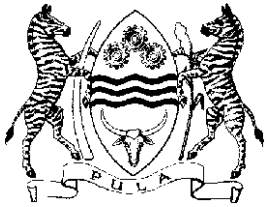

REPUBLIC OF BOTSWANA

BOTSWANA GENERAL CERTIFICATE OF SECONDARY EDUCATION

TEACHING SYLLABUS

PHYSICS

Ministry of Education
Department of Curriculum Development and Evaluation

FOREWORD

The Ministry of Education is pleased to authorise the publication of this senior secondary syllabus which marks a watershed in the development of the public education system in Botswana and signals another milestone of progress in fulfilment of the goals set by the Revised National Policy on Education, Government Paper No. 2 of 1994.

In this era of widespread and rapid technological change and an increasingly inter-dependent global economy, it is essential that all countries foster human resources by preparing children adequately for their future. Survival in the coming millennium will depend on the ability to accommodate change and to adapt to environmental needs and emerging socio-economic trends. It is the wish of government to prepare Batswana for future growth and adaptation to ongoing change in the socio-economic context; specifically the transition from an agro-based economy to the more broadly based industrial economy which we are aiming at.

The senior secondary programme builds on the Ten Year Basic Education programme and seeks to provide quality learning experiences. It aims to prepare our students for the world of work, further education and lifelong learning. However, secondary education must also pay attention to the all round development of the individual. It should provide not only for the acquisition of those skills needed for economic, scientific and technological advancement. It should also provide for the development of cultural and national identity and the inculcation of attitudes and values which nurture respect for one's self and for others.

Critical to the success of our secondary education programme is the recognition of individual talents, needs and learning styles. Hence, the role of the teacher in the classroom has changed. S/he must be a proficient manager and facilitator; a director of learning activities. S/he should be conscious of students' needs to take on board a measure of accountability and responsibility for their own learning. S/he must also take into account the widening range of ability of the student body and the different levels of achievement which they aspire to. This means active participation for all and the creation of rich and diverse learning environments.

It is important then that we value the students' own experiences, build upon what they know and reward them for positive achievement. At the same time, we must be prepared to offer them guidance and counselling at all levels; assisting them to make the best decisions in keeping with their own interests, career prospects and preferences. In that way we shall prevail in nurturing at the roots of our system, the

national ideals of democracy, development, self-reliance, unity and social harmony.

This syllabus document is the outcome of a great deal of professional consultation and collaboration. On behalf of the Ministry, I wish to record my appreciation and thank sincerely those who contributed to and were involved in the production of this syllabus.

P. T. Ramatsui
Permanent Secretary
Ministry of Education

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Introduction

Senior Secondary Science is a two-year programme designed for learners who have completed Junior Secondary education. It is designed to provide learners with scientific knowledge, skills and attitudes needed for understanding and responsible participation in the society. It also prepares the learners for tertiary education, vocational training and provides them with foundation skills for employment.

Subjects for the Senior Secondary programme are categorised into groups: core and optional. All the Science subjects fall into one optional group: Sciences. There are four forms of Science offered in the group and learners are expected to choose one. These are:

- **Single Science;**
- **Double Science;**
- **Pure Sciences: Biology, Physics and Chemistry;**
- **Human Social Biology (only offered to private candidates)**

The syllabuses have been developed on the assumption that each Science will be allocated 160 minutes per week.

Rationale

The Science Programme for the two years of senior secondary education is expected to facilitate the holistic development of the learner in a global context. The programme intends to instil a sense of appreciation for science and to make sure that the learners can cope in a technologically changing world. The programme will help learners to explore and apply the scientific knowledge, skills and attitudes acquired to address environmental, social, economic and political issues in their day-to-day lives. Through this programme learners will get an opportunity to explore and understand the natural world (life processes, physical phenomena and nature of substances).

Science is an experimental discipline and its method of inquiry allows learners to appreciate the practical impact of science on their lives and society as a whole. The Science programme will equip learners with skills that will be of long term value and encourage them to participate in lifelong learning. In the process the learners will exercise their creativity and develop skills such as critical thinking, innovativeness, communication, analysis, observation, recording, drawing conclusions, making judgement etc.

