measure p.d and current using shunts and multipliers
- Definitions, derivations of expressions and calculations involved

Unit 5B: Electronic Devices

Duration: 10 Periods

This unit deals with cathode-ray oscilloscope, semi-conductors and their applications.

General Unit Objective

By the end of this unit, the learner should be able to describe the structures and mode of operation of cathode ray oscilloscopes and junction transistors

Sub-Unit 5: Cathode Ray Oscilloscope

This sub-unit deals with the behaviour of electron beams in an electric field inside a vacuum.

Specific Objectives	Content
The learner should be able to: • describe the structure and operation of the CRO. • state the applications of the CRO. • compare the use of the CRO with that of moving coil instruments. • solve numerical problems.	• The CRO • Applications of a CRO • Comparison with moving coil instruments • Numerical problems

Suggested Teaching and Learning Strategies

- Demonstrate use of CRO to measure frequency, voltage, current and study wave forms.

Notes

- Include use of the linear time-base but no details of its circuit.

Teaching/Learning Resources

- CRO
- Batteries
- Resistors

Applications

- To measure frequency, voltage, current, display and study wave forms

Sub-Unit 6: Transistors

Transistors are electronic devices made from semiconductors. They are used as automatic switches and amplifiers in circuits.

Specific Objectives	Content
The learner should be able to:	
• explain what is meant by a **p-n** junction.	• The **p-n** junction (intrinsic and extrinsic conductors, doping, included)
• sketch **I-V** characteristic for a junction diode.	• The junction diode (rectification included)
• explain applications of a junction diode.	• Applications of a **p-n** junction diode
• describe the structure of **n-p-n** and **p-n-p** type transistors.	• The transistor
• sketch **I-V** characteristic for a transistor.	• Transistor characteristics (Only the following characteristics should be considered - I_B-V_{BE} - I_C-V_{CE} - I_C-I_B)
• demonstrate the use of transistors as automatic switches and amplifiers.	• Two-transistor amplifier (Darlington pair)
• apply Boolean algebra in designing logic circuits.	• Logic gates and their combinations Boolean algebra
• express numbers in base 2, 8, 10 and 16.	• Numbers in base 2, 8, 10 and 16
• use logic gates to solve logic questions.	• Solution to logic questions
• construct a truth table for each logic gate.	• Truth tables
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Demonstrate the behaviour of transistors in electronic circuits.
- Practically investigate the operation of the transistor and include rectification.
- Emphasis should be on the achievement of useful practical results of the components and not on details of how they work.

Notes

- Knowledge of structure of Silicon, Germanium and Carbon atoms is important.
- Knowledge of holes and electrons included.
- Intrinsic and extrinsic conductors are included.
- Doping is included.
- The combination of gates should not exceed three.
- Only the following characteristics should considered:
  - I_B-V_{BE}
  - I_C-V_{CE}
  - I_C-I_B
- Consider only **AND, NOT, AND OR**.

Teaching/Learning Resources

- Transistors
- Switches
- Source of e.m.f.
- Resistors
- Logic gate IC (Integrated Circuit)
- Light emitting diodes (LED)
- Cathode-ray oscilloscope
- Circuit board
- Batteries

Applications

- Automating watering systems
- Safety thermostats
- Light activated burglar alarms
- Burton push locks
- Heat and fire detectors
- Electronic devices such as calculators, computers, digital watches and robots
- Light emitting diodes (LED)
- Uses of transistors (as switches and as amplifiers)

Assessment

- Construction of truth tables
- Designing logic circuits
- Using logic gates to solve logical questions
- Sketching I-V circuits for a junction diode

Unit 6: Electromagnetism

Period: 64 Periods

Electromagnetism is a fundamental interaction between electric and magnetic fields.

General Unit Objectives

By the end of the unit, the learner should be able to:

- determine magnetic field strength using angle of dip and equations for different coil configurations.
- apply the knowledge of magnetic force.
- describe devices that operate on the principle of magnetic force on current-carrying coils.
- Use the principles of electromagnetic induction to describe the production of alternating Emf and solve problems involving A.C. circuits.

Sub-Unit 1: Magnetism in Matter

Magnetism is a property of materials that respond at atomic and subatomic levels to an applied magnetic field.

Specific Objectives	Content
The learner should be able to: • define magnetic field and magnetic field lines. • describe a method of comparing the strengths of two magnetic fields using a deflection magnetometer.	• Magnetic field and magnetic field lines • Comparing the strengths of two magnetic fields (e.g. comparison of the strength of magnetic field with the horizontal component of the earth's field) • The earth as a magnet
• define magnetic meridian, declination, angle of dip.	• magnetic meridian
• investigate the magnetic field pattern around a bar magnet in the earth's magnetic field and between two magnets.	• Magnetic field patterns
• define the neutral point.	• Neutral point
• Explain magnetism in materials in terms of molecules or atoms	Molecular theory of magnetism (include domain theory)

Specific Objectives	Content
(dipoles). • explain magnetic saturation. • explain magnetisation and demagnetisation using molecular theory. • define magnetic flux and flux density. • define the Tesla. • solve numerical problems.	• Magnetic saturation • Magnetisation and demagnetisation • Magnetic flux and magnetic flux density • The Tesla • Numerical problems

Suggested Teaching and Learning Strategies

- Practically investigate the magnetic fields using plotting compass and iron filings.
- Experiments to compare the strength of two magnetic fields using a magnetometer.
- Discuss definitions, derivations of expressions and calculations involved.
- Plot magnetic field lines around a bar magnet.
- Demonstrate angle of dip (inclination).
- Practically locate the neutral point in a magnetic field.
- Experimentally determinate the magnetic flux and magnetic flux density.

Notes

- Declination (variation) is included.
- Include domain theory.
- The idea of magnetic field, magnetic flux density B, magnetic flux ϕ, permeability of free space and relative permeability is included.
- Include the earth's magnetic field and molecular theory of magnetism.
- Calculations of magnetic flux density due to oscillations of a magnet in a magnetic field **not** required.
- Experimental determination of permeability **not** required.
- Experimental determination of magnetic flux ϕ and magnetic flux density **B** by means of an induced emf or by calibrated ballistic galvanometer (or fluxmeter) and search coil or by force on a current.

Teaching/Learning Resources

- Plotting compass
- Tangent galvanometer
- Iron filings
- Magnets, paper and a board
- Magnetometer

Applications

- Mobile phones
- Electronic inductors
- Transformers
- Computers
- Loud speakers
- Electric motors

Assessment

- Definitions, derivations of expressions and calculations involved
- Plotting magnetic fields

Sub-Unit 2: Magnetic Effect of an Electric Current

A current-carrying conductor produces a magnetic field around itself. The strength of this field depends on the magnitude of the current.

Specific Objectives	Content
The learner should be able to:	
• investigate the existence of a magnetic field around a current carrying conductor.	• Existence of a magnetic field around a current carrying conductor
• investigate the dependence of the field at the centre of a circular coil on the number of turns and radius.	• Dependence of field at the centre of a circular coil on the number of turns and radius
• use the Right Hand Grip (corkscrew rule) to determine the direction of magnetic field due to a current in a current carrying conductor.	• Direction of magnetic field due to a current
• sketch magnetic field patterns: - around a straight conductor. - inside a narrow circular coil. - inside a solenoid carrying current.	• Magnetic field patterns around a current carrying conductor
• define magnetic flux linkage and flux density.	• Magnetic flux linkage and flux density
• derive the expression $\varphi = BA\cos\theta$.	• The expression $\varphi = BA\cos\theta$
• measure magnetic flux and flux density.	• Measurement of flux and flux density (e.g. by means of an induced emf, calibrated

Specific Objectives	Content
	ballistic galvanometer (fluxmeter) and search coil or by force on a current)
• quote Biot-Savart's law.	• Biot-Savart's law (Derivation of expressions of $\boldsymbol{B}$ using Biot - Savart's law not required)
• quote an expression for the flux density: - at the centre of a narrow circular coil. - due to a long straight wire. - inside a solenoid.	• Expressions for flux density using Biot - Savart's rule
• carry out experiments to investigate the dependence of the field at the centre of a circular coil on the number of turns and the radius.	• Experimental investigation of dependence of the field at the centre of a circular coil on the number of turns and the radius
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Carry out experimental investigation of the dependence of the field at the centre of a circular coil on the number of turns and the radius of the coil.
- Practically investigate the existence of magnetic field around a current-carrying conductor for coils and solenoids.
- Demonstrate magnetic field patterns using the right-hand grip rule.
- Demonstrate Biot-Savart's law.

Notes

- Include formulae for the strength of magnetic field due to a current in a situation.
- Derivation of expressions of $\boldsymbol{B}$ using Biot-Savart's law **not** required.
- Mathematical proof of proportionality between charge and throw (deflection) in a ballistic galvanometer is **not** required.
- Ignore calculations of magnetic field due to a magnet and oscillations of a magnet in a magnetic field.

Teaching/Learning Resources

- Plotting compass
- Connecting wires
- Iron filings
- Enamelled copper wires

- Soft iron
- Switch, cardboard
- Dry cells (battery)

Applications

- Mobile phones
- Computers
- Transformers
- Voltmeters
- Ammeters
- Loud speakers
- Electric motors
- Car induction coil
- Circuit breakers

Assessment

- Practical exercise on investigation of magnetic field patterns around a current-carrying conductor, the short coil and a long coil.
- Project for making electro-magnets and devices using electromagnets.
- Definitions, derivations of expressions and calculations involved.

Sub-Unit 3: Force on a Current-Carrying Conductor

A coil in a uniform magnetic field experiences two equal but opposite parallel forces due to the interaction of two magnetic fields.

Specific Objectives	Content
The learner should be able to:	
• investigate the existence of a force on a current-carrying conductor.	• Force on a current carrying conductor
• use Fleming's left hand rule to find the direction of the force on a current carrying conductor placed in a magnetic field.	• Direction of the force on a current carrying conductor placed in a magnetic field
• derive the expression ***F = BIl sin θ.***	• The expression ***F = BIl sin θ***
• derive the expression for the magnetic force between two long parallel current carrying conductors.	• Force between two long parallel current carrying conductors
• define the ampere.	• The ampere
• describe a simple form of a current balance.	• The current balance

Specific Objectives	Content
• derive the expression **$F = Bqv \sin\theta$.**	• Force on a charge moving in a magnetic field
• explain Hall effect.	• The Hall effect
• derive an expression for the Hall voltage.	• Expression for the Hall voltage
• derive the expression for the torque on a coil in a magnetic field: $\tau = BANI \sin\theta$.	• Torque on a coil in a magnetic field.
• describe the structure and action of a moving coil galvanometer.	• The moving coil galvanometer.
• explain the modifications necessary to turn a moving coil galvanometer into a ballistic galvanometer.	• Modifications necessary to turn a moving coil galvanometer into a ballistic galvanometer.
• describe the structure and action of a moving coil loudspeaker.	• Moving coil loudspeaker
• describe the structure and action of a simple D.C. motor.	• D.C. motor
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Demonstrate practically:
    - the action of a motor and generator (a.c and d.c.).
    - Fleming's left-hand rule.

Teaching/Learning Resources

- Motor
- Magnets
- Cells
- Coils
- Moving-coil meters.

Applications

- Motors

Assessment

- Project on design of a:
    - d.c. motor.
    - Definitions, derivations of expressions and calculations involved.

Sub-Unit 4: Electromagnetic Induction

This sub-unit deals with the production of current in a conductor from magnetism due to change in flux linkage.

Specific Objectives	Content
The learner should be able to:	
• demonstrate production of electricity from magnetism.	• Electricity from magnetism
• use Fleming's right-hand rule to determine direction of induced current.	• Fleming's right-hand rule
• explain the relationship between change of flux linkage and induced current.	• Magnetic flux linkage
• state Faraday's and Lenz's laws of electromagnetic induction.	• Laws of electromagnetic induction
• derive the expressions - ***E = Blv sin θ.*** - ***E = BANω sin ωt.***	• Induced emf
• describe the structure and operation of simple A.C. and D.C. generators.	• A.C. and D.C. generators
• describe the processes that lead to the production of a back e.m.f. in a motor coil.	• Production of back e.m.f in motor coil
• define back e.m.f.	• Definition of back e.m.f
• derive the expression.	• The expression $V_a I_a = E_b I_a + I_a^2 R_a$
• explain the relationship between the speed of rotation of the coil and current flowing in the coil.	• Relationship between the speed of rotation of the coil and current flowing in the coil
• define Eddy currents.	• Eddy currents
• explain production of Eddy currents.	• Production of Eddy currents
• describe applications of Eddy currents.	• Applications of Eddy currents
• define self and mutual induction.	• Self and mutual induction
• explain self and mutual induction.	• Explanation of self and mutual induction
• derive the expressions $E = -L\frac{dI}{dt}$	• Induced Emf due to a changing flux linkage

Specific Objectives	Content
and $E = -M\dfrac{dI}{dt}$.	• The transformer
• describe the structure and action of the transformer.	• Energy losses in a transformer
• explain the energy losses in a transformer and how they can be minimised.	
• describe the principle of a method for direct determination of resistance such as rotation of a disc within a solenoid.	• Direct determination of resistance
• explain how electric power is transmitted over long distances.	• Power transmission
• state the advantages of high voltages and small currents during the transmission of electrical power.	• Suitable voltages and currents during the transmission of electrical power
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Demonstrate practically:
  - Lenz's law.
  - Faraday's law.
  - the action of a generator (a.c and d.c.).
  - the action of transformers.
  - Fleming's right-hand rule.
- Ensure learners distinguish between use of the left and right hand.
- Demonstrate Faraday's and Lenz's laws of electromagnetic induction.
- Discuss the advantages and disadvantages of a.c. and d.c. generators.
- Describe other applications of electromagnetic induction.

Notes

- Qualitative treatment for self and mutual induction

Teaching/Learning Resources

- Transformer
- Generator
- Dynamos
- Magnets
- Cells
- Coils

Applications

- Power transmission
- Motors
- Generators
- Dynamos
- Induction coils
- Speedometer
- Electromagnetic relay

Assessment

- Project on design of a transformer.
- Definitions, derivations of expressions and calculations involved.

Sub-Unit 5: A.C. Circuits

In this sub-unit you will deal with the applications of inductors, resistors and capacitors in electronic and electric circuits.

Specific Objectives	Content
The learner should be able to:	
• describe the structure and mode of operation of the: - hot wire ammeter (thermal). - moving iron ammeter. - rectifier type of ammeter.	• Measurement of A.C.
• define the root-mean-square value of a sinusoidal current.	• Root mean square (r.m.s) value of an A.C.
• derive the r.m.s expressions - $\mathbf{I_{r.m.s}} = \frac{I_{max}}{\sqrt{2}}$ and - $\mathbf{V_{r.m.s}} = \frac{V_{max}}{\sqrt{2}}$.	• r.m.s expressions for current and voltage
- define the term peak value.	• Peak value
• explain how a capacitor conducts A.C.	• A.C. through a capacitor
• derive expressions for V, I and reactance for a capacitor and inductor in a circuit separately.	• Expressions for V, I and reactance for a capacitor and inductor in a circuit separately.
• explain the terms lead and lag in relation to capacitance and inductance in A.C. circuits.	• Lead and lag
• sketch the curves of reactance against	• Variation of reactance with

Specific Objectives	Content
frequency.	frequency
• compare the effects of L, R and C separately on the current through an a.c. circuit.	• Effects of L, R and C separately on the current through an A.C circuit.
• derive the condition for resonance in an a.c. circuit with L, C and R in series.	• Condition for resonance
• define the term impedance.	• Impedance
• use the expression $\boldsymbol{E = \frac{1}{2} LI^2}$	• Energy and power in A.C. circuits (Derivation of $E = \frac{1}{2}LI^2$ not required.)
• explain sparking in inductive circuits.	• Sparking in inductive circuits
• describe how sparking is minimised in inductive circuits.	• Minimisation of sparking
• calculate the average power in a capacitor, inductor and resistor connected separately in an A.C. circuit.	• Average power in a capacitor, inductor and resistor in an A.C. circuit
• describe applications of capacitors and inductors in A.C circuits.	• Applications of capacitors, inductors in A.C circuits
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Practical approach to the measurement of a.c.
- Demonstrate the effects of L, R and C on the current through an A.C circuit to determine resonant frequency, f.
- Use the CRO to show the **V – I** relationships.
- Use of capacitors and coils in a.c circuits should be discussed.

Notes

- Simple qualitative treatment in terms of oscillograms included.
- Include the choke as one of the application.
- Derivation of $E = \frac{1}{2}LI^2$ **not** required.

Teaching/Learning Resources

- CRO capacitors, inductors and resistors

Assessment

- Definitions, derivations of expressions and calculations involved

Unit 7: Atomic and Nuclear Physics

Period: 56 Periods

This unit generally deals with:

- photo-electricity and the Einstein photon theory.
- energy levels in an atom and their application to spectra, x-rays and their properties.
- wave particle duality.
- radioactivity and nuclear stability.

General Unit Objectives

By the end of this unit, the learner should be able to:

- explain how cathode rays and positive rays are produced in discharge tubes at low pressures.
- use concept of photoelectric effect to introduce quantum theory.
- explain emission / absorption spectra and x-rays.
- determine the stability of nuclei.
- calculate the decay rates for various unstable isotopes.

Sub-Unit 1: Charged Particles

In this sub-unit, you will deal with the behaviour of cathode rays and positive rays. You will also deal with determination of charge per unit mass of an electron.

Specific Objectives	Content
The learner should be able to:	
• describe the discharge tube phenomena as pressure is reduced.	• Discharge tube phenomena
• describe the production of cathode rays.	• Cathode rays – production
• state the properties of cathode rays.	• Cathode rays -properties
• describe the production of positive rays.	• Positive rays production
• state the properties of positive rays.	• Positive rays - properties
• explain, qualitatively and quantitatively, the deflection of electron and ion beams through electric and magnetic fields.	• Motion of cathode rays and ion beams in electric and magnetic fields
• define specific charge.	• Specific charge

Specific Objectives	Content
• describe Thomson's experiment for determining specific charge. • describe the principle of operation of a mass spectrometer. • describe the Millikan's oil drop experiment to determine electronic charge. • define a mole, Avogadro's number and Faraday's constant. • solve numerical problem.	• Thomson's experiment • Mass spectrometer (Bainbridge or Dempster) • The Millikan's oil drop experiment • The mole, Avogadro's number and Faraday's constant • Numerical problems

Suggested Teaching and Learning Strategies

- Demonstration of production of cathode rays.
- Guided discovery on production of positive rays, motion of cathode rays in electric and magnetic fields.
- Guided discovery on the principle of operation of a mass spectrometer.
- Discussion of Millikan's oil drop experiment.
- Study tour to electronics workshops.
- Guided discovery on the qualitative and quantitative explanation on behaviour of electron and ion beams in electric and magnetic fields.
- Description of experiments to show some properties of cathode rays.

Teaching/Learning Resources

- CRO
- Electron gun of a TV
- Bar magnets

Applications

- TV set
- Computer monitors
- Visual displays in radiology

Assessment

Exercises on:

- definitions, derivations of expressions and calculations involved
- behaviour of electron and ion beams in electric and magnetic fields

Sub-Unit 2: Quantum Theory

This sub-unit deals with photo-electricity and Einstein's photon theory. It also deals with the energy levels in atoms and their application to spectra, x-rays and their properties, the de Broglie formula and the wave particle duality.

Specific Objectives	Content
The learner should be able to: • define photoelectric effect. • state the characteristics of photoelectric emission. • explain photoelectric emission using quantisation of e/m radiation. • define work function and threshold frequency. • state Einstein's equation $hf = W_o + \frac{1}{2}mv^2$ • describe an experiment to verify Einstein's equation and to determine Plank's constant using Millikan's apparatus. • define stopping potential. • draw sketch graphs to show the variation of stopping potential with frequency of radiation for various metals. • describe applications of photoelectric effect. • describe Rutherford's scattering experiment. • describe Rutherford's atom. • describe Bohr's atom. • explain energy levels in atoms. • explain line emission, line absorption, band and continuous spectra.	• Photoelectric effect • Characteristics of photoelectric emission • Quantisation of electromagnetic (e/m) radiation • Work function and threshold frequency • Einstein's photoelectric equation • Experiment to verify Einstein's equation and measure Plank's constant (the principles but not the details) • Stopping potential – definition • Graphs to show the variation of stopping potential with frequency of radiation for various metals. • Applications of photoelectric emission • Rutherford's scattering experiment • Rutherford's atomic model • Bohr's atom • Stable electron energy levels (qualitative ideas of stable electron energy levels and emission or absorption of light quanta with transition of electrons between levels). • Emission and absorption spectra • Wave particle treatment of the

Specific Objectives	Content
• derive the expression **$\Delta E = \frac{k}{n^2}$** for a Hydrogen atom • define ground, excited and ionisation states. • calculate the energy radiated/absorbed using the expression ΔE = hf. • describe the structure and mode of operation of an X-ray tube (hot cathode tubes). • explain the production of X-rays. • list the properties of X-rays. • draw a sketch graph to show the variation of X-ray intensity against wavelength. • explain the characteristics of X-ray radiation. • explain the formation of the continuous (background) radiation, line X-ray spectra and cut off wavelength. • derive the expression $\frac{hc}{\lambda_{min}}$ **= eV** • mention uses of X-rays. • explain diffraction of X-rays. • derive Bragg's law ***2d sin θ = nλ*** • describe hazards of X-rays. • mention the safety precautions against X-rays. • solve numerical problems.	electron • Ground, excited and ionisation states • The expression ΔE = hf • X-ray tube • X-rays • Properties of X-rays • X-ray radiation • Characteristics of X-ray radiation • Continuous (background) radiation, line X-ray spectra and cut off wavelength • The expression $\frac{hc}{\lambda_{min}}$ **= eV** • Uses of X-rays • Diffraction of X-rays • Bragg's law • Hazards of X-rays • Safety precautions of X-rays. • Numerical problems

Suggested Teaching and Learning Strategies

- Experimental treatment of photo-electric effects and characteristics of photo-electric emission.
- Experimental approach to verification of Einstein's equation and measuring of Planck's constant.

- Guided discovery on derivation of formulae involved, applications of photoelectric effect, Rutherford's discovery and the alpha scattering experiment.
- Field trip to hospitals to observe the mode of operation of an X-ray tube.

Notes

- Proof for calculation of the closest distance of approach is **not** required.
- Only simple qualitative treatment of stable electron energy levels and emission or absorption of light of electrons between levels should be done.
- Discuss quanta associated with transition.
- Knowledge of centripetal force, kinetic energy, electrostatic force and electric potential energy is relevant.
- Calculations to include scattering of X-rays by cubic crystals.

Teaching/Learning Resources

- Zinc plate, gold leaf electroscope, mercury vapour lamp (source of UV radiation), photo electric cell, potential divider, d.c. amplifier, colour filter.

Applications

- Photocell (photo emission and photovoltaic)
- X-rays are used in hospitals to inspect teeth and broken bones and to cure cancer.
- Detection of flaws and cracks in metal castings.
- Investigating the structure of crystals.
- Detection of hidden objects and fractures.

Assessment

- Describing Rutherford's and Bohr's atoms
- Exercise on definitions, derivations of expressions and calculations involved
- Explaining X-ray radiation characteristics

Sub-Unit 3:Nuclear Physics

This is a field of Physics that studies the building blocks and interactions of atomic nuclei. It describes nuclear energy, Einstein's mass-energy applications, the principle of nuclear fission, fusion and the nuclear reactor.

Specific Objectives	Content
The learner should be able to: • define the nuclide. • identify the constituents of the	 • The atomic nucleus- the nuclide • Constituents of the nucleus

Specific Objectives	Content
nucleus.	
• define the terms atomic number and mass number.	• Atomic number and mass number
• represent a nuclide using a symbol.	• Scientific representation of a nuclide
• define isotopes.	• Isotopes
• identify examples of isotopes.	• Examples of isotopes
• define the unified atomic mass unit.	• Unified atomic mass unit (u)
• calculate the equivalent of the atomic mass unit in electron-volts.	• The equivalent of the atomic mass unit in electron-volts
• state Einstein's mass-energy relation ($\Delta E = \Delta mc^2$).	• Einstein's mass-energy relation.
• define binding energy and mass defect.	• Binding energy and mass defect
• define binding energy per nucleon.	• Binding energy per nucleon
• draw a graph of binding energy per nucleon and explain its features.	• Variation of binding energy per nucleon with mass number
• explain the significance of binding energy per nucleon.	• Significance of binding energy per nucleon
• define nuclear fission and fusion.	• Nuclear fission and fusion.
• write balanced equations representing nuclear fission and fusion.	• Balanced equations
• solve numerical problems.	• Numerical problems

Suggested Teaching and Learning Strategies

- Guided discovery towards the definition of terms involved and writing balanced equations representing nuclear fusion and fission.

Notes

- The constituents of the atomic nucleus and the definitions of the terms: atomic number, mass number, isotopes, unified atomic mass, binding energy and mass defect, nuclear fusion and nuclear fission.
- The significance of binding energy per nucleon should be clearly explained in relation with the graph of variation of binding energy per nucleon with mass number.
- Stability against α, β and neutron –proton ratio should be left out.
- The structure and mode of operation of a thermal reactor should be left out.
- Details including chain reactions are **not** required.

Teaching/Learning Resources

- Animations
- Graph papers

Applications

- Nuclear reactor (electricity production)
- Atomic bombs/nuclear weapons
- Hydrogen bomb
- In medicine
- Fusion of the hydrogen nuclei in the sun to release solar energy
- Material engineering (ion implantation)
- Archaeology (radio-carbon dating)

Assessment

- Definitions, derivations of expressions and calculations involved
- Analysing a graph of binding energy per nucleon against mass number

Sub-Unit 4: Radioactivity

This sub-unit deals with radioactive detectors and counters, properties of radiation emitted by disintegration of the nucleus. Half life and its application in radioactive atoms are also considered.

Specific Objectives	Content
The learner should be able to:	
• define radioactivity and radioisotopes.	• Radioactivity
• identify radiations emitted during radioactivity.	• Radiations emitted during radioactivity
• balance decay equations.	• Decay equations
• state the properties of the radiations emitted during radioactivity.	• Properties of radiations emitted during radioactivity
• describe the structure and mode of operation of the Geiger Müller tube and counter, cloud chamber (expansion and diffusion), scintillation counter and photographic emulsion.	• Detection of ionising radiation
• define background radiation.	• Background radiation
• state sources of background radiation.	• Sources of background radiation

Specific Objectives	Content
• state the law of radioactivity ($\frac{dN}{dt} \alpha$ N) • define the decay constant. • derive the expression $\mathbf{N = N_0 e^{-\lambda t}}$ • draw the decay curve. • define half life. • derive the expression $\lambda T_{\frac{1}{2}}$ **= ln 2** • describe the production of artificial isotopes (induced radioactivity). • describe applications of radiation in medicine, agriculture and industry. • describe hazards of radiation emitted by radioisotopes. • list safety precautions against radiation. • solve numerical problems.	• Law of radioactivity • Decay constant • The expression $\mathbf{N = N_0 e^{-\lambda t}}$ • Decay curve • Half life • The expression $\lambda T_{\frac{1}{2}}$ **= ln 2** • Artificial (induced) radioactivity • Applications of radioisotopes (one biological and one industrial) • Hazards of radiation • Safety precautions • Numerical problems

Suggested Teaching and Learning Strategies

- Practical demonstrations on:
  - detection of radioactivity.
  - distinction between different radiations.
  - penetrating powers.
- Practically use water running out of a burette to simulate decay.
- Practically demonstrate radioactive decay using several wooden cubes or dice with one marked face.
- Role-play radioactive decay.

Notes

- Give safety precautions against radiations as radiation can be dangerous.
- Details of the detectors are **not** required.
- Details of radioactive series are **not** required.
- The use of accelerating machines in the production of artificial radioactive isotopes and neutrons should be mentioned but details of methods are **not** required.

Teaching/Learning Resources

- Photographic film (for blackening of film by radioactivity), gold leaf electroscope (ionisation of air by radiation), GM tube, rate metre, loud

speaker, paper, 3 mm aluminium, lead and other materials to slow penetration of radiations
- Horse-shoe magnet and GM tube to detect charge on radiations; wooden cubes or dice and graph paper

Applications

- Radioactive tracers (radioactive fertilisers, medical uses, industry, that is, leakage from a pipeline carrying oil or gas can be detected)
- Sterilising (Gamma rays can be used to kill bacteria)
- Cancer cells can be destroyed using Gamma rays.
- Thickness control
- Smoke detection (homes with smoke alarms)
- Checking welds
- Radioactive dating in Archaeology
- Medical uses

Assessment

- Definitions, derivations of expressions and calculations involved
- Exercise on production of artificial isotopes and applications of radiations in medicine and industries.

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TEACHING SYLLABUS

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Introduction

Mathematics has been part of the Advanced Level curriculum for a long time. However, there has been no Teaching Syllabus in place. The National Mathematics Panel has organised what is being taught in schools into a Teaching Syllabus purposely to ensure uniformity in the teaching of Advanced Level Principal Mathematics in all categories of secondary schools in Uganda, whether first or third world; urban or peri-urban; and those in rural areas.

The flow of the teaching has been carefully considered from the point that some topics give rise to prerequisite knowledge for other topics. Mechanics, for example, has to be taught after some basic topics such as Vectors, Trigonometry and Algebra have been properly covered in Pure Mathematics.

Details of the breakdown of the subject content to be taught per level per term per part are as indicated in the given table. Teachers are advised to follow the suggested and harmonised flow for consistence and uniformity in the teaching of Advanced Level Principal Mathematics. This will ensure efficient inter-school interactions and networking through seminars and workshops.

Purpose

This Teaching Syllabus is intended to promote national uniformity of content coverage for Mathematics throughout all the Advanced Level secondary schools in the country. The content to be covered for each class in all the four major areas, that is, Pure Mathematics, Mechanics, Statistics and Probability and Numerical Methods has been given. The content has been arranged in a sequential way per term to enable effective and efficient acquisition of knowledge and development of concepts, skills, values and attitudes.

Aims of Teaching Mathematics

The aims of teaching Mathematics are to:

i) To inspire learners in developing an attitude of logical thought.

ii) To build on basic mathematical concepts for better understanding.

iii) To enable learners develop an ability to use and construct mathematical models by:

- developing mathematics to the limits of their ability.
- applying mathematics with confidence to unfamiliar real problems.
- specialising in mathematical techniques required for further education or vocation.
- having a positive attitude towards problem-solving.

- appreciating as far as possible the satisfaction and enjoyment that may be gained from pursuing the subject for its own sake.
- presenting information in diagrammatic, tabular and graphic form.
- interpreting and analysing everyday mathematical-related problems.

Examination Format

There will be two papers of 3 hours each. Paper One will consists of Pure Mathematics (Part 1) and Paper Two will consist of Applied Mathematics (Part 2) questions. Each paper will consist of two sections, A and B. Section A will contain 8 short compulsory questions carrying 40 marks. Section B will contain 8 questions of which candidates will be required to attempt 5 questions carrying 60 marks.

Target

This Teaching Syllabus is intended to be used by teachers of Mathematics at Advanced Level.

Scope and Depth

The Teaching Syllabus covers Pure Mathematics, Mechanics, Statistics and Probability and, Numerical Methods.