The syllabuses will also expose learners to the practical applications of Science. This will contribute towards popularising Science and developing an interest in and positive attitudes towards Science among all learners.

The Senior Secondary Science syllabuses recognise the importance of offering key concepts and principles of Science in Physics, Chemistry and Biology to provide learners with a more unified view of the Sciences and awareness of the connections among them and technology.

Aims of Senior Secondary Programme

On completion of the two year secondary programme learners should have: -

1. **acquired knowledge, developed confidence and ability to assess their personal strengths and weaknesses and be realistic in choosing appropriate career/employment opportunities and/or further education and training.**
2. **developed skills to assist them in solving technical and technological problems as they relate to day-to-day life situations.**

developed desirable attitudes and behavioural patterns in interacting with the environment in a manner that is protective, preserving and nurturing.

3. **acquired attitudes and values, developed basic skills and understanding to allow for execution of rights and responsibilities as good citizens of Botswana and the world.**
4. **developed information technology skills as well as an understanding and appreciation of their influence in day-to-day activities.**
5. **acquired knowledge, attitudes and practices that will ensure good family and health practices, including awareness and management of epidemics (such as HIV/AIDS), that prepare them for productive life.**
6. **developed pre-vocational knowledge and manipulative skills that will enable them to apply content learnt and attitudes and values developed to practical life situations in the world of work.**

7. **developed an understanding of and acquired basic skills in business, everyday commercial transactions and entrepreneurship.**
8. **developed foundation skills such as problem solving, critical thinking, communication, inquiring, team work / interpersonal to**

help them to be productive and adaptive to survive in a changing environment.

Aims of Senior Secondary Science

On completion of the 2 year Senior Secondary Science Programme, each student is expected to have:

1. **developed the ability to assess personal achievement and capabilities realistically in the pursuit of appropriate career/employment opportunities and/or further education.**
2. **developed manipulative skills to assist them in solving technical and technological problems as they relate to day-to-day life situations.**
3. **become confident citizens in a technological world to make informed decisions in matters of scientific interest.**
4. **developed desirable attitudes and behavioural patterns in interacting with the environment in a manner that is protective, preserving, developmental and nurturing.**
5. **developed an understanding of the applications of science and of the technological, economic, ethical and social implications of these.**
6. **developed an understanding of the significance of information and communication technology in the day-to-day life situations and the world of work.**
7. **acquired knowledge, attitudes and practices that will promote good family life and health including awareness and management of epidemics such as HIV/AIDS practices that prepare them for productive life.**
8. **developed positive attitudes such as open-mindedness, inventiveness, concern for accuracy and precision, objectivity, integrity and initiative towards scientific skills**
9. **developed an interest in and an enjoyment of science and science related-work.**
10. **developed an understanding of key concepts and principles of science as they are experienced in everyday life.**
11. **developed abilities and skills that are relevant to the study, safe practice and application of science (such as experimenting and investigating).**
12. **developed problem solving, critical thinking, communication, inquiry and teamwork/interpersonal skills to help them to be productive and adaptive to cope in a changing environment.**
13. **developed an appreciation of the role of science in improving the quality of life.**
14. **recognised the usefulness of science, and limitations of scientific method.**

15. **promoted an awareness that the applications of science may be both beneficial and detrimental to the individual, the community and the environment.**

Aims of Senior Secondary Physics Programme

The aims of the science programme are the same for all students. They describe the intended educational outcomes of the physics programme. The list is not in any order of preference.

The aims are to:

1. **develop abilities and skills that are relevant to the study, practice and application of physics, which are useful in everyday life, and which encourage safe practice.**
2. **develop an understanding of the technological and environmental application of physics and of the economic, ethical and social implications of these.**
3. **develop an understanding of the significance of information and communication technology in the day-to-day life situations and the world of work.**
4. **develop positive attitudes relevant to physics such as**
   - **open-mindedness**
   - **inventiveness**
   - **concern for accuracy and precision**
   - **objectivity**
   - **integrity**
   - **initiative towards scientific skills**
5. **stimulate curiosity, interest and enjoyment of physics and its methods of enquiry.**
6. **develop an understanding of key concepts and principles of physics as they are experienced in everyday life.**
7. **recognise the usefulness and limitations of the scientific method and to appreciate its applicability in other disciplines and in everyday life.**
8. **encourage students to pursue and be suitably prepared for further studies in physics and physics related courses.**
9. **promote an awareness that the concepts of science are of a developing and sometimes transient nature.**

10.show awareness that Physics applications may be both beneficial and detrimental to the individual, the community and the environment.