Outline of the Teaching Syllabus

Part 1 Pure Mathematics Senior Five

Term	Topic	Periods
One	• Indices, Logarithms and Surds • Equations • Polynomials • Partial Fractions • Trigonometry	08 10 08 06 22
		54
Two	• Vectors • Coordinate Geometry I • Differentiation 1	24 06 24
		54
Three	• Integration 1 • Series • Permutations and Combinations • Binomial Theorem	22 12 10 10
		54
One	• Trigonometry (Calculus) • Exponential and Logarithmic Function • Maclaurins' Expansions • Integration II • Differential Equations	08 10 04 18 14
		54
Two	• Inequalities • Further Curve Sketching • Coordinate Geometry II • Coordinate Geometry III	04 10 14 26
		54
Three	• Complex Numbers	24

Part 2 Statistics and Probability *Senior Five*

Term	*Statistics and Probability*	Periods	*Mechanics*	Periods	*Numerical Methods*	Periods
One	• Descriptive Statistics • Index Numbers • Correlation and Scatter Graphs • Probability Theory	16 06 06 12	• No Mechanics		• Linear Interpolation and Linear Extrapolation • Location of Roots	06 08
		40				**14**
Two	• Discrete Probability Distribution	08	**Dynamics I** • Linear Motion • Newton's Laws • Resultant and components of Forces • Momentum • Connected Particles	06 12 06 06 10	• Error Analysis	06
		08		**40**		**06**
Three	• Binomial Distribution • Continuous Random Variable	06 12	**Dynamics II** • Work, Power and Energy • Resultant Velocity • Relative Motion • Vectors in Mechanics • Projectile Motion	06 06 06 04 10	• Errors in Functions	04
		18		**32**		**04**

Senior Six

Term	*Statistics and Probability*	*Periods*	*Mechanics*	*Periods*	*Numerical Methods*	Periods
One	• Normal Distribution • Normal	10 06	Statics I • Friction • Moment of a	08 08	• Trapezium Rule	04

	approximation to binomial		Force • Coplanar Forces	18		
		16		**34**		**04**
Two	• Sampling Distribution	10	**Dynamics III** • Circular Motion • Elasticity • Simple harmonic motion	 08 08 16	• Iterative Methods	12
		10		**32**		**12**
Three			**Statics II** • Centre of Gravity	 10	• Flow Charts	12
				10		**12**

Teaching Sequence

It is proposed that the teaching sequence should follow the order in which the topics have been arranged as outlined by this syllabus in order to promote effective and efficient teaching, learning and national uniformity.

PART 1: PURE MATHEMATICS

SENIOR FIVE TERM ONE

Topic 1: Indices, Logarithms and Surds

Duration: 8 Periods

General Objectives

By the end of this topic, the learner should be able to simplify indices, simplify and prove logarithmic expressions and rationalise surds.

Sub-Topic 1: Indices

Specific Objectives	Content
The learner should be able to: • relate powers to indices and express numbers using indices. • state the laws of indices. • apply the laws of indices to simplify and solve expression. • use the laws to solve equations involving indices.	• Powers as indices • Laws of indices • Simplification of expressions • Solving unknowns

Methodology

- Guide the learners to write in short form multiples of the same number.
- In groups, guide learners how to cut paper and relate the number of cuts to powers.
- Through brainstorming, guide learners through multiplication and division of indices.

Practical Problems / Activities

- Folding/cutting sheets of papers
- Thread folding
- Learners should be able to determine the whole number powers / indices to base 2 or 3 and extend to other bases and fractional powers.

Activity
- Get a sheet of paper and cut it into equal parts sequentially and observe.
- Before being cut, it was one sheet, so degree is 0 so $2^0 = 1$
- Cut it once to get two parts, the degree is 1 so $2^1 = 2$.
- Cut each piece once to get four parts, the degree is 2 so, $2^2 = 4$, etc.

Note: For base three, you cut three times. For higher bases greater than 3, a thread is folded around the arm and the number of times is equivalent to the base of your own interest.

Sub-Topic 2: Logarithms

Specific Objectives	Content
The learner should be able to:	
• relate logarithms to indices.	• Laws of logarithms
• state and prove the laws of logarithms.	
• change from one base to another base.	• Change of base
• simplify logarithms expression.	• Simplification of logarithmic expression.
• solve equations involving logarithms.	• Equations involving logarithms.
• prove logarithmic identities.	• Proof of identities involving logarithms

Methodology
- Through exposition, guide the learners to state the laws of logarithms.
- Provide worksheets for learners to practice application of the laws of logarithms, simplify and evaluate expressions.
- Through guided discussions, guide the learners on how to solve equations involving logarithms and prove logarithmic identities.

Practical Problems / Activities
- Using calculators to find logarithms and antilogarithms and comparing the results with the mathematical tables.

Note: $\log \frac{1}{a} = -\log a$. Logarithm of a negative number does not exist.

- Given $2^x = -3$, then x is invalid.

Assessment Strategy

- Give learners tests, exercises and assignments.

Sub-Topic 3: Surds

Specific Objectives	Content
The learner should be able to:	
• differentiate between rational and irrational numbers.	• Rational and irrational numbers
• simplify surds to the lowest form.	• Simplification of surds
• rationalise surds.	• Rationalisation of surds
• solve equations involving surds.	• Equations with surds

Methodology

- Through teacher exposition, define rational numbers with examples and explain the significance of rationalisation.
- Through brainstorming, guide learners to rationalise the denominator. (May be extended to three terms in the denominator).
- Provide worksheets/activities for learners to practise and develop skills in rationalising the denominator.

Practical Problems / Activities

- Using squared papers, learners can determine the length of a side of a square of some known area by counting the squares.

Note

i) A surd is equivalent to any unknown. Use squares with integral values then extend the knowledge like it can be done with any number.
ii) The learners should realize the possible (exact) and challenging square roots using graph papers.

Assessment Strategy

- Project work, exercises, tests and assignments

Topic 2: Equations

Duration: 10 Periods

General Objective

By the end of the topic, the learner should be able to solve linear equations, quadratic equations and simultaneous equations.

Sub-Topic 1: Linear and Simultaneous Equations

Specific Objectives	Content
The learner should be able to: • identify linear equations. • solve linear equations in one variable. • solve simultaneous linear equations with two variables using elimination, substitution and graphical methods. • solve simultaneous linear equations with three variables using elimination, substitution, row reduction and Echelon form.	• Linear equations in one variable • Linear simultaneous equations in two variables • Linear simultaneous equations in three variables.

Methodology

- Through brainstorming, help learners to solve linear equations in one and two variables.
- Through teacher exposition, help learners to solve linear equations in three variables using the different methods.

Practical Problems / Activities

- Formation and solving of linear equations in one variable from a word problem e.g. number of books bought given the amount of money spent and cost of one book.
- Decision-making using linear equations on graphs for purchase of commodities from either different shops or from the same shop, use models of money for such activities.

Assessment Strategy

- Give exercises, assignments, project and tests

Note

i) One way of solving simultaneous equations is row reduction and back substitution and reducing to Echelon form.

ii) The teacher should emphasise the **augmented matrix**.
iii) Echelon form the leading diagonal MUST have only 1s and the other terms are 0.

Sub-Topic 2: Quadratic Equations

Specific Objectives	Content
The learner should be able to: • form a quadratic equation. • solve quadratic equations using factorisation and completing squares. • express the roots as a sum and product using the coefficients of the quadratic equation. form quadratic equations using new roots. • solve simultaneous equations involving linear and non linear equations. • solve the equations involving logarithms • solve equations reducing to quadratics. • use the discriminant to state the nature of the roots. • state the maximum and minimum values of quadratic functions.	• Quadratic equations • Methods of solving quadratic equations • Sum and product of roots of a quadratic equation • Simultaneous equations, one linear and the other non linear • Simultaneous equations involving logarithms • Equations reducing to quadratics • Discriminant • Maximum and minimum using the graph and completing squares. $a \pm b(x+c)^2$

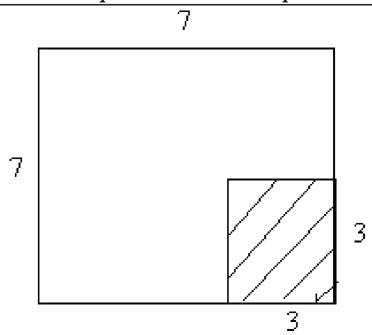
Methodology

- Through brainstorming, help learners to form quadratic equations.
- Through teacher exposition, help learners to solve equations using factorisation and completing squares and solve linear and quadratic equations.
- Through brainstorming, help learners to identify equations reducing to quadratic equations.
- Through teacher guided research, help learners to draw graphs of quadratic functions and deduce the maximum and minimum points.

Practical Problems / Activities

- Folding wires of known length into rectangles of known area bounded by the sides, formation of a cuboids of known volume and height using manila paper, etc.

Activity
Difference of two squares: use a square of known dimension.

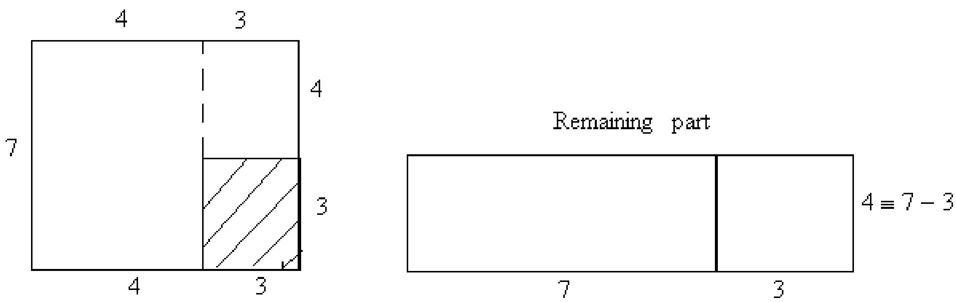


E.g.

The area of the big square is $7 \times 7 = 7^2$.

The area of the small square is $3 \times 3 = 3^2$.

The area of the remaining part is $7^2 - 3^2$.



The area of the remaining part is $(7+3)(7-3)$, thus $7^2 - 3^2 = (7+3)(7-3)$

Assessment Strategy

Give exercises, tests, projects and assignments

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Topic 3: Polynomials

Duration: 8 Periods

General Objective

By the end of the topic, the learner should be able to factorise and solve polynomials of degree greater than 2 using the remainder theorem.

Sub-Topic 1: Operation on Polynomials

Specific Objectives	Content
The learner should be able to: • form a polynomial. • identify the order of a polynomial. • divide polynomials. • factorise polynomials. • solve the polynomial $f(x)=0$	• Formation of polynomial • Order of a polynomial • Long division • Factorisation of polynomials • Solving a polynomial $f(x)=0$

Methodology

- Through brainstorming, guide the learners to form and define polynomials.
- Through teacher exposition, guide the learners to identify or state the order of a polynomial.
- Through brainstorming, guide the learners on how to divide polynomials.

Practical Problems/ Activities

- Using a metallic cube and a cylinder of known volume and water, learners should find the sides of the cube.

Assessment Strategy

- Give exercises, tests and assignments

Sub-Topic 2: Remainder Theorem

Specific Objectives	Content

The learner should be able to:
• state the remainder theorem.
• Find the remainder when the divisor is:
  - Linear
	• The remainder theorem.
	• Remainder when the divisor is:
	  - Linear

Specific Objectives	Content
- Quadratic • find the remainder when the polynomial is not known. • use the remainder theorem to find the quotient and reminder of a polynomial with repeated roots. • state and use the factor theorem.	- Quadratic • Remainder when the polynomial is unknown • Repeated roots • Factor theorem

Methodology

- Through guided research, guide the learners to state the remainder theorem.
- Through teacher exposition, help learners to solve polynomials.

Practical Problems / Activities

- Cut a rectangular cardboard into squares and determine the remainder.

Note

- Teachers are encouraged to use other methods such as synthetic approach.
- The concept $f(x) = f'(x) = 0$ for a repeated root should be taught after differentiating a polynomial.

Assessment Strategy

- Give exercises, tests and assignments.

Topic 4: Partial Fractions

Duration: 6 Periods

General Objective

By the end of the topic, the learner should be able to express identities as single fractions and partial fractions, and distinguish between proper and improper fractions.

Sub-Topic 1: Type of Partial Fractions

Specific Objectives	Content
The learner should be able to: • express algebraic fractions as single fractions. • identify a proper algebraic fraction. • solve identities. • express proper algebraic fractions as partial fractions. • identify and express improper algebraic fractions as a quotient and a proper algebraic fraction.	• Algebraic fractions • Identities • Proper algebraic fractions • Improper algebraic fractions

Methodology

- Through brainstorming, guide the learners to express simple algebraic fractions as single fractions.
- Through teacher exposition, guide the learners to express algebraic expressions as simple fractions.
- Through teacher exposition, help the learners to differentiate between proper and improper fractions and express them in partial fractions.

Practical Problems/Activities

- Using easily available materials such as sheets of paper, the concept can be introduced from the concept of subtraction or addition of fractions.
- Look at this: $\frac{1}{2\times 3}=\frac{1}{2}-\frac{1}{3}$, $\frac{1}{5\times 6}=\frac{1}{5}-\frac{1}{6}$ so $\frac{1}{x(x+1)}=\frac{1}{x}-\frac{1}{(x+1)}$

  Provided the numbers are consecutive.

Assessment Strategy

Give assignments, tests and exercises.

Note

i) Always factorise the denominator as far as possible.

ii) Limit the degree of the denominator to a maximum of four.

Topic 5: Trigonometry

Duration: 22 Periods

General Objective

By the end of the topic, the learner should be able to use the trigonometric ratios to derive and prove identities, deduce different identities and apply them to solve and prove equations.

Sub-Topic 1: Trigonometrical Ratios

Specific Objectives	Content
The learner should be able to: • derive trigonometrical ratios from a right-angled triangle. • find the sine, cosine, tangent of an angle of any magnitude using the quadrants of a unit circle. • deduce trigonometrical ratios of "special" angles. • draw trigonometrical graphs. • use Pythagoras theorem to derive and simplify trigonometrical identities. • prove identities. • solve trigonometrical equations. • eliminate the parameter Θ from a pair of parametric equations.	• All the six ratios: sine, cosine, tangent, cotangent, cosecant, secant • Special angles and their trigonometrical ratios • Graphs of trigonometrical functions • Trigonometric identities • Trigonometric equations • Parametric equations

Methodology

- Through teacher exposition, guide the learners on deriving the trigonometric ratios.
- Through guided research, help the learners to draw graphs of different trigonometric ratios.
- Through teacher exposition, help the learners to relate the Pythagoras theorem to the trigonometric ratios.

Practical Problems / Activities

- Using a graph paper, learners can draw a unit circle and use it to generate sines, cosines of both positive and negative angles and draw graphs of $\sin\theta$, $\cos\theta$ and $\tan\theta$.

Assessment Strategy

- Give assignments, tests and exercises.

Sub-Topic 2: Compound Angle Formulae

Specific Objectives	Content
The learner should be able to: • use the ratios: $\sin(A \pm B)$, $\cos(A \pm B)$, and $\tan(A \pm B)$. • prove identities. • solve trigonometrical equations. • deduce formulae for double angles, half angles and other multi-angles using compound angle formula. • Simplify, derive and solve equations involving inverse trigonometrical ratios.	• Formulae of $\sin(A \pm B)$ $\cos(A \pm B)$ $\tan(A \pm B)$ and corresponding reciprocals • Double angle identities • Half angle identities Inverse trigonometrical functions

Methodology

- Through teacher exposition, guide the learners on deriving the compound trigonometric ratios.
- Through teacher exposition, guide the learners to prove and solve trigonometric equations.
- Through brainstorming, guide the learners derive double angle formulae and relate them to other multi angles.

Practical Problems / Activities

- Learners should prove the compound angle formulae for $\sin(A+B) = \sin A \cos B + \cos A \sin B$ geometrically for A and B being acute angles and hence deduce the compound angle formulae for other trigonometrical ratios.

Assessment Strategy

- Assignments and exercises should be given.

Common mistakes

i) At first sight, learners dangerously think that $\sin(A+B)$ is sinA + sinB.

The teacher is advised to first give an example such as let $A = 30^o$ and $B = 60^o$ then $\sin\left(30^o + 60^o\right) = \sin 90 = 1$.

Whereas $\sin 30^o + \sin 60^o = \frac{1}{\sqrt{2}} + \frac{\sqrt{3}}{2} \neq 1$

This shows that the sine function is not distributive and this is the same for all the other trigonometrical ratios.

ii) Learners confuse the terms "Show" and "Prove". Teachers should endeavour to explain to the learners the difference between the two words.