Recommended teaching methods

The syllabus encourage a learner-centred approach as emphasised in the curriculum blueprint. This involves laying emphasis on science (Physics) process skills, problem-solving skills, and the acquisition of hands-on experience which should increase the participation and performance of all groups e.g. groups of different abilities, learners with special needs, girls, boys. Teachers should approach the teaching-learning process in a learner-centred way. Therefore, it means that the teacher should use a variety of methods to achieve this e.g. inquiry, demonstration, practical work, project work, case study, field trips, discussions, computer guided learning etc.

In order to facilitate a learner-centred approach there should be pre-planning of activities to be done and there should be adequate working space to accommodate these activities.

Teaching methods should expose learners to practical applications of Science. They should present Science (Physics) in an interesting and challenging way that should popularise it and encourage learners to opt to pursue Science and Science-related fields for careers.

Domains

Physics experiences to be provided to learners should aim to cover the following domains: knowledge and understanding; handling information, application and solving problems; investigation and experimental skills and attitudes in Physics and Science in general. These domains should provide guidance in assessment of the learners.

Learners should be able to demonstrate:-

1. knowledge and understanding of

1.1 concepts, laws, theories and principles of Science (Physics).

1.2 scientific vocabulary, terminology, convention (including symbols, quantities and units).

1.3 applications of science and of their technological, economic, environmental, ethical and social implications.

1.4 the significance of information and communication technology in the day-to-day life situations and the world of work.

1.5 good family life and health practices including awareness and management of epidemics such as HIV/AIDS that prepare them for productive life.

2. handling information, application and solving problems to
2.1. solve problems as they relate to day-to-day life situations including some of a quantitative nature
2.2. use information to identify patterns, report trends, draw inferences, make predictions and propose hypotheses
2.3 locate, select, organise and present information from a variety of sources
2.4 translate information from one form to another
2.5 manipulate numerical and other data
2.6 present explanations for phenomena, patterns and relationships

3. investigation and experimental skills
3.1 follow a sequence of instructions
3.2 use appropriate techniques, apparatus and materials
3.3 handle instruments, apparatus and materials safely
3.4 make and record observations, measurements and estimates
3.5 interpret and evaluate observations and data
3.6 plan investigations and/or evaluate methods and suggest possible improvements
3.7 convert acquired skills into creative innovations

4. attitudes in Science (Physics) such as
4.1 open-mindedness, inventiveness, concern for accuracy and precision, objectivity, integrity and initiative towards scientific skills
4.2 respect for life
4.3 awareness and appreciation for the environment
4.4 promotion of indigenous science and technology
4.5 recognition of the usefulness of science, and limitations of scientific method.
4.6 promotion of an awareness that the applications of science (Physics) may be both beneficial and detrimental to the individual, the community and the environment.

Assessment

To ensure that learners attain the set aims, the course will be assessed through a variety of continuous assessment techniques. Projects, tests, experiments, surveys etc. will be used. The outcome of these will be used to improve instruction and guide progression.

At the end of the course a terminal examination will be administered. Continuous assessment in the form of coursework will also contribute to certification. Where it is not possible to offer coursework, alternative papers to test the same knowledge, skills and attitudes will be used.
Examination syllabuses will be developed by the examining body to provide teachers with guidelines on objectives to be tested.

Organisation of the syllabus

The syllabus is organised around broad content areas subdivided into topics. Each topic consists of general objectives which give rise to specific objectives. The specific objectives describe what learners are expected to do. These objectives are divided into core and extended. The extended specific objectives are highlighted in *bold italics*. All learners are expected to follow the core specific objectives. The extended objectives provide more challenging work for those learners able to benefit from it.