Note

i) When solving trigonometrical equations, learners cancel trigonometrical ratios instead of factorising them. This leads to loss of some values of Θ required in the given range. e.g. $\cos\theta + 2\sin\theta\cos\theta = 0$. In this case, learners cancel out $\cos\theta$ instead of factoring it out.

ii) The teacher should guide the learners on how to obtain all the possible angles in the given range.

Sub-Topic 3: The Forms $R\cos(\theta \pm \alpha)$ Or $R\sin(\theta \pm \alpha)$

Specific Objectives	Content
The learner should be able to: • use the expressions: $R\cos(\theta \pm \alpha)$ or $R\sin(\theta \pm \alpha)$ • solve trigonometrical equations of the form: $a\cos\theta \pm b\sin\theta + c = 0$ • find the maximum and minimum of trigonometrical functions involving $a\cos\theta \pm b\sin\theta + c$ =0 and $\frac{1}{a\cos\theta \pm b\sin\theta + c}$	• The form $a\cos\theta \pm b\sin\theta$ to be expressed as $R\cos(\theta \pm \alpha)$ or $R\sin(\theta \pm \alpha)$

Methodology

- Through teacher guided research, group the learners and assign them to draw graphs of trigonometric functions to help them understand the term harmonic motion.
- Through teacher exposition, guide the learners as to how express $a\cos\theta \pm b\sin\theta + c = 0$ in the harmonic form.

- Through guided discussions, guide the learners on how to deduce the maximum and minimum values and relate them to the graphs.

Note

May be extended to $R\cos(2\theta \pm \alpha)$ or $R\sin(2\theta \pm \alpha)$

The teacher may also use the Pythogras identity when solving $a\cos\theta \pm b\sin\theta + c = 0$.

Assessment Strategy

- Give exercises, tests and assignments.

Sub-Topic: 3 $t-$ Formulae

Specific Objectives	Content
The learner should be able to: • express trigonometrical ratios in terms of $t = \tan\frac{1}{2}x$, $t = \tan x$. • use the $t-$formulae to: - solve equations. - prove identities.	• $t-$ formulae for sine, cosine and tangent

Methodology

- Through teacher exposition, guide the learner as to how express the trigonometric ratios in terms of $t = \tan\frac{1}{2}x$, $t = \tan x$.
- Provide worksheets for the different expressions of the $t-$ formula.
- Through guided discussions, guide the learners on how to use the $t-$formulae to solve equations and prove identities.

Practical Problems/Activities

- Learners should prove the factor angle formulae.

Assessment strategy

- Assignments and exercises should be given

Sub-Topic 4: Solution of Triangles

Specific Objectives	Content
The learner should be able to: • derive the cosine, sine and tangent rules. • solve the triangles using the rules. • derive the formulae for angles of a triangle in terms of the sides. • derive formulae for area of a triangle.	• cosine, sine and tangent rules • Formulae for angles of triangles and the sides of a triangle • Area of a triangle

Methodology

- Through teacher exposition, guide the learners to derive the sine rule and cosine rule.
- Through teacher exposition, guide the learners to express the double angle formula in terms of the sides of a triangle.
- Through guided discussions, guide the learners on how to derive the area of a triangle.

Practical Problems/Activities

- Use a protractor and a ruler to measure the size of angles and lengths of triangular cardboards. Use them to verify the angle sum of a triangle, sine rule and cosine rule.

Assessment Strategy

- Give exercises, assignments and tests.

PART 1: PURE MATHEMATICS

SENIOR FIVE TERM TWO

Topic 6: Vectors

Duration: 24 Periods

General Objective

By the end of the topic, the learner should be able to use express vectors as column vectors in two and three dimension, and find the angle between two lines and planes.

Sub-Topic 1: Vectors in Two and Three Dimensions

Specific Objectives	Content
Learner should be able to:	
• identify a vector.	• Definition of a vector
• express a vector in a column form	• Vector notations
• express a column vector in the form i, j, k.	
• determine the displacement vector.	• Displacement vector
• identify a position vector.	• Position vector
• add and subtract vectors.	• Addition and subtraction of vectors
• multiply a vector by a scalar.	• Multiplication by a scalar
• calculate the magnitude of a vector.	• Magnitude of a vector
• determine a unit vector.	• Unit vectors
• find a unit vector in a given direction.	
• identify parallel vectors.	• Parallel vectors
• identify equal vectors.	• Equal vectors
• find the dot product of two vectors.	• Dot/scalar product of two vectors
• state and apply the ratio theorem.	• Ratio theorem

Methodology

- Through teacher exposition, guide the learner to express a vector in column form.
- Provide worksheets for equal vectors, parallel vectors and perpendicular vectors.

Practical Problems/Activities

- Moving from one point A to another point B in a straight line would give a good illustration of the concept of a displacement vector.
- Making two bodies to move equal distances in a specified direction from the same point to illustrate the concept of equal vectors.

Note: A minds activity by use of graph papers should be utilised to bring out the concept.

Assessment Strategy

Five class exercises, assignments and tests.

Sub-Topic 2: Lines in Two and Three Dimensions

Specific Objectives	Content
The learner should be able to: • form a vector equation for a line. • write the parametric and the Cartesian equation of a line. • apply the dot product to find the angle between two lines. • find the perpendicular distance from a point to a line. • find a point of intersection of two lines. • identify parallel and skew lines.	• Vector equations of lines • Parametric and Cartesian equations of lines • Angle between lines • Shortest distance of a point from a line • Intersection of two lines • Parallel and skew lines

Methodology

- Through teacher exposition, guide the learners to derive the parametric and Cartesian equation of a line.
- Through teacher exposition, guide the learners to find the angle between two lines.
- Through guided discussions, guide the learners on how to determine the point of intersection of two lines.

Practical Problems/Activities

- Use of two pens or rods or sticks to demonstrate the angle between two lines and point of intersection of the two lines.

- Use of a marked point on the blackboard and the blackboard ruler to act as a line in order to demonstrate finding the perpendicular distance of a point from a line.

Assessment strategy

- Give exercises, assignments and tests.

Sub-Topic 3: Planes

Specific Objectives	Content
The learner should be able to:	
• form a vector equation of a plane.	• Equation of a plane
• write the parametric equation and the Cartesian equation of a plane.	• Parametric and Cartesian equations
• find the perpendicular distance of a point from a plane.	• Shortest distance of a point from a plane
• find the point of intersection between a line and a plane.	• Intersection of a line and a plane
• find the point of intersection of 3 planes.	• Intersection of planes
• find the angle between a line and a plane using the dot product.	• Angle between a line and a plane
• use the dot product to find the angle between a plane and a plane.	• Angle between a plane and a plane

Methodology

- Through teacher exposition, guide the learners to form the vector equation of a plane.
- Through teacher exposition, guide the learners to find the angle between a line and a plane and the angle between two planes.

Practical Problems/Activities

- Opening a book to demonstrate the angle between two planes.
- Use of a pen and a book to demonstrate the angle between a line and a plane.
- Use of a blackboard and the blackboard ruler to demonstrate the angle between the plane and the line.

Assessment Strategy

- Give class exercises, assignments and projects.

Note: Avoid points of intersection of two planes.

Topic 7: Coordinate Geometry I

Duration: 6 Periods

General Objective

By the end of the topic, the learner should be able to find the equation of a straight line, mid points, length between two points and distinguish between parallel and perpendicular lines.

Sub-Topic 1: Straight Lines

Specific Objectives	Content
The learner should be able to:	
• form Cartesian equations of lines.	• Cartesian equations
• find the gradient of a straight line using the general equation of a line.	• Gradient of a straight line
• find the intercepts of a line.	• Intercepts
• find the coordinates of the midpoint of a line.	• Midpoint of a line
• find the distance between two points.	• Distance between two points
• find the point(s) of intersection by solving the equations simultaneously.	• Point(s) of intersection
• find the perpendicular distance between a line and a point.	• Perpendicular distance between a point and a line
• find the relationship between the gradient and tangent of the angle.	• Angle between a line and the $x-$axis
• determine the relationship between the gradients of parallel lines.	• Parallel lines
• determine the relationship between gradient of perpendicular lines.	• Perpendicular lines

Methodology

- Through teacher exposition, guide the learner to find the gradient, equation and intercept of a line.
- Provide for worksheets to illustrate the point of intersection between two lines.

- Through peer presentation, learners can illustrate parallel and perpendicular lines.

Assessment Strategy

- Give assignments, tests and exercises.

Topic 8: Differentiation I

Duration: 24 Periods

General Objective

By the end of the topic, the learner should be able to determine the gradient of a curve at a point by differentiating from first principles.

Sub-Topic 1: Gradient of a Curve

Specific Objectives	Content
The learner should be able to: • find the gradient of a chord. • identify the small increment as ∂x • define the gradient of a curve at a point. • deduce the gradient of the tangent at a point on the curve.	• Gradient of a chord • Limit of gradient of chord • Gradient of a curve at a point • Gradient of a tangent at a point

Methodology

- Through teacher exposition, guide the learners to find the gradient of a curve at a point from first principles.
- Through teacher guided discussions, guide the learners to determine the gradient of the tangent to the curve at a point.

Practical Problems/Activities

- Use two straight rods meeting at 90^0 with a curved object to show how the chord changes into the tangent at same given point.
- Throw objects upwards to illustrate the trajectory of the maximum distance attained.
- Finding the maximum and minimum of some geometrical quantities such as length, area.

Assessment Strategy

Give class exercises, assignments and tests.

Sub-Topic 2: Gradient Function

Specific Objectives	Content
The learner should be able to: • differentiate from first principles. • deduce the formula of differentiation. • differentiate a polynomial. • find the equation of the tangents and normals to the curve at a point.	• Differentiation from first principles • Derivative of ax^n, $n \in R$ • Derivative of a polynomial • Tangents and normals to the curve at a point

Methodology

- Through teacher exposition, guide the learners to understand the idea of a limit of a function.
- Through guided discussions, guide the learners to differentiate polynomials.
- Through teacher exposition, guide the learners to find the equations of the tangents and normals to curves at different points.

Practical Problems/Activities

- Construction of roads by engineers in mountainous or hilly areas considering sides with lower slopes.
- Finding the maximum and minimum of some geometrical quantities such as length, area, etc.
- Use a piece of paper to form a curve and a straight edge to vary the steepness of the curve.

Assessment Strategy

- Give projects, exercises, assignments and tests

Sub-Topic 3: Curve Sketching

Specific Objectives	Content
The learner should be able to: • find the nature of turning points using differentiation. • apply the second derivative to determine the nature of the turning points. • sketch curves	• Maximum, minimum points and points of inflexion (stationary points) • Second derivative • Curve sketching

Methodology

- Through peer presentations, learners should be able to sketch quadratic curves.
- Through brainstorming, help learners identify the maximum and minimum points of quadratic curves.
- Through teacher exposition, help learners sketch curves of higher order functions.

Practical Problems/Activities

- The maximum point of a path can be demonstrated using curved rods and two straight rods to demonstrate right angles.
- Illustrate a stationary point when a ball is projected upwards at different angles.
- Cut an orange into two pieces to locate maximum and minimum and a use a straight edge to show that $\frac{dy}{dx}$ is zero.

Assessment Strategy

- Give assignments, tests and exercises.
- You may test for symmetry when sketching curves. i.e When $f(x)=f(-x)$ then the curve is symmetric about the $x-$ axis, e.t.c

Sub-Topic 4: Velocity and Acceleration

Specific Objectives	Content
• The learner should be able to apply the use of differentiation to velocity, displacement acceleration and word problems.	• Displacement, velocity, acceleration and word problems

Methodology

- Through teacher exposition, help learners to relate differentiation to velocity and acceleration.

Practical Problems/Activities

- Throwing bodies upwards to demonstrate the maximum distance attained by a body.
- Illustrate the position when the body is momentarily at rest.

Assessment Strategy

- Assignments, Tests and exercises

Sub-Topic 5: Composite Functions

Specific Objectives	Content
The learner should be able to: • derive the chain rule for differentiating higher order functions. • apply the chain rule to differentiating: - parametric functions. - rates of change.	• Chain rule and its applications

Methodology

- Through teacher exposition, guide the learners to derive the chain rule.
- Through teacher exposition, guide the learners to derive the product and quotient rules and use them to differentiate composite functions.

Practical Problems/Activities

- Drips put on patients in hospitals work on the principle of rates of change.
- Pumping water into an empty trough.
- Global warming - scientists say the earth has warmed up about 1 degree Fahrenheit the last 100 years. The rate of change, they say, is speeding up.
- Errors in measurements

Assessment Strategy

- Give assignments, exercises and tests.

Note: Derivation of the Product and Quotient rules from first principles.

Sub-Topic 6: Implicit Functions

Specific Objectives	Content
The learner should be able to: • differentiate implicit functions. • find the second derivative of implicit and parametric equations.	• Implicit functions • Second derivative of implicit and parametric equations

Methodology

Sub-Topic 7: Small Changes

Specific Objectives	Content
The learner should be able to approximate using calculus.	• Small changes

Sub-Topic 8: Products and Quotients of Functions

Specific Objectives	Content
The learner should be able to: • derive the product and quotient rule from 1st principles. • Calculate: - product of functions. - quotient of functions.	• Product rule from 1st principles • Quotient rule from 1st principles

Assessment Strategy

Give assignments, exercises and tests.

Note: Derivation of the Product and Quotient rules from first principles.

PART 1: PURE MATHEMATICS

SENIOR FIVE TERM THREE

Topic 9: Integration I

Duration: 22 Periods

General Objective

By the end of the topic, the learner should be able to find definite and indefinite integrals and use them to find the area under a curve.

Sub-Topic 1: Indefinite Integral

Specific Objectives	Content
The learner should be able to: • relate integration to differentiation. • determine indefinite integrals with an arbitrary constant.	• The reverse of differentiation

Methodology

- Through brainstorming, help learners to reverse the process of differentiation.
- Through teacher exposition, help learners to integrate indefinite integrals.

Practical Problems/Activities

- When differentiating, two operations are used, that is, multiplying and subtracting. The reverse of these two operations are addition and dividing.
- Cut a rectangular card board into small rectangles of equal dimensions. Sum all the areas of the small rectangles to get the total area. Here, the summation symbol is introduced.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 2: Definite Integral

Specific Objectives	Content
The learner should be able to: • relate the limit of summation to the integral sign. • evaluate a definite integral using the limits.	• Limits of integration

Methodology

- Through teacher exposition help learners to evaluate definite integrals.
- Clearly define the upper limit and lower limit. The upper limit is always greater than the lower limit. Thus $\int_a^b f(x)dx = -\int_b^a f(x)dx$. Change of the limits when the upper limit is less than the lower limit.
- Note: The Arbitrary constant of integration not to be included with definite integrals.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic: 3 Application of Integration

Specific Objectives	Content
The learner should be able to use: • integration to find displacement and velocity. • initial condition.	• Displacement, velocity and acceleration

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 4: Area under a Curve

Specific Objectives	Content
The learner should be able to find the area: • under a curve and a line. • between two curves.	• Area under a curve • Area between two curves

Methodology

- Through exposition, guide the learners to evaluate definite integrals.
- Through guided discussions, guide the learners on how to find the area between a line and a curve and between two curves.

Practical Problems/Activities

- Draw a line $y = x$ on squared paper and shade the area under the line between $x = 0$, $x = 5$ and the $x-$axis. On shading, the figure is a triangle. Find its area, and use calculus to explore on the concept.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 5: Volume of Revolution

Specific Objectives	Content
• The learner should be able to find the volume of revolution on rotation about: - the $x-$ axis - the $y-$ axis	• Solids of revolution

Methodology

- Through exposition, guide the learners to find the volume of a cylinder.
- Provide worksheets for volumes of different objects.
- Through guided discussions, guide the learners on how to rotate the area enclosed to find the volume of the solid generated.