GENERAL PHYSICS

Topic	General Objective	Specific Objective
	Students should be able to:	**Students should be able to:**
Length and Time	**perform accurate measurement of length and time**	**- state fundamental physical quantities and give their SI units.** **- measure small lengths accurately using rulers vernier and micrometer.** **- identify sources of errors in measurement of length from a given measuring instrument.** **- measure time accurately using stop clock/watch.** ***- estimate the accuracy of a given measuring instrument.*** ***- identify sources of errors in measurements of time.*** ***- determine the period of a pendulum.***

Motion	**show understanding of motion and the relationship between the variables**	**- define distance, displacement, speed, velocity and acceleration** **- identify motion with uniform and non-uniform velocity** **-identify uniformly accelerated and non uniformly accelerated motion.** **- plot and interpret distance-time, speed-time graphs for uniform motion.** ***- plot and interpret distance-time, speed-time graphs for non uniform motion.*** ***- use equations of motion in simple calculation*** **- define *g* (acceleration due to gravity)** ***- use g in solving problems on motion*** **- state that acceleration of free fall for a body near earth is constant** **- describe motion of a body freely falling in air** ***- describe qualitatively motion of objects falling in a liquid.*** **- understand the meaning of the term "terminal velocity"**

Mass, Weight and Centre of mass	**show the relationship between mass, weight and centre of mass**	**- demonstrate an understanding that mass is a measure of the amount of substance in a body.** **- define inertia and relate it to mass** **- define weight and its relationship to mass** **- measure mass and weight using appropriate balances** **- define centre of mass** **- determine centre of mass of plane laminas** **- perform and explain an experiment to determine the centre of mass of a irregular lamina** **- demonstrate and describe factors affecting stability of objects**
Density	**measure density of various objects**	**- define density** **- determine densities of solids and liquids experimentally** **- use the equation ρ =m/V in simple calculations** ***- describe an experiment to determine the density of air*** **- use hydrometer to measure densities of liquids**

Forces **a) effects on shape and size**	**show understanding of the effects of forces on shape and size of objects**	**- demonstrate that force may cause change in shape/size of objects** **- determine the relationship between load and extension.** **- plot, draw and interpret extension-load graphs and describe the associated experimental procedure** **- recognise the significance of the term "Limit of Proportionality" for an extension -load graph and use proportionality in simple calculations** ***- describe quantitatively the extensions of elastic materials in series and parallel***
b) effects on motion	**show understanding of the effects of force on motion**	**- describe ways in which a force may cause change in motion of a body** **- use the relationship F=ma in calculations.** **- demonstrate the effects of friction on motion of a body** ***- perform simple calculations in cases where there is friction*** ***- describe the effects of centripetal force on motion along curved paths.*** ***- state and use Newton's laws of motion.***

c) turning effects of forces	**acquire knowledge on turning effects of forces and appreciate their role in everyday life**	**- describe the moment of a force in terms of its turning effect, including levers, and give everyday examples** **- perform and describe an experiment to verify the principle of moments** **- use the concept of moment of force in simple calculations** ***- describe the effects of parallel forces on an object*** ***- determine the conditions of equilibrium for parallel forces*** ***- describe couples and give simple examples of couples in equilibrium and causing rotation.***
Scalars and vectors	**distinguish between scalar and vector quantities**	**- define scalar and vector quantities and give examples** **- determine the resultant of any two vectors.** **- classify any physical quantity as a vector or a scalar.**

Energy, Work and Power **a) Energy**	**acquire knowledge on sources of energy and their limitations**	**- list various forms of energy and identify their sources** **- describe energy conversions and apply the principle of conservation of energy giving examples.** **- describe and express a qualitative understanding of processes by which energy is converted from one form to another, including reference to** **(i) chemical/fuel energy (a re-grouping of atoms)** **(ii) hydroelectric generation (emphasising the mechanical energies involved)** **(iii) solar energy (nuclei of atoms in the Sun)** **(iv) nuclear energy (fusion and fission)** **(v) geothermal energy** **(vi) wind energy** **- define kinetic and potential energy (mechanical)** **- use kinetic and gravitational potential energy in calculations involving energy conversions** **- list major energy sources in Botswana** **- describe the socio economic and environmental impact of each**

b) Work	**show the relationship between work, energy**	**- relate work done to the magnitude of a force and the distance moved and make calculations involving *F x s*** **- describe the relationship between work and energy**
c) Power	**show the relationship between work and power**	**- define power** **- use the equation P=W/t in simple calculations**