Practical Problems/Activities

- From the line $y = x$ on squared paper, the area under the line between $x = 0$, $x = 5$ and the $x-$axis is rotated about the $x-$axis. The resulting figure is a cone with radius 5 units and height 5 units. The volume of the cone can be found. Use calculus to find the volume of the solid generated.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 6: Mean Value of a Function

Specific Objectives	Content
• The learner should be able to calculate the mean value of a function	• Mean value of a function

Methodology

- Through teacher exposition, guide the learners to evaluate the mean value of a function.

Note: Caution the learners not to confuse the mean value of a function with the expectation.

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 10: Series

Duration: 12 Periods

General Objective

By the end of the topic, the learner should be able to distinguish between an arithmetic progression and a geometric progression.

Sub-Topic 1: Arithmetic Progression (A.P)

Specific Objectives	Content
The learner should be able to: • identify a sequence. • identify a series. • generate an arithmetic progression (A.P). • derive and use the formula of finding the sum of an arithmetic progression. • apply knowledge to simple interest.	• Sequences • Series • n^{th} term of an arithmetic progression • Sum to $n-$terms of an arithmetic progression

Methodology

- Through peer presentations, guide learners to generate an Arithmetic Progression.
- Through guided discussions, guide the learners to generate the sum of an A.P
- Through guided discussions and peer presentations, guide the learners to relate the knowledge of an A.P to real life situations involving simple interest problems.

Sub-Topic 2: Geometric Progression (G.P)

Specific Objectives	Content
The learner should be able to: • identify a geometric progression. • generate geometric progression. • derive and use the formula for finding the sum of n-terms. • deduce the formula for the sum to infinity. • apply knowledge to compound interest.	• n^{th} term of a geometric progression • Sum of $n-$ terms of a geometric progression • Sum to infinity of a geometric progression

Methodology

- Through peer presentations, guide learners to generate a Geometric Progression.
- Through guided discussions, guide the learners to generate the sum of a G.P and relate it to recurring decimals to generate the sum to infinity.
- Through guided discussions and peer presentations, guide the learners relate the knowledge of a G.P to real life situations involving compound interest problems.

Practical Problems/Activities

- Use sticks of equal length and determine the total length at any position.
- Determining the total amount of money at the end of a given period of time with interest paid like in banks and insurance companies.

Note

i) Apply and relate knowledge on series to simple interest and compound interest situations.
ii) Relate sum to infinity to recurring numbers.
iii) Use the summation notation (Σ) in series.

Sub-Topic 3: Proof by Induction

Specific Objectives	Content
The learner should be able to: • prove by induction the sum of finite series. • determine the sum of series.	• Proof by induction • Sum of series

Methodology

- Through teacher exposition, guide the learners to prove the sum of finite series by induction.
- Through teacher guided discussions, guide the learners to determine the sum of any series.

Note

- Emphasis should be laid upon cumulative summation and test for $n = 1, 2, \ldots k, k+1$ and conclude. Some summations do not hold for $n = 1 \; or \; 2$.
- Divisibility and multiples to be mentioned.

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 11: Permutations and Combinations

Duration: 10 Periods

General Objective

By the end of the topic, the learner should be able to find the number of ways objects can be arranged with or without restrictions.

Sub-Topic 1: Permutations

Specific Objectives	Content
The learner should be able to: • form arrangements of unlike items in a row. • identify a permutation. • relate the number of permutations to the factorial notation. • deduce and apply the formula of permutation. • determine the number of ways objects can be arranged in a circle.	• Arrangement of objects in a row • Concept of permutation • Factorial notation $n!$ • Permutation notation ${}^{n}P_{r}$ • Arranging objects in a circular form or ring

Methodology

- Through peer presentations, guide learners to generate patterns from a number arrangements like; handshakes, arranging books in a pattern, etc.
- Through guided discussions, guide the learners to generate the factorial notation.
- Through guided discussions and peer presentations, guide the learners to find the number of ways objects may be arranged.

Practical Problems/Activities

- The teacher may use the objects around us like books, chairs, students, boxes, etc, to illustrate different arrangements.

Activity
• Counting the number of handshakes if students are made to shake their hands once. Start with 2 and sequentially increase until a pattern is developed.

Note

- The teacher should illustrate how ${}^{n}P_{r} = \dfrac{n!}{(n-r)!}$.
- Take note of the order in which the objects are arranged.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 1: Combination

Specific Objectives	Content
The learner should be able to: • identify a combination. • state and apply the combination notation. • compute the combinations.	• Ways of selecting objects • Identify a combination • Combination notation ${}^{n}C_{r}$ • Selection of any size r from a group • Application of combinations

Methodology

- Through peer presentations, guide learners to select objects in a set of items.
- Through guided discussions, guide the learners to generate the combination notation.
- Through guided discussions and peer presentations, guide the learners to compute different combinations.

Practical Problems/Activities

- Systematic grouping of objects, e.g. students at S5 are required to select subjects form the subject combinations with restriction.

Assessment Strategy

- Give class exercises, assignments and tests.

Note

Simplification of numerical/algebraic examples is important. The teacher should explain the formula $\begin{pmatrix} n \\ r \end{pmatrix} = {}^{n}C_{r} = \dfrac{n!}{(n-r)!\,r\,!}$.

Topic 12: Binomial Theorem

Duration: 10 Periods

General Objective

By the end of the topic, the learner should be able to expand all functions with rational powers using the binomial theorem.

Sub-Topic: Binomial Expansion

Specific Objectives	Content
The learner should be able to: • construct Pascal's triangle and use it to generate coefficients of the terms in the expansion. • state the binomial theorem. • expand in ascending or descending order using binomial expansion. • find a particular term of a binomial expansion. • compute roots of numerical values using binomial expansion. • state range of validity of binomial expansion.	• Pascal's triangle • Binomial expansion • Formulae for binomial coefficients for any rational index • Approximation of values • Validity of binomial expansion

Methodology

- Through peer presentations, guide learners to generate Pascal's triangle.
- Through guided discussions, guide the learners on how to use Pascal's triangle.
- Through teacher guided discussions, guide the learners to state and use the Binomial theorem.

Practical Problems/Activities

- Review expanding $(a+b)^n$ for $n = 1, 2, 3$
- Let the learners develop Pascal's triangle for $n = 1,2,3,4$. What happens for $n \geq 5$?

Assessment Strategy

- Give class exercises, assignments and tests.

Note

i) Extend the binomial expansion to expressions like; $(1 + x + x^2)^n$.
ii) Use partial fractions in binomial theorem.

PART 1: PURE MATHEMATICS

SENIOR SIX TERM ONE

Topic 12: Trigonometry (Calculus)

Duration: 8 Periods

General Objective

By the end of the topic, the learner should be able to use the concept of small angles to find the derivatives of trigonometric ratios (from first principles).

Sub-Topic 1: Radians

Specific Objectives	Content
The learner should be able to: • convert degrees to radians and vice versa. • find the value of the length of an arc and the area of a sector.	• Circular measure • Length of an arc • Area of a sector

Methodology

- Through peer presentations, guide the learners to understand the terms chord, sector and an arc.
- Through teacher exposition, guide the learners to understand the radian measure of angles.
- Through teacher guided discussions, guide the learners to find the length of an arc and the area of a sector.

Practical Problems / Activities

- Use of a clock to demonstrate the relationship between:
  - time and angles in degrees.
  - time and angles in radians.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 2: Derivatives of Trigonometrical Functions

Specific Objectives	Content
The learner should be able to: • find a relationship between $\sin\theta$, $\cos\theta$, $\tan\theta$ and $\theta(rads)$ for θ is a small angle. • differentiate the trigonometrical ratios from 1st principles. • differentiate the inverse trigonometrical functions.	• Small angles • Derivatives of trigonometrical ratios • Derivatives of inverse trigonometrical functions

Methodology

- Through teacher guided discussions, guide the learners to differentiate the trigonometric ratios from first principles.
- Through teacher guided discussions, guide the learners to differentiate the inverse trigonometric functions.

Note

i) Product and Quotient rules to be applied.

ii) Deduce the general form for $\sin^{-1}x$, $\cos^{-1}x$, $\tan^{-1}x$, as they are preparing for integration by parts and further differentiation.

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 13: Exponential and Logarithmic Functions

Duration: 10 Periods

General Objective

By the end of the topic, the learner should be able to identify and differentiate exponential and logarithmic functions.

Sub-Topic 1: Exponential Functions

Specific Objectives	Content
The learner should be able to:	
• identify exponential functions.	• Concept of exponential functions
• sketch smooth curves for exponential functions.	• Graphs of exponential functions
• find the gradients of the tangents of exponential functions.	• Gradients of tangents at various points of exponential functions
• deduce the general formula for differentiating exponential functions.	• Derivative of an exponential function
• differentiate exponential functions.	• Differentiation of exponential functions
• integrate exponential functions.	• Integration of exponential functions

Methodology

- Through teacher exposition, guide the learners to differentiate the exponential functions.
- Through teacher exposition, guide the learners to integrate exponential functions.

Practical Problems/Activities

- Sketching graphs of $y = 2^x$, $y = 3^x$ on squared paper.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 1: Logarithmic Function

Specific Objectives	Content
The learner should be able to: • identify a logarithmic function. • state the properties of logarithmic functions. • find derivative of natural logarithm. • apply the natural logarithm to differentiate exponential functions.	• Concept of logarithmic functions • Properties of logarithmic functions • Derivative of natural logarithms

Methodology

- Through teacher exposition, guide the learners to differentiate the natural logarithm.

Assessment Strategy

- Give class exercises, assignments and tests.

Note: Sketch graphs of logarithmic functions using squared paper.

Topic 14: Maclaurin's Theorem

Duration: 4 Periods

General Objective

By the end of the topic, the learner should be able to apply the knowledge acquired in differentiating to find the Maclaurin's theorem and use it for approximations.

Sub-Topic: Maclaurin's Theorem

Specific Objectives	Content
The learner should be able to: • relate Maclaurin's theorem to the binomial expansion. • apply Maclaurin's theorem in expansions for approximations.	• Maclaurin's theorem

Methodology

- Through teacher exposition, guide the learners to derive Maclaurin's theorm.
- Through teacher guided discussions, guide the learners to relate Maclaurin's theorem to the Binomial theorem.

Assessment Strategy

- Give class exercises, assignments and tests.

Note: Sketch graphs of logarithmic functions using squared paper.

Topic 15: Integration II

Duration: 18 Periods

General Objective

By the end of the topic, the learner should be able to integrate functions using the different methods of integration.

Sub-Topic 1: Change of Variables

Specific Objectives	Content
• The learner should be able to integrate by change of variable.	• Other methods of integration: change of variable

Methodology

- Through teacher guided discussions, guide the learners to integrate by change of variable for both definite and indefinite integrals.

Assessment Strategy

- Give class exercises, assignments and tests.

Note

i) The teacher should emphasise cases where they may ask for the first three non zero terms in case $f(0)=0$ or any other middle term.

ii) State the validity of the expressions.

iii) Guide students to avoid early rounding off when approximating values.

Sub-Topic 2: Function and its Derivative

Specific Objectives	Content
The learner should be able to: • recognise a function and its derivative and integrate. • use Pythagoras identities for odd powers of trigonometrical functions.	• Function and its derivative • Odd powers of trigonometrical functions

Methodology

- Through teacher guided discussions, guide the learners to integrate by recognising a function and its derivative.

- Through teacher guided discussions, guide the learners to integrate odd powers of trigonometric functions.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 3: Even Powers

Specific Objective	Content
The learner should be able to use double angle formulae for integrating even powers of cosine and sine.	• Even powers of $\sin x$ and $\cos x$

Methodology

- Through teacher exposition, guide the learners to integrate even powers of sine and cosine.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 4: Inverse Trigonometrical Functions

Specific Objective	Content
The learner should be able to integrate functions of the form: i) $\frac{1}{\sqrt{(a^2 - b^2x^2)}}$ ii) $\frac{1}{a^2 + b^2x^2}$ iii) $\int \frac{f'(x)}{f(x)} dx = \ln f(x) + c$	• Integral leading to: - inverse trigonometrical functions - the form $\int \frac{f'(x)}{f(x)} dx = Inkf(x)$

Methodology

- Through teacher exposition, guide the learners to integrate functions leading to inverse trigonometric functions.
- Through teacher guided discussions, guide the learners to recognise a function and its derivative leading to natural logarithms.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 5: Partial Fractions

Specific Objective	Content
• The learner should be able to integrate partial fractions.	• Integration of partial fractions

Methodology

- Through brainstorming, guide the learners to express in partial fractions.
- Through teacher guided discussions, guide the learners to integrate partial fractions.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 6: t – Substitution

Specific Objective	Content
• The learner should be able to use $t = \tan x$ substitution in integration.	$t = \tan x$, $t = \tan \frac{x}{2}$,

Methodology

- Through teacher exposition, guide the learners on how to use the substitution.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 6: Integration by Parts

Specific Objective	Content
The learner should be able to integrate by parts.	• Integration by parts

Methodology

Through teacher exposition, guide the learners to integrate by parts.

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 16: Differential Equations

Duration: 14 Periods

General Objectives

By the end of the topic, the learner should be able to form and solve differential equations.

Sub-Topic 1: Differential Equations

Specific Objectives	Content
The learner should be able to:	
• identify a differential equation.	• Concept of a differential equation
• form a differential equation.	• Formation of a differential equation
• state the order of a differential equation.	• Order of a differential equation
• find the general and particular solution of a differential equation.	• General and particular solution of a differential equation

Methodology

- Through brainstorming, guide the learners to recognise a differential equation.
- Through teacher guided discussions, guide the learners to state the order of a differential equation.
- Through teacher exposition, guide the learners to solve the differential equation.

Sub-Topic 2: Solving Differential Equations

Specific Objective	Content
The learner should be able to solve first order differential equations using: - separation of variables. - the integrating factor. - a particular substitution.	• Types of first order differential equations: - separable d.es - exact d.es - linear d.es - homogeneous d.es

Methodology

- Through teacher exposition, guide the learners to solve first order differential equations by separating the variables, using a particular substitution and the integrating factor.

Sub-Topic 3: Application of Differential Equations

Specific Objective	Content
The learner should be able to form and solve differential equations related to natural occurrences.	• Differential equations of natural occurrences

Methodology

- Through teacher exposition, guide the learners to solve the natural occurrence differential equations.

Common Mistakes

- Most learners fail to interpret the word problem and hence fail to form correct differential equations.
- Failure to apply initial conditions to obtain the arbitrary constant and the constant of proportionality.
- They also fail to apply the knowledge of integration.

Note

- The teacher needs to emphasise the application of differential equations in daily life situations and to demonstrate how differential equations are formed and handled.
- Learners usually interchange the given variables to what they are used to e.g. the learners may be required to form a differential equation in θ, $\frac{d\theta}{dt} = -k(\theta - 10)$ instead they commonly write the differential equation in T as $\frac{dT}{dt} - -k(T - 10)$.
- It should also be noted that differentials where one variable decreases as the other increases should have a negative, for example, rate of cooling.

PART 1: PURE MATHEMATICS

SENIOR SIX TERM TWO

Topic 17: Inequalities

Duration: 4 Periods

General Objective

By the end of the topic, the learner should be able to solve inequalities and write solutions using the different notations.

Sub-Topic: Linear and Quadratic Inequalities

Specific Objectives	Content
The learner should be able to: • identify and illustrate the solution of linear inequalities on a number line. • write the solutions using set notation, interval notation and inequality notation.	• Linear Inequalities on a number line
• solve simultaneous linear inequalities.	• Simultaneous linear inequalities
• solve quadratic inequalities. • sketch graphs of inequalities. • sketch modulus of inequalities.	• Quadratic inequalities • Graphs of inequalities • Modulus of inequalities

Methodology

- Through brainstorming, guide the learners to solve linear inequalities.
- Through teacher guided discussions, guide the learners to solve simultaneous linear inequalities.
- Through teacher exposition, guide the learners to solve quadratic inequalities.

Practical Problems/Activities

- Use graph papers to investigate the feasible region.

Note: Review O level properties of inequalities.

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 18: Further Curve Sketching

Duration: 10 Periods

General Objective

By the end of the topic, the learner should be able to draw graphs of rational functions by clearly indicating the feasible region.