Pressure	**acquire knowledge on pressure and appreciate the wide application of pressure in everyday life situations**	**- relate pressure to force and area, using appropriate examples and the equation *p = F/A*** **- describe the effects of atmospheric pressure** **- describe the simple mercury barometer and its use in measuring atmospheric pressure** **- use isobar patterns on weather charts and pressure (in millibars) to predict type of weather, including wind strength and direction** **- relate quantitatively the pressure beneath a fluid surface to depth and density of fluid, using appropriate examples** **- use and describe the use to a manometer**

THERMAL PHYSICS

Topic	General Objective	Specific Objective
	Students should be able to:	**Students should be able to:**
Simple kinetic molecular model of matter	**recognise the differences between the three states of matter**	**- state the distinguishing properties of solids, liquids and gases**

show understanding of the molecular model	**- describe qualitatively, with relation to the forces and distances between molecules, the molecular structure of solids, liquids and gases** **- interpret the temperature of a gas in terms of the motion of its molecules** **- interpret the pressure of a gas in terms of the motion of its molecules** **- describe qualitatively the effect of a change of temperature on the pressure of a gas at constant volume** **- show an understanding of the random motion of particles in a suspension** **- describe this motion (Brownian motion) in terms of random molecular bombardment**

	show understanding of the term evaporation and its applications	**- describe evaporation in terms of the escape of more energetic molecules from the surface of a liquid** **- demonstrate an understanding of how temperature, humidity, surface area and draught over a surface influence evaporation** **- explain how evaporation causes cooling and give examples** **- give everyday applications of cooling by evaporation**
	acquire knowledge on the behaviour of a fixed mass of a gas in relation to pressure and volume	**- relate the change in volume of a gas to change in pressure applied to the gas at constant temperature** **- use the equation pV = constant at constant temperature in simple calculations**

Thermal expansion of matter	**understand the concept of thermal expansion of matter**	**- describe and demonstrate the thermal expansion of solids, liquids and gases** **- show an appreciation of the relative order of magnitude of the expansion of solids, liquids and gases** **- identify and explain some of the everyday applications and consequences of thermal expansion including thermostat** **- describe and show qualitatively the effect of a change of temperature on the volume of a gas at constant pressure** ***- show an understanding of absolute zero as the minimum possible temperature*** ***- relate the Kelvin scale to the Celsius scale***

Measurement of temperature	**demonstrate understanding of the concepts and instruments involved in the measurement of temperature**	**- appreciate how a physical property which varies with temperature may be used for the measurement of temperature e.g. thermal expansion and e.m.f.** **- recognise the need for and identify fixed points of a temperature scale** **- demonstrate understanding of sensitivity, range and linearity** **- describe the structure and action of liquid-in-glass thermometers (Laboratory and Clinical)** **- describe the structure and action of a thermocouple** **- show understanding of the use of a thermocouple for measuring high temperatures and those which vary rapidly**

Heat capacity	**understand the concept of heat capacity**	**- relate a rise in temperature of a body to an increase in internal energy (random thermal energy)** **- show understanding of the term heat capacity and specific heat capacity** **- *perform and describe experiments to measure the specific heat capacity of solids and liquids*** **- perform simple calculations related to heat capacity**

Melting and boiling	**acquire knowledge on the concepts of melting and boiling**	**- describe melting/solidification and boiling/condensation in terms of energy input without a change in temperature** **- state the meaning of melting point and boiling point** **- state the difference between boiling and evaporation** **- sketch and interpret cooling curves** ***- describe and appreciate the unusual expansion of water and its consequences*** **- show understanding of the terms latent heat and specific latent heat** **- use the term latent heat and give a molecular interpretation of latent heat** **- relate the concept of latent heat to refrigeration.** ***- describe an experiment to determine the specific latent heat for steam and for ice and make the necessary calculations***

Transfer of thermal energy	**acquire knowledge on heat transfer by conduction, convection and radiation**	**- give a simple molecular account of heat transfer in solids** **- perform and describe experiments to demonstrate good and bad conductors of heat** **- relate convection in fluids to density changes** **- perform and describe experiments to illustrate convection** **- show understanding of the term radiation (infrared)** **- perform and describe experiments to distinguish between good and bad emitters/absorbers of heat.**
	acquire knowledge on the applications and consequences of energy transfer	**- identify and explain some of the everyday applications of conduction, convection and radiation including Thermos flask, car cooling system, water heating system** **- identify and explain some of the everyday consequences of conduction, convection and radiation including cyclones, land and sea breezes, days and nights in deserts, typhoons, global warming and the green house effect**