Sub-Topic: Graphs of Functions

Specific Objectives	Content
The learner should be able to: • find the intercepts and turning points. • define an asymptote. • state and identify different types of asymptotes. • sketch the graphs of: - $y = f(x)$ from curve sketching I - $y = \frac{1}{f(x)}$, $y = \frac{g(x)}{h(x)}$, • determine regions where the curve is (not) defined and deduce the turning points.	• Intercepts and turning points • Types of asymptotes: - vertical - horizontal - slanting (oblique) • Functions of the form $y = \frac{1}{f(x)}$, $y = \frac{g(x)}{h(x)}$

Methodology

- Through brainstorming, guide the learners to determine the intercepts of the curves.
- Through brainstorming, guide the learners to determine the values for which the functions are not defined, hence the vertical asymptotes.
- Through teacher guided discussions, guide the learners to determine the turning points and the feasible regions of the curve.
- Through teacher guided discussions, guide the learners to sketch the curves.

Practical Problems / Activities

- Using squared paper, graphs of functions are drawn from the tabulated values. Then sketch the graphs of the functions using investigation of stationary points and asymptotes, by shading unwanted regions and nature towards infinity.

Assessment Strategy

- Give class exercises, assignments and tests.

- **Note:** Sketch $y = f(x)$ and $y = \dfrac{1}{f(x)}$ on the same axes and find the points of intersection.

Topic 19: Coordinate Geometry II

Duration: 10 Periods

General Objective

By the end of the topic, the learner should be able to determine the equation of a locus of a point and find the locus of a circle.

Sub-Topic 1: Locus

Specific Objectives	Content
The learner should be able to: • identify different types of loci. • find the equation of a locus of a variable point.	• Locus of a variable point • Equation of a locus

Methodology

- Through brainstorming, guide the learners to find the distance between two points and the distance of a point from a line.
- Through teacher guided discussions, guide the learners to find the equation of a locus.

Assessment Strategy

- Give class exercises, assignments and tests.

Common Mistakes

- Learners find it hard to interpret the given condition to find the locus e.g. “A point P is twice as far from the line $x + y = 5$ as from the point $(3, \ 0)$.
- Learners lack the understanding of the word Cartesian equation of the locus. Teachers should make it clear to the learners that the Cartesian equation of the locus is the same as the equation of the locus.

Sub-Topic 2: The Circle

Specific Objectives	Content
The learner should be able to: • form and identify the equation of a circle. • find the centre and radius of a circle. • find the equation of a circle given any points. • determine the equation of the tangent at	• General equation of circle • Centre and radius of the circle • Equation of the circle through any given points • Equation to the tangent to a

Specific Objectives	Content
a given point. • determine the points of intersection of two circles. • find the condition for external, internal and orthogonal intersection of two circles. • determine the length of the tangent to a circle.	circle at a given point • Intersecting circles: - externally - internally - orthogonal • Length of the tangent from a given external point to a circle

Methodology

- Through brainstorming, guide the learners to form and identify the equation of a circle.
- Through teacher guided discussions, guide the learners to find or state the centre and radius of the circle.
- Through teacher guided discussions, guide the learners to find the points of intersection and state the conditions for the intersecting circles.

Activity
Materials required: piece of string, drawing pin, pencil a) Get a piece of string about 6-10cm long. b) Fix a drawing pin at one end of the string and a pencil at the other end. c) Move the pencil while keeping the string taut. **d)** Trace the path of the pencil.

Common Mistakes

- Learners commonly use programmable calculators to solve simultaneous equations formed when a circle passes through three points. The teacher should encourage the learner to show the proper workings. However, the teacher is also encouraged to use other methods.

Activity

i) Materials required: graph paper, pair of compass, ruler, pencil

ii) Plot the three given points on a Cartesian grid.

iii) Join any two plotted points and draw two chords.

iv) By construction, draw the perpendicular bisectors of the chords drawn.

v) Find the point of intersection. This gives the centre of the circle, (from the geometrical fact that perpendicular bisectors of a chord passes through the centre of the circle).

vi) Join one of the given points to the point of intersection.

vii) Hence find the radius of the circle by measuring the distance between the two points.

viii) Substitute the coordinates of the point of intersection and the value of the radius in the formula $(x \pm a)^2 + (v \pm b)^2 = r^2$

Topic 20: Coordinate Geometry III (Conics)

Duration: 26 Periods

General Objective

By the end of the topic, the learner should be able to find the locus of a parabola, ellipse, hyperbola and rectangular hyperbola.

Sub-Topic 1: Parabola

Specific Objectives	Content
The learner should be able to:	
• identify the conics.	• Terms used in conics
• identify a parabola.	• Concept of a parabola
• draw a sketch of a parabola and identify the equation of parabola.	• General form (equation) of a parabola
• find the parametric equations of a parabola.	• Parametric equations of parabola
• find the equation of tangent, normal and chord of a parabola.	• Equation of tangent and normal and cord parabola

Methodology

- Through brainstorming, guide the learners to sketch and find the equation of a parabola.
- Through teacher guided discussions, guide the learners to find the equation of the tangent and normal of the parabola.

Assessment Strategy

- Give class exercises, assignments and tests.

Note

- Determine the Lactus rectum.
- The teacher should emphasise change of origin, thus change of axis.

Common Mistakes

- Learners often draw wrong sketches of the parabolas when there is change of origin.

Sub-Topic 2: Ellipse

Specific Objectives	Content
The learner should be able to:	
• identify and sketch an ellipse.	• Concept of an ellipse
• identify the major axis, minor axis and semi axis.	• Axes of an ellipse
• determine the length of the major axis, minor axis and semi axis.	• Length of the axes
• derive the general equation of an ellipse.	• General equation of an ellipse
• find the eccentricity foci, equations of the directrices from the given ellipse.	• Eccentricity, foci and directrices of an ellipse
• determine the equation of the tangent and normal to the ellipse at a point.	• Equation of the tangent and normal to the ellipse at a point and in parametric form
• write parametric coordinates of an ellipse.	• Parametric coordinates
• determine the equation of the tangent and normal to the ellipse in parametric form.	

Methodology

- Through teacher guided discussions, guide the learners to find the eccentricity of an ellipse.
- Through teacher guided discussions, guide the learners to find the equation of the tangent and normal to the ellipse.

Practical Problems / Activities

- On a squared paper, draw the directrix along one line near the edge, take the focus 2.7cm in and plot an ellipse with a pair of compasses, taking e= 0.8. Measure the width of the ellipse parallel and perpendicular to the directrix.

Common Mistakes

- Failure to discard the negative value of the eccentricity.

Sub-Topic 3: Hyperbola

Specific Objectives	Content
The learner should be able to:	
• identify and sketch a hyperbola.	• Concept of a hyperbola
• derive the general equation of a hyperbola.	• General equation of hyperbola.
• determine the equation of tangent and normal to the hyperbola at a given point.	• Equation of the tangent and normal to the hyperbola.
• determine the parametric equations of the hyperbola.	• Parametric equations to a hyperbola
• write the equations of all the asymptotes of a hyperbola.	• Asymptotes of a hyperbola

Methodology

- Through brainstorming, guide the learners to derive the equation of a hyperbola.
- Through teacher guided discussions, guide the learners to determine the parametric equations.
- Through teacher exposition, guide the learners to determine the equations of the tangent and normal to the hyperbola.

Sub-Topic 4: Rectangular Hyperbola

Specific Objectives	Content
The learner should be able to:	
• derive the general equation of rectangular parabola.	• Equation of a rectangular hyperbola
• write the equation of asymptotes of a rectangular hyperbola.	• Asymptotes of a rectangular hyperbola
• represent the equation of a rectangular hyperbola in parametric form.	• Parametric equation to the rectangular hyperbola
• determine the parametric equation of: - tangent - normal - chord	• Equation of the tangent, normal, chords to the rectangular hyperbola

Methodology

- Through brainstorming, guide the learners to derive the equation of a rectangular hyperbola.
- Through teacher guided discussions, guide the learners to determine the parametric equations.
- Through teacher exposition, guide the learners to determine the equations of the tangent and normal.

Activity

- Show that the gradient of the chord joining the points $(ct_1,\ c/t_1)$, $(ct_2,\ c/t_2)$ on the hyperpola $xy = c^2$ is $-\dfrac{1}{t_1 t_2}$ and that the equation of the chord is $x + t_1 t_2 y - c(t_1 + t_2) = 0$

Assessment Strategy

- Give class exercises, assignments and tests.

PART 1: PURE MATHEMATICS

SENIOR SIX TERM THREE

Topic 21: Complex Numbers

Duration: 24 Periods

General Objective

By the end of the topic, the learner should be able to find the square root of a negative number.

Sub-Topic 1: Imaginary Numbers

Specific Objectives	Content
The learner should be able to:	
• identify a complex number.	• Concept of imaginary numbers
• simplifying powers of i .	• Multiples of i
• solve quadratic equations having imaginary roots.	• Quadratic equations with imaginary roots
• identify the real and imaginary parts of complex numbers.	• Real and imaginary parts of complex numbers
• identify and state a conjugate of a complex number.	• Conjugate of complex numbers

Methodology

- Through teacher exposition, guide the learners to identify the square root of a negative number.
- Through teacher guided discussions, guide the learners to simplify powers of i.
- Through teacher guided discussions, guide the learners to solve quadratic equations with complex roots.
- Through brainstorming, guide the learners to identify and state the conjugate root of a complex number and how it can be used to find other roots.

Practical Problems / Activities

- Use of a calculator to investigate the square root of a negative number.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 2: Algebra of Complex Numbers

Specific Objectives	Content
The learner should be able to: • add, subtract, multiply and divide complex numbers. • solve unknowns by: - comparing coefficients. - using sum and product of root for quadratics. • formulate equations using complex roots. • use of the identity $\left(a^3 \pm b^3\right) = (a \pm b)(a^2 \pm ab + b^2)$ in finding roots of real numbers.	• Mathematical operations on complex numbers • Solutions of the unknowns • Equations from complex roots • Roots of real numbers

Methodology

- Through teacher exposition, guide the learners to add, subtract, multiply and divide complex numbers.
- Through teacher guided discussions, guide the learners to solve for unknowns.

Assessment Strategy

- Give class exercises, assignments and tests.

Note: The process of creating a real denominator from a complex one is known as "REALISATION" but not "RATIONALISATION."

Sub-Topic 3: Argand Diagram and Polar Form

Specific Objectives	Content
The learner should be able to: • find the modulus and argument of a complex number. • represent complex numbers on an Argand diagram. • express complex numbers in terms of polar coordinates. • express complex numbers in the polar form.	• Modulus and argument of a complex number • Argand diagram • Polar coordinates • Polar form

Methodology

- Through teacher exposition, guide the learners to find the modulus and argument of a complex number.
- Through teacher guided discussions, guide the learners to draw argand diagrams.
- Through teacher guided discussions, guide the learners to express complex numbers in polar form.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 4: Locus

Specific Objectives	Content
The learner should be able to: • find and define the locus of given complex equations and inequalities. • describe and represent the locus on an Argand diagram.	• Cartesian representation of a complex number • Inequalities

Methodology

- Through teacher exposition, guide the learners to find the locus in the complex plane and represent it on the Cartesian plane.
- Through brainstorming, guide the learners to describe the locus.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic: De Moivre's Theorem

Specific Objectives	Content
The learner should be able to: • prove De Moivres' theorem by mathematical induction. • use De Moivres theorem to prove trigonometrical identities. • simplify products and quotients of polar forms. • find the roots of unity by using De Moivre's theorem and other complex numbers.	• Proof of De Moivres' theorem by induction • Trigonometrical identities • Products and quotients • Application of the theorem to roots of unity and other complex numbers

Methodology

- Through teacher exposition, guide the learners to prove De Moivre's theorem by mathematical induction for all integers.
- Through teacher guided discussions, guide the learners to use the theorem to prove trigonometric identities.
- Through teacher exposition, guide the learners to find the roots of unity.

Assessment Strategy

- Give class exercises, assignments and tests.

PART 2A: STATISTICS AND PROBABILITY

SENIOR FIVE TERM ONE

Topic 22: Descriptive Statistics

Duration: 16 Periods

General Objective

By the end of the topic, the learner should be able to collect, organise and analyse data using the different statistical methods.

Sub-Topic 1: Types of Data

Specific Objectives	Content
The learner should be able to: • define statistics. • categorise raw data. • differentiate between ungrouped and grouped data.	• Concept of statistics • Discrete and continuous data • Ungrouped and grouped data

Methodology

- Through peer presentations, guide the learners to collect data.
- Through brainstorming, guide the learners to differentiate between grouped and ungrouped data.

Practical Activity

- An activity involving learners collecting, organising, presenting and analysing data, for example, putting things in order (The case of organising books in a library, arrangements of playing cards, taking measurements of heights of learners, etc.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 2: Organisation of Data

Specific Objectives	Content
The learner should be able to: • construct frequency distribution tables. • draw histograms with equal and unequal class widths. • draw a frequency polygon. • superimpose a frequency polygon. • draw a cumulative frequency curve.	• Frequency distribution tables • Histograms • Cumulative frequency curve (Ogive)

Methodology

- Through peer presentations, guide the learners to represent statistical data.

Practical Problems/ Activities

- (Labelled cards could be used)
- The three categories of data to be handled in this sub-topic include;
  i) Unrepeated manageable data of about 10 entries.
  ii) Repeated manageable data of about 15 entries.
  iii) Many repeated data about 30 entries.

Assessment Strategy

- Give class exercises, assignments and tests.
- Let the learners repeat the above for the grouped data.

Note

- Review O level work on bar charts and pie charts.
- Differentiate between a bar graph and histogram.
- Find frequency density.

Sub-Topic 3: Measures of Central Tendency

Specific Objectives	Content
The learner should be able to: • calculate mean, mode and median of grouped and ungrouped data. • estimate the mode from the histogram. • estimate the median from the Ogive.	• Mean, mode and median

Methodology

- Through teacher guided discussions, guide the learners to find the mean, mode and median.
- Through peer presentations, guide the learners to estimate the median and mode using the graph.

Practical Problems/ Activities

- Use of squared paper to construct the Histogram and frequency polygon.

Note

i) Use suitable scales, proper labeling of axes and drawing bars.
ii) Emphasise on data when class boundaries are given. e.g $8 - \leq 10,\ 10 - \leq 15$.
iii) Shading of the histogram is not important.
iv) Use assumed mean as another method to calculate the mean.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 4: Measures of Dispersion

Specific Objectives	Content
The learner should be able to: • determine the: - range - quartile - inter quartile range - percentile - decile	• Range • Quartile • Interquartile range • Percentile • Decile
• use the Ogive curve to estimate the quartiles, percentiles and deciles.	• Variance
• calculate the variance and standard deviation.	• Standard deviation

Methodology

- Through teacher guided discussions, guide the learners to calculate the variance and standard deviation.

Practical Problems/ Activities

- Use students marks in a test, heights, etc.

- Use squared paper to draw the ogive curve and use it for estimating.

Assessment Strategy

- Give class exercises, assignments and tests.

Note: Calculate the variance and standard deviation using the assumed mean.

Topic 23: Index Numbers

Duration: 6 Periods

General Objective

By the end of the topic, the learner should be able to understand the use of index numbers.

Sub-Topic: Index Numbers

Specific Objectives	Content
The learner should be able to: • identify index numbers. • calculate the simple price index and the simple aggregate price index. • calculate the weighted and price index and the weighted aggregate price index. • determine the value index.	• Concept of price indices (price relatives) • Unweighted price indices • Weighted price indices: - weighted aggregate price indices - value index

Methodology

- Through teacher exposition, guide the learners to find the price index.

Practical Problems or Activities

- Use cards to represent money and any available object to represent items.

Assessment Strategy

- Give class exercises, assignments and tests.

Note: Emphasis should be made upon Laspeyre's and Paasche.

Topic 24: Scatter Diagrams

Duration: 6 Periods

General Objective

By the end of the topic, the learner should be able to plot points and interpret the statistical data.