PROPERTIES OF WAVES, INCLUDING LIGHT AND SOUND

Topic	General Objective	Specific Objective
	Students should be able to:	**Students should be able to:**
General wave properties	**acquire basic knowledge about wave motion**	**- describe wave motion** **- define the terms wave front, speed, frequency, wavelength and amplitude** **- perform experiments to show:** **(i) wave motion and wave front** **(ii) relationship between speed, frequency and wavelength** **- use the wave equation v = f λ** ***- sketch and interpret Amplitude-Time graphs***
	recognise the differences between transverse and longitudinal waves.	**- describe transverse and longitudinal waves and their nature** **- give examples of transverse and longitudinal waves** **- demonstrate how transverse and longitudinal waves are formed**

	use water waves to show reflection, refraction and diffraction of waves.	**- demonstrate the formation of water waves** **- perform an experiment to show the effect of depth on the speed of a wave** **- use a ripple tank to show and describe:** **(i) reflection at a plane surface** **(ii) refraction due to a change of speed.**
Light	**demonstrate understanding of reflection of light by plane and curved surfaces**	**- define reflection and give examples** **- perform and describe an experiment to illustrate the laws of reflection.** **- observe and describe the characteristics of images formed by plane surfaces.** **- construct ray diagrams to show images formed by plane mirrors** **- give examples of uses of plane and curved mirrors** **- use the law i=r in reflection** **- perform measurements and calculations involving angles**

	demonstrate understanding of refraction of light, total internal reflection and refractive index	**- describe and perform experiments to demonstrate refraction of light through glass blocks** **- use the terminology for the angles i and r in refraction and describe the passage of light through parallel-sided transparent material** **- use the equation sin i/sin r = constant** **- give the meaning of refractive index** ***- understand the terms real depth and apparent depth and use them to determine the refractive index*** **- give the meaning of critical angle** **- show understanding of total internal reflection and the formation of mirages** **- describe the action of optical fibres.** ***- explain the formation of mirages.***

understand the action of a thin lens on a beam of light	**- differentiate between the converging and diverging lenses** **- describe the action of a thin lens on a beam of light** **- use and understand the meaning of the terms focal length, principal focus and principal axis with respect to a thin converging lens** **- determine experimentally the focal length of a thin converging lens** **- draw ray diagrams to illustrate the formation of real and virtual images of an object by a thin converging lens** **- *use and describe the use of a single lens as a magnifying glass*** **- describe the use of a single lens to form a real image, e.g. a camera, a projector, a photographic enlarger** **- determine the magnification of a thin converging lens.**

Electro-magnetic spectrum	**show an understanding of the main features of the electro-magnetic spectrum**	**- describe the main components of the electromagnetic spectrum** **- state and describe their methods of detection** **- state the uses, sources and side effects of the components of the electromagnetic spectrum.**
	appreciate that all e.m. waves travel with the same high speed in vacuum	**- state that all e.m. waves travel with the same high speed in vacuum** **- state the magnitude of this speed** **- use the wave equation c=fλ in simple calculations**
Sound	**understand how sound is produced**	**- describe the production of sound by vibrating sources** **- describe the longitudinal nature of sound waves and describe compression and rarefaction in relation to pressure variations**

	recognise that sound waves require a medium for their transmission	**- show understanding that a medium is required in order to transmit sound waves** **- state the approximate range of audible frequencies for human beings and other animals** **- perform an experiment to determine the range of audible frequencies for human beings** **- state the uses of ultra sonic sound waves** **- understand noise pollution** ***- perform an experiment to determine the speed of sound in air and make necessary calculations*** **- state the order of magnitude of the speeds of sound in gases, liquids and solids** ***- perform simple calculations based on the speed of sound in gases, liquids and solids.***
	understand reflection of sound waves	**- describe how the reflection of sound may produce an echo** ***- describe how multiple reflections may produce reverberations***

	understand the terms pitch, loudness and quality of sound	**- perform an experiment to relate the loudness and pitch of sound to amplitude and frequency respectively** ***- describe the factors which influence the quality (timbre) of sound waves*** ***- describe the effect of multiple reflections of sound waves (acoustics) on the quality of sound***