Sub-Topic: Scatter Diagram

Specific Objectives	Content
The learner should be able to: • identify correlations. • draw scatter diagram and lines of best fit. • find coefficients of correlations and comment.	• Concept of correlation • Scatter diagram • Rank correlation coefficient

Methodology

- Through peer presentations, guide the learners to draw scatter diagrams.
- Through teacher exposition, guide the learners to calculate the rank correlation coefficient.

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 25: Probability Theory

Duration: 6 Periods

General Objective

By the end of the topic, the learner should be able to find the probability that an event occurs.

Sub-Topic: Probability

Specific Objectives	Content
The learner should be able to:	
• list down the possible outcomes of an experiment.	• Experimental probability
• define an event, a sample space, probability of an event, complementary event.	• Terminologies in probability theory
• apply the probability laws	
• calculate the probability of the: - and situation or situation. - mutually exclusive events. - exhaustive events. - independent events.	• Probability laws and notations in relation to set theory • Probability situations
• calculate numerical problems related to conditional probability.	• The conditional probability
• use tree diagram to calculate probability problems.	• Probability tree diagram

Methodology

- Through peer presentations, guide the learners to list down events with likely outcomes.
- Through teacher exposition, guide the learners to calculate the probability of different events with different outcomes.
- Through teacher guided discussions, guide the learners to use the set theory and probability tree diagrams to calculate probabilities.

Assessment Strategy

- Give class exercises, assignments and tests.

PART 2A: STATISTICS AND PROBABILITY

SENIOR FIVE TERM TWO

Topic 26: Discrete Probability Distribution

Duration: 8 Periods

General Objectives

By the end of the topic, the learner should be able to find the p.d.f of a discrete random variable.

Sub-Topic: Discrete Random Variable

Specific Objectives	Content
The learner should be able to:	
• identify the: - random variable. - discrete random variable.	• Concept of discrete random variable
• identify the p.d.f of a discrete r.v.	• Probability density function(p.d.f) of a discrete r.v
• use the properties of a p.d.f of a discrete r.v.	• Properties of a p.d.f of a discrete r.v.
• calculate the expectation $E(X)$, variance, $Var(X)$, and standard deviation of a discrete r.v.	• Expectation $E(X)$, variance, $Var(X)$, and standard deviation of a discrete r.v.
• generate a probability distribution table.	• Probability distribution table
• find the mode and median of a discrete r.v.	• Mode, median
• determine: - the c.d.f from p.d.f. - the p.d.f. from c.d.f.	• c.d.f, $F(x)$

Methodology

- Through teacher exposition, guide the learners to determine a p.d.f.
- Through guided discussions, guide the learners to calculate the expectation and variance of a discrete random variable.
- Through teacher exposition, guide the learners to determine the c.d.f from the p.d.f and the p.d.f from a c.d.f.

Assessment Strategy

- Give class exercises, assignments and tests.

PART 2A: STATISTICS AND PROBABILITY

SENIOR FIVE   TERM THREE

Topic 27: Binomial Distribution

Duration: 6 Periods

General Objective

By the end of the topic, the learner should be able to interpret a binomial distribution.

Sub-Topic: Binomial Distribution

Specific Objectives	Content
The learner should be able to:	
• identify a binomial distribution.	• Concept of a binomial distribution
• apply properties of a binomial distribution.	• Properties of a binomial distribution
• interpret the notation $B(n, \ p)$.	• Binomial notation
• calculate the probability of event using formulae or tables.	• Binomial tables
• find the most likely outcome.	• Mode
• find the $E(X)$ and $Var(X)$ of binomial distribution.	• Expectation, variance

Methodology

- Through teacher guided discussions, guide the learners to identify a binomial distribution.
- Through teacher exposition, guide the learners to find the probability of an event using tables and the formula.
- Through teacher guided discussions, guide the learners to find the expectation and the variance.

Practical Problems / Activities

- Comparing students marks in different subjects, etc.

Assessment Strategy

- Give class exercises, assignments and tests.

Note

i) Students should be exposed to either Spearman's or Kendall's but not both.
ii) Find line of best fit by eye inspection only.

Topic 28: Continuous Random Variables

Duration: 12 Periods

General Objective

By the end of the topic, the learner should be able to identify a continuous random variable.

Sub-Topic: Continuous Random Variables

Specific Objectives	Content
The learner should be able to: • identify a continuous random variable.	• Concept of continuous random variable • Continuous probability function
• identify a p.d.f. of a continuous random variable. • apply properties of a continuous random variable. • sketch graphs of $f(x)$. • find $E(X)$ and $Var(X)$.	• Properties of a continuous random variable • Graphs of $f(x)$ • Expectation $E(X)$ and Variance $Var(X)$ • The c.d.f , $F(x)$
• find c.d.f. and p.d.f and sketch it. • find p.d.f from c.d.f and sketch it. • find the mode using calculus and the graph. • find the median by calculation and graphical method.	• Mode, median
• identify a rectangular distribution. • apply properties of rectangular distribution. • find the $E(X)$ and $Var(X)$ of a rectangular distribution.	• Uniform rectangular distribution • Properties of rectangular distribution • Expectation and variances.

Methodology

- Through teacher exposition guide the learners to identify a c.r.v.
- Through teacher exposition guide the learners to calculate the mean and variance of a c.r.v.

Practical Problems/ Activities

- Using common objects e.g. coins, dice, playing cards, darts, etc, to determine the possibility of occurrence.

Assessment Strategy

- Give class exercises, assignments and tests.

PART 2A: STATISTICS AND PROBABILITY

SENIOR SIX TERM ONE

Topic 29: Normal Distribution

Duration: 10 Periods

General Objective

By the end of the topic, the learner should be able to interpret the concept of a normal distribution.

Sub-Topic: Normal Distribution

Specific Objectives	Content
The learner should be able to: • interpret the notation $N(\mu, \delta^2)$ of normal distribution. • apply properties of the normal distribution. • standardise the r.v into the standard normal variable Z . • read and use the standard normal tables to find probabilities. • find the values/limits of x when the probability is known. • find values of μ or δ or both.	• Concept of normal distribution • Properties of normal distribution • Standardisation • Standard normal tables • Standard normal tables in reverse (De-standardisation)

Methodology

- Through teacher exposition, guide the learners to interpret a normal distribution.
- Through teacher guided discussions, guide the learners to standardise the random variable to a standard normal variable.
- Through discussions, guide learners to read and use standard normal tables to find probabilities.

Practical Problem/ Activities

Picking of a card(s) from a pack of playing cards, tossing coins, dice, e.t.c.

Assessment Strategy

- Give exercises, tests and assignments.

Note

i) Sketches of p.d.f. and c.d.f needed.
ii) Use the c.d.f to determine the median.
iii) The teacher should include properties of $E(X)$ and $Var(X)$.

Topic 30: Normal Approximation to Binomial

Duration: 6 Periods

General Objective

By the end of the topic, the learner should be able to use the normal distribution and approximate it to the binomial.

Sub-Topic: Normal Approximation to the Binomial Distribution for $n \rangle 20$

Specific Objectives	Content
The learner should be able to: • transform a binomial r.v to a normal using continuity corrections. • calculate the expectation and variance. • calculate probabilities.	• Continuity correction

Practical Problems / Activities

- Events with two outcomes i.e. a failure and a success e.g.
  i) Tossing a coin, dice,
  ii) Real life experiences, e.g. raining, passing exams, games, etc

Assessment Strategy

- Give class exercises, assignments and tests.

Note: If the value of p is not in the tables, strictly use the formula.

PART 2A: STATISTICS AND PROBABILITY

SENIOR SIX TERM TWO

Topic 31: Sampling Distribution

Duration: 10 Periods

General Objective

By the end of the topic, the learner should be able to use sample means and calculate the confidence interval.

Sub-Topic 1: Distribution of Sampling Mean

Specific Objectives	Content
The learner should be able to: • find the probabilities involving sample means. • determine standard error of the mean. • standardise the sample mean. • calculate probabilities involving sample mean.	• Concept of the sampling distribution of the sample mean when the population is normal

Methodology

- Through teacher exposition, guide the learners to identify a sample and a parameter.
- Through teacher guided discussions, guide the learners to estimate the population mean and variance from the sample.

Practical Problems / Activities

- Weight, height, etc, of objects.
- Use of tape measure on a single person.

Assessment Strategy

- Give class exercises, assignments and tests.

Note

i) Sometimes the students should sketch $f(x)$ before finding the constant.
ii) Graphs MUST be labeled.
iii) The expectation and variance of any function of X .

Sub-Topic 2: Interval Estimation

Specific Objectives	Content
The learner should be able to: • find interval estimates. • calculate the confidence interval of the population mean parameter when: - population variance is known. - population variance is unknown for a large $n \geq 30$.	• Concept of interval estimation • Confidence interval when: - population variance is known - population variance is unknown

Methodology

- Through teacher exposition, guide the learners to determine the confidence interval.

Assessment Strategy

- Give class exercises, assignments and tests.

PART 2B: MECHANICS

SENIOR FIVE TERM TWO

Topic 32: Dynamics I

Duration: 6 Periods

General Objective

By the end of the topic, the learner should be able to use the three equations of linear motion.

Sub-Topic: Linear Motion

Specific Objectives	Content
The learner should be able to: • calculate the distance, velocity, acceleration and average speed. • draw velocity-time graphs. • apply the equations of uniform linear motion.	• Distance, velocity acceleration and average speed • Graphs • Equations of linear motion

Methodology

- Through peer presentations, guide the learners to draw the graphs of linear motion.
- Through brainstorming, remind the learners about the equations of linear motion.

Practical Problem/Activities

- A trolley moving a known distance, when timed.

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 33: Newton's Laws of Motion

Duration: 12 Periods

General Objective

By the end of the topic, the learner should be able to state and apply Newton's laws of motion.

Sub-Topic: Newton's Law of Motion

Specific Objectives	Content
The learner should be able to state and apply Newton's laws of motion.	• Newton's laws of motion

Methodology

- Through brainstorming, learners should recall Newton's laws of motion.
- Through teacher guided discussions, guide the learners to apply Newton's laws of motion.

Practical Problems/Activities

- Case of book resting on a table
- Case of lifting up and down
- Case of a car moving with constant velocity and then brakes are applied
- Car pulling a trailer

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 34: Component and Resultant of Forces

Duration: 6 Periods

General Objective

By the end of the topic, the learner should be able to find the resultant of two or more forces and find the component of a force.

Sub-Topic: Component and Resultant of Forces

Specific Objectives	Content
The learner should be able to: • calculate resultants of parallel and non-parallel forces. • calculate the resultant forces in a polygon.	• Component of forces • Resultant of forces

Methodology

- Through teacher exposition, guide the learners to calculate the resultant of forces.

Practical Problems/ Activities

- Consider a case of two forces pulling an object in the same direction. The result is with a bigger effect than when one of the forces is used to pull the same object to explain resultant of forces.
- Consider a stone being projected using a catapult to explain resultant and components of forces.

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 35: Momentum

Duration: 6 Periods

General Objective

By the end of the topic, the learner should be able to differentiate between an elastic and inelastic collision and find the momentum of a body.

Sub-Topic: Momentum

Specific Objectives	Content
The learner should be able to: • apply Newton's laws of motion. • calculate the impulse.	• Elastic and inelastic collisions • Impulse

Methodology

- Through teacher guided discussions, guide the learners to use Newton's second law of motion to calculate the momentum and impulse.

Practical Problems/ Activities

- Activities involving pulleys
- Lifting loads to the top of building/cranes
- Drawing water from a well

Assessment Strategy

- Give class exercises, assignments and tests.

Note

i) Connecting strings should be light and inelastic.
ii) Pulleys should be smooth.
iii) Wedges can be smooth or rough.
iv) Moving wedges should be avoided

Topic 36: Connected Particles

Duration: 10 Periods

General Objective

By the end of the topic, the learner should be able to apply Newton's laws to connected bodies along smooth and rough surfaces and bodies hanging.

Sub-Topic: Connected Particles

Specific Objectives	Content
The learner should be able to: • apply Newton's laws of motion to pulley systems. • work out problems involving smooth and rough surfaces for horizontal and inclined planes.	• Pulley systems • Connected bodies along a horizontal and inclined planes

Methodology

- Through simulations, guide learners to make models of pulley systems.
- Through teacher exposition, guide the learners to use Newton's second and third law to find the acceleration of connected bodies and the tension in the strings.

Practical Problems/ Activities

- Activities involving pulleys
- Lifting loads to the top of building/cranes
- Drawing water from a well

Assessment Strategy

- Give class exercises, assignments and tests.

PART 2B: MECHANICS

SENIOR FIVE TERM THREE

Topic 37: Work, Power and Energy

Duration: 6 Periods

General Objective

By the end of the topic, the learner should be able to find the work, power and energy done by a body.

Sub-Topic: Work, Power and Energy

Specific Objectives	Content
The learner should be able to: • solve problems involving work.	• Work done: - against gravity - by a constant force - against friction
• apply the principle of conservation of energy.	• Principle of conservation of energy
• relate work done to change in energy.	• Power
• solve power related problems.	

Methodology

- Through teacher exposition, guide the learners to apply the principle of conservation of energy to solve problems involving work done and power.

Practical Problems/ Activities

- A block of wood pulled across a horizontal surface
- A cyclist riding a bicycle on a rough surface when wind is blowing
- Pump raising and ejecting water at a given speed

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 38: Resultant Velocity

Duration: 6 Periods

General Objective

By the end of the topic, the learner should be able to find the resultant velocity of a body.

Sub-Topic: Resultant Velocity

Specific Objectives	Content
The learner should be able to: • find the resultant velocity of more than one velocity. • find the resultant velocity of a body moving in a current.	• Resultant velocity vectors • Body moving in a current i.e. water or air

Methodology

- Through teacher exposition, guide the learners to find the resultant velocity.

Practical Problems/Activities

- Where possible, illustrate crossing a river by a boat or swimming
- Aircraft in wind

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 39: Relative Motion

Duration: 6 Periods

General Objective

By the end of the topic, the learner should be able to find the relative displacement and relative velocity of a body.

Sub-Topic: Relative Motion

Specific Objectives	Content
The learner should be able to: • find the relative velocity. • find relative displacement. • calculate the velocity of a body relative to another. • calculate time, course, distance of closest approach. • calculate time, course taken for interception to occur.	• Concept of relative velocity • Concept of relative displacement • Closest distance and time when it occurs • Concept of closest approach • Interception

Methodology

- Through teacher exposition, guide the learners to determine the relative displacement and relative velocity.
- Through teacher guided discussions, guide the learners to find the distance of closest approach and the time taken.

Practical Problems/ Activities

- Consider the case of two bodies moving in:
  - i) Same direction
  - ii) Opposite direction
  - iii) Different direction

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 40: Vectors in Mechanics

Duration: 4 Periods

General Objective

By the end of the topic, the learner should be able to distinguish between scalar quantities and vector quantities.

Sub-Topic: Vectors in Mechanics

Specific Objectives	Content
The learner should be able to: • find: - magnitude of a vector. - unit knowledge of a vector. • apply knowledge of calculus to obtain acceleration, velocity, displacement, work done and power.	• Vector involving calculus

Methodology

- Through teacher guided discussions and using knowledge from Pure Mathematics, guide the learners to use the knowledge of calculus and vectors to find the acceleration, work done, power, etc.

Practical Problems/ Activities

- Straight passes made by footballers
- A golf ball being projected in space

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 41: Projectiles

Duration: 6 Periods

General Objective

By the end of the topic, the learner should be able to understand the motion of projectiles.

Sub-Topic: Projectile Motion

Specific Objectives	Content
The learner should be able to: • define and apply the terminologies: projectile, horizontal ranges, maximum horizontal range, trajectory, time of flight and greatest height to related numerical problems. • calculate numerical problems related to vertical and horizontal projections.	• Terminologies used • Concept of projection: - vertical projection - horizontal projection - particle projected at an angle to the horizontal

Methodology

- Through simulations, illustrate the motion of projected bodies.
- Through teacher exposition, guide the learners to calculate the range, maximum height and other problems relating to projectile motion.