ELECTRICITY AND MAGNETISM

Topic	General Objective	Specific Objective
	Students should be able to:	**Students should be able to:**

Magnetism	**understand simple phenomena of magnetism**	**- state the properties of magnets** **- distinguish between magnetic and non-magnetic materials** **- describe the phenomenon of induced magnetism** **- describe different methods of magnetisation e.g. electricity, stroking, . . .** **- describe different methods of demagnetisation e.g. electricity, hitting and heating** ***- give an account of magnetic saturation*** **- describe and demonstrate methods of detecting a magnetic field around a magnet** ***- use a plotting compass to plot the field lines of a magnetic field of a bar magnet*** **- distinguish between the magnetic properties of iron and steel** **- distinguish between the design and use of permanent magnets and electromagnets** **- give reasons for the choice of material for, and use of, magnetic screening** **- give examples of the use of magnetic materials.**

Electricity	**understand the concept of electric charge**	**- describe the phenomenon of electrostatic charging** **- perform simple experiments to show electrostatic charging** **- state the two types of charges, namely positive and negative** **- state that charge is measured in coulombs** **- demonstrate that unlike charges attract and that like charges repel** ***- understand how the gold leaf electroscope is used to detect charge*** ***- understand the concept of discharging and relate it to occurrence of lightning*** ***- describe the design and use of a lightning conductor*** **- describe an electric field as a region in which an electric charge experiences an electric force** **- state the direction of lines of force and describe simple field patterns** ***- give an account of charging by induction e.g. touching and separation of charges*** **- use the electron model to distinguish between** 27 **electrical conductors and insulators and give examples**

	understand the concept of electric current	**- perform simple experiments to show the relationship between flow of charge and current** **- define electric current as the rate of flow of charge.** **- use the equation I= Q/t** **- use and describe the use of an ammeter with different ranges including a milliampere range**
	understand the concept of electro-motive force	***- understand that the e.m.f. is measured by the energy dissipated by a source in driving a charge round a complete circuit (e.m.f =W/Q)*** **- state that the e.m.f of a source of electrical energy is measured in volts** **- give a definition of the volt [Energy/Charge (J/C)]**
	show an understanding of potential difference	**- give an explanation of potential difference** **- state that the potential difference across a circuit component is measured in volts** **- use and describe the use of a voltmeter with different ranges**

	show an understanding of resistance	**- give an explanation of resistance** **- state that resistance is measured in ohms** **- state that resistance = p.d./current and use the equation R = V/I** **- perform and describe an experiment to determine resistance using a voltmeter and an ammeter and make the necessary calculation** **- describe qualitatively the relationship between resistance, length and cross-sectional area.** ***- use quantitatively the proportionality between resistance and the length and the cross-sectional area of a wire (R=$\rho\ \ell$/A)*** **- show understanding of internal resistance**
	show an understanding of *V/I* characteristic graph (Ohms Law)	**- sketch and interpret the V/I characteristic graphs for metallic (ohmic) conductors.** ***- sketch and interpret the V/I characteristic graphs for non-ohmic conductors*** **- appreciate the limitations of Ohm's law**

	show an understanding of electric circuits	**- identify circuit components and their symbols** **- perform experiments using simple electric circuits** **- draw and interpret circuit diagrams** **- perform experiments to show that** **(i) current is the same at every point in a series circuit** **(ii) the sum of the p.d's in a series circuit is equal to the terminal p.d. across the source.** **(iii) the current from the source is the sum of the currents in the separate branches of a parallel circuit.** **(iv) the p.d across components in parallel is the same as the terminal p.d.** **- calculate the total resistance of two resistors in series** **- calculate the total resistance of two or three resistors in parallel** **- *perform calculations involving components in different circuit combinations***

Practical electric circuitry	**appreciate the use of electricity in everyday life situations**	**- state the use of electricity in heating, lighting machines, security, communication** **- use the equations P = VI, E = VIt** **- calculate the cost of using electrical appliances**
	understand the dangers of electricity	**- state the hazards of** **(i) damaged insulation** **(ii) overheating of cables** **(iii) damp conditions** **(iv) overloading of sockets** **- explain how these hazards can be prevented**

	acquire knowledge on the safe use of electricity in the home	**- show understanding of the use of fuses and fuse ratings** **- explain the need for earthing metal cases and for double insulation of electrical appliances** **- give the meaning of the terms: live, neutral and earth** **- describe and correctly wire, a mains plug** **- understand simple lighting (including lamps in parallel), and ring-main circuits in the house** **- give the reason for connecting switches and fuses in live wires** **- describe the necessary diagnostic steps to be followed when there is an electrical fault in an appliance**
Electromagnetic effects	**understand the concept of electromagnetic induction**	**- perform and describe an experiment which shows that a changing magnetic field can induce an e.m.f. in a circuit** **- state the factors affecting the magnitude of the induced e.m.f.** **- show understanding that the direction of an induced e.m.f. opposes the change producing it (Lenz's law)**

acquire basic knowledge on the operation of an a.c. generator	**- describe a simple form of an a.c. generator (e.g. rotating coil or rotating magnet) and the use of slip rings** **- sketch and interpret a graph of voltage output against time for a simple a.c. generator**
acquire knowledge on the operation of a Transformer	**- describe the structure of a basic iron-cored transformer as used for voltage transformations** **- *describe the principle of operation of a transformer.*** **- use the equations*(Vp/Vs) = (Np/Ns)* and VpIp= VsIs (for 100% efficiency) in calculations** **- perform experiments to demonstrate the difference between a step-up transformer and a step-down transformer** **- describe the use of the transformer in high voltage transmission of electricity** **- discuss the energy loss in cables and transformers** **- give the advantages of high voltage transmission**

show understanding of the magnetic effect of a current	**- perform and describe an experiment to show the pattern and direction of the magnetic field due to currents in straight wires and in solenoids** **- state the qualitative variation of the strength of the magnetic field over salient parts of the pattern** **- describe the effect on the magnetic field of changing the magnitude of the current**
acquire knowledge on the structure and use of electromagnets	**- describe the structure of a simple electromagnet** **- demonstrate the factors that affect the strength of an electromagnet** **- *describe applications of the magnetic effect of a current including the circuit and action of an electric bell and a simple relay***

	recognise that a current carrying conductor experiences a force in a magnetic field	**- perform and describe an experiment to show the force on a current-carrying conductor in a magnetic field, including the effect of reversing (i) the current, (ii) the direction of the field** **- determine the relative directions of force, field and current** **- describe the field patterns between parallel conductors carrying currents and relate these to the forces which exist between the conductors**

	acquire basic knowledge on the operation of a d.c. motor	**- show understanding that a current-carrying coil in a magnetic field experiences a turning effect and that the effect is increased by increasing (i) the number of turns on the coil, (ii) the current** **- relate this turning effect to the action of an electric motor** **- construct a simple d.c. motor** ***- describe and show understanding of the action of a split-ring commutator in a two-pole, single-coil motor and the effect of a soft-iron cylinder between the poles of the magnet*** **- state the uses of electric motors**
	show understanding of the operation of a microphone and a loudspeaker	***- describe the action of a microphone*** ***- describe the action of a loudspeaker (details of the cone will*** **not** ***be required)*** ***- relate the use of microphones and loudspeakers to communication e.g. telephone receiver***

Introductory electronics	**acquire basic knowledge on thermionic emission**	**- show understanding that charged particles are emitted by a hot metal filament and describe their deflection in electric fields and magnetic fields** **- deduce that the particles emitted in thermionic emission are negatively charged and can be identified as electrons** **- distinguish between the direction of flow of electron current and conventional current**
	understand the basic structure and use of cathode-ray oscilloscope	**- describe in outline the basic structure and action of a cathode-ray oscilloscope (detailed circuits are *not* required)** **- use and describe the use of a cathode-ray oscilloscope to display wave forms.** ***- measure p.d's and short intervals of time (detailed circuits are* not *required)*** ***- relate the principle of the CRO to a TV set***

	acquire knowledge on action and use of circuit components	**- show understanding