Practical Problems/Activities

- A bob projected along the table
- Throwing a ball into the net e.g. in netball, basketball, etc.

Assessment Strategy

- Give class exercises, assignments and tests.

Note: Projectile on an inclined plane should not be considered.

PART 2B: MECHANICS

SENIOR SIX TERM ONE

Topic 42: Friction

Duration: 8 Periods

General Objective

By the end of the topic, the learner should be able to realise that friction force is ever present when bodies are moving.

Sub-Topic: Friction

Specific Objectives	Content
The learner should be able to: • explain the term friction. • relate limiting equilibrium to maximum friction force. • calculate the coefficient of friction. • apply the laws of friction to different situations. • calculate the friction force or any other force acting on the body moving on: - horizontal plane. - inclined plane. • determine the angle of friction and relate it to the coefficient of friction.	• Concept of friction • Limiting equilibrium • Coefficient of friction • Laws of friction • Friction on horizontal and inclined planes • Angle of friction

Methodology

- Through brainstorming, explain the meaning of friction force.
- Through teacher exposition, guide the learners to determine the coefficient of friction for bodies along a horizontal plane and an inclined plane.

Practical Problems/ Activities

- A man riding a bicycle on a rough road
- Striking a match
- A wooden block on a rough/smooth surface

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 43: Moment of a Force

Duration: 8 Periods

General Objectives

By the end of the topic, the learner should be able to determine the moment of a force and its turning effect.

Sub-Topic: Moment of a Force

Specific Objectives	Content
The learner should be able to: • find moment of a force. • relate moments to real life experiences. • identify clockwise, anticlockwise and zero moments. • take moments about any given point. • distinguish between like and unlike parallel forces. • use concept of parallel and non-parallel forces to find moment of a couple • deduce that a system of forces forms a couple. • determine the equation and position of the line of action of the resultant.	• Concept of moment of a force • Sign of moments and sense of rotation • Moment about a point • Parallel forces • Couple • Line of action of resultant

Methodology

- Through peer presentations, guide the learners to identify clockwise and anti clockwise turnings.
- Through teacher exposition, guide the learners to take moments of forces about any point.

Practical Problems/ Activities

i) Opening a door
ii) Balancing a see saw
iii) Turning a spanner
iv) Balancing masses on a weighing balance

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 44: Coplanar Forces

Duration: 18 Periods

General Objective

By the end of the topic, the learner should be able to state the conditions for bodies in equilibrium and apply the principle of moments to solve problems.

Sub-Topic: Coplanar Forces in Equilibrium

Specific Objectives	Content
The learner should be able to: • apply the conditions for forces in equilibrium to exist. • apply the principle of moments to solve problems on: - ladders - rods - jointed rods	• Forces in equilibrium: - triangle of forces - Lami's theorem - polygon of forces • Ladders • Rods • Jointed rods

Methodology

- Through teacher exposition, guide the learners to understand the concept of bodies in equilibrium.
- Through teacher guided discussions, guide the learners to apply the principle of moments to different bodies in equilibrium.

Practical Problems/Activities

i) A man climbing a ladder
ii) Bridges
iii) Frames

Assessment Strategy

- Give class exercises, assignments and tests.

PART 2B: MECHANICS

SENIOR SIX TERM TWO

Topic 45: Circular Motion

Duration: 8 Periods

General Objective

By the end of the topic, the learner should be able to appreciate the motion of bodies around circular paths and how they move along the corners.

Sub-Topic: Circular Motion

Specific Objectives	Content
The learner should be able to: • derive the relationship between linear and angular speed. • apply the relationship to motion of a particle on a string, along a vertical ring or on a spherical surface.	• Relationship between linear and angular speed. • Motion on: - circular path - horizontal circle (conical pendulum) - vertical circle

Methodology

- Through peer presentations, guide the learners to illustrate bodies moving in circular paths.
- Through teacher exposition, guide the learners to determine the angular velocity, amplitude and energy stored in elastic bodies.

Practical problems/activities

- Swinging a pendulum bob
- Bob moving on the surface of a globe

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 46: Elasticity

Duration: 8 Periods

General Objective

By the end of the topic, the learner should be able to look at motion of elastic bodies by stating Hooke's laws.

Sub-Topic: Elasticity

Specific Objectives	Content
The learner should be able to: • distinguish between natural length and extension. • use modulus of elasticity. • state and use Hooke's law. • calculate elastic potential energy stored in a string. • solve problems involving: - one elastic string with a mass attached at one end or in the middle. - two strings /springs with a mass attached at the end or at the joint.	• Elastic strings/springs • Hooke's law • Energy (elastic potential energy) • Conservation of energy in an elastic string

Methodology

- Through peer presentations, guide the learners to find the extension in an elastic body.
- Through teacher guided discussions, guide the learners to state and use Hooke's law.
- Through teacher exposition, guide the learners to solve problems involving elastic strings to find the energy stored and the displacement moved.

Practical Problems/Activities

- Stretching a spring
- Stretching an elastic string e.g. a rubber band

Assessment Strategy

- Give class exercises, assignments and tests.

Topic 47: Simple Harmonic Equation

Duration: 16 Periods

General Objective

By the end of the topic, the learner should be able to understand the concept of oscillating bodies.

Sub-Topic: Simple Harmonic Motion

Specific Objectives	Content
The learner should be able to: • identify amplified, period, displacement and angular velocity. • determine expressions relating to s.h.m. • calculate maximum velocity and find the acceleration. • Derivation of the equation $\ddot{x} + \omega^2 x = 0$. • apply the expressions of s.h.m for horizontal and vertical springs. • apply s.h.m for bodies moving s.h.m.	• Concept of simple harmonic motion. • Equations of simple harmonic motion • Maximum velocity • Concept of circular s.h.m • Springs on horizontal and in vertical positions • Bodies oscillating with s.h.m

Methodology

- Through simulations, help learners to see bodies moving with different harmonics.
- Through teacher guided discussions, guide the learners to understand the terms used in S.H.M.
- Through teacher guided discussions, guide the learners to find the maximum velocity and acceleration of bodies moving with S.H.M.

Practical Problems/ Activities

- Oscillations using a pendulum bob
- Bob and an elastic spring/string

Assessment Strategy

- Give class exercises, assignments and tests.

PART 2B: MECHANICS

SENIOR SIX TERM THREE

Topic 48: Centre of Gravity

Duration: 10 Periods

General Objective

By the end of the topic, the learner should be able to understand the stability of different bodies.

Sub-Topic: Centre of Gravity

Specific Objectives	Content
The learner should be able to: • apply moment of force in finding the centre of gravity of system of particles. • find the centre of gravity of system of particles. • find the C.O.G of uniform rods, disks, triangular and rectangular laminas, spheres, cuboids and combinations of bodies. • find the C.O.G of the remainder of bodies. • calculate centre of gravity of the remaining portion of the body.	• Concept of C.O.G of bodies • Centre of gravity of systems of particles

Methodology

- Through peer presentations, guide the learners to understand the concept of Centre of gravity of regular and irregular bodies.
- Through teacher exposition, guide the learners to find the centre of gravity of laminas and composite bodies.

Practical Problems/ Activities

- Freely suspending a uniform cardboards and non uniform cardboards to find their centre of gravity.
- Balancing a rod on a knife edge or a perforated cardboard

Assessment Strategy

- Give class exercises, assignments and tests.

PART 2C: NUMERICAL METHODS

SENIOR FIVER TERM ONE

Topic 49: Interpolation and Extrapolation

Duration: 6 Periods

General Objective

By the end of the topic, the learner should be able to use the concept of the gradient of a straight line to interpolation.

Sub-Topic: Linear Interpolation and Linear Extrapolation

Specific Objectives	Content
The learner should be able to: • estimate the value between two given values using gradient method for linear interpolation. • estimate the value outside two given values using gradient method for linear extrapolation.	• Linear interpolation • Linear extrapolation

Methodology

- Through teacher guided discussions, guide the learners to use the gradient of a line method to linear interpolation and linear extrapolation.

Practical Problems / Activities

- Using ticker timer to determine the number of dots/speed against time
- Draw a graph for some known tabulated values.

Assessment Strategy

- Give class exercises, assignments and tests.

Common Mistakes

- Many students have difficulties in locating the interval within which the wanted values lie. Teachers should enable the students to know how to locate the wanted values in linear interpolation and the use of similar triangles.
- Students normally fail to get the difference between the interpolation and extrapolation. The teacher should be clear on the difference between linear interpolation and linear extrapolation.

Note

- Teachers should not dwell so much on the formula.
- Mention inverse interpolation and extrapolation.

Topic 50: Location of Roots

Duration: 8 Periods

General Objective

By the end of the topic, the learner should be able to use the tabulated values to draw graphs of functions and locate the position of a root by noting the sign change.

Sub-Topic: Location of Roots

Specific Objectives	Content
The learner should be able to: • sketch graphs of functions. • estimate the roots of equation $f(x)=0$ using the graphical method. • show that the root(s) exist in the given interval using graphical approach. • estimate the roots of $f(x)=0$ using the sign-change method. • show that the root(s) exist in the given interval using sign-change approach.	• Graphs of functions • Location of roots by graphical methods • Location of root by analytical method (sign change method)

Methodology

- Through peer presentations, guide the learners to draw graphs and locate the roots by graphical method.
- Through teacher guided discussions, guide the learners to find the roots using the sign-change approach.

Practical Problems/ Activities

- Sketch the graph and locate the root(s)

Assessment Strategy

- Give class exercises, assignments and tests.

Common Mistakes

- Poor choice of range of values to be used.
- There is always poor choice of scales and use of ruled papers instead of a graph paper.
- Wrong labelling of the axes in graphs.
- Use of degrees in trigonometric functions.

Note

- Teachers should emphasise the use of radians when dealing with trigonometric functions.
- Apply knowledge of analysis to sketch the curves.
- Theory of turning points is not required.

PART 2C: NUMERICAL METHODS

SENIOR FIVE TERM TWO

Topic 51: Error Analysis

Duration: 6 Periods

General Objective

By the end of the topic, the learner should be able to find the errors in different figures.

Sub-Topic: Errors

Specific Objectives	Content
The learner should be able to: • apply formula of errors. • determine the limits of accuracy. • distinguish between the terms random, rounding and truncation errors. • round off and truncate numbers. • find the absolute, relative and percentage errors of simple numbers.	• Concept of errors • Limits of accuracy • Random errors, rounding off errors and truncation errors • Absolute errors, relative errors, and percentage errors

Methodology

- Through teacher guided discussions, guide the learners to find errors.

Assessment Strategy

- Give class exercises, assignments and tests.

PART 2C: NUMERICAL METHODS

SENIOR FIVE TERM THREE

Topic 52: Errors in Functions

Duration: 4 Periods

General Objective

By the end of the topic, the learner should be able to find the maximum and minimum errors in functions with the different operations.

Sub-Topic 1: Propagation of Errors using Simple Interval Arithmetic Method

Specific Objectives	Content

The learner should be able to:
• calculate the working value.
• determine the maximum and minimum values
• determine the maximum possible error
• find the maximum error in:
  - addition and subtraction
  - multiplication and division
• determine the range/interval or the limits of the true value.
	• Working value/true value
	• Maximum and minimum values
	• Maximum possible error
	• Mathematical operations on errors
	• Range and interval of true value

Methodology

- Through teacher guided discussions, guide the learners to find the maximum error and minimum error you can make in adding, subtracting, dividing and multiplying numbers.

Practical Problems /Activities

- Measuring the lengths of the students' desks using different instruments.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 2: Propagation of Errors using Simple Interval Arithmetic Method

Specific Objectives	Content
The learner should be able to: • derive and use the formula for maximum possible absolute error, relative error and percentage error in addition, subtraction, multiplication and division.	• Formula for maximum possible absolute error, relative error and percentage error

Methodology

- Through teacher guided discussions, guide the learners to find the maximum and minimum error you can make in adding, subtracting, dividing and multiplying numbers.

Practical Problems / Activities

- Numerous examples for practice

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 3: Errors in Functions

Specific Objectives	Content
The learner should be able to: • identify a function. • derive the formula for finding: - the maximum absolute error. - the relative error. - the percentage error in a function. - use algebra and calculus to find errors in functions.	• Errors in powers e.g. $y = ax^n$

Methodology

- Through teacher guided discussions, guide the learners to find the maximum error and minimum error you can make in adding, subtracting, dividing and multiplying numbers.

Practical Problems / Activities

- Numerous examples for practice

Assessment Strategy

- Give class exercises, assignments and tests.

PART 2C: NUMERICAL METHODS

SENIOR SIX TERM ONE

Topic 53: Trapezium Rule

Duration: 4 Periods

General Objective

By the end of the topic, the learner should be able to use trapezium(s) to find the area under a curve.

Sub-Topic: Trapezium Rule: Estimating an Integral

Specific Objectives	Content
The learner should be able to: • distinguish between ordinate, strip and subinterval/sub-division.	• Terminologies: - ordinates - strips - subintervals/subdivision
• derive the trapezium rule. • use the trapezium rule to approximate the value of an integral. • determine the exact value using integration.	• Trapezium rule to approximate the value of an integral
• calculate the percentage error.	• Percentage error

Methodology

- Through teacher exposition, guide the learners to use algebra and calculus to determine errors in functions.

Practical Problems/Activities

- Sketch a curve and determine the area under the curve in the given range by approximating to small trapeziums.

Common Mistakes

- Most students normally have difficulties with the number of decimal places or significant figures to work with. For example, if the answer is to three decimal places, the students should work with at least four decimal places.
- Students fail to differentiate between ordinates, sub-intervals and strips.
- Students have the tendency of using the calculator directly to find the exact solution of the given integral. The teacher should emphasise the direct integration.

PART 2C: NUMERICAL METHODS

SENIOR SIX TERM TWO

Topic 54: Iterative Methods

Duration: 12 Periods

General Objective

By the end of the topic, the learner should be able to derive the Newton Raphson formula and use it to find the accurate roots.

Sub-Topic 1: Newton Raphson Method

Specific Objectives	Content
The learner should be able to: • derive the general Newton Raphson method formula. • use the general formula of Newton Raphson methods to estimate the roots of the equation $f(x)=0$. • identify the initial approximation of the given equation $f(x)=0$. • test for the $TOL \le \frac{1}{2}\times 10^{-n}$.	• General formula for Newton Raphson method • Tolerance limit (TOL)

Methodology

- Through teacher exposition, guide the learners to derive the general Newton Raphson method.
- Through teacher guided discussions, guide the learners to use the formula to find roots of functions whose roots are not exact.

Assessment Strategy

- Give class exercises, assignments and tests.

Sub-Topic 2: General Iterative Methods

Specific Objectives	Content
The learner should be able to: • generate different expressions for x from the given equation or function.	• Iterative formula for $f(x)=0$ as

Specific Objectives	Content
• select the best iterative formula by testing for convergence. • approximate the root of the equation $f(x)=0$ using the best iterative formula selected.	$x_{n+1}=g(x_n)$ • Test of convergence

Methodology

- Through teacher guided discussions, guide the learners to find a better iterative formula that could give you an accurate and better answer.

Assessment Strategy

- Give class exercises, assignments and tests.

Common Mistakes

- Here the handling of the concepts of variables and constants are normally mixed up. For example $f(x)=xe^{x}+5x-10$ is a variable while $f(x_n)=x_n e^{x_n}+5x_n-10$ is a constant. The teacher should NOT first substitute for x as xn then differentiate the function. This derivative will be zero.
- Differentiation of exponential and trigonometric functions remains a problem to students. Premature approximation should be discouraged.

Sub-Topic: Further Linear Interpolation

Specific Objectives	Content
• The learner should be able to find the root(s) of the equation of $f(x)=0$ using linear interpolation.	• Root(s) of an equation $f(x)=0$ using linear interpolation

Practical Problems/Activities

- Plot a graph of linear equation e.g. $f(x)=2x-3$ and verify that the root lies between 1 and 2 then use linear interpolation to find the root.

Assessment Strategy

- Give class exercises, assignments and tests.

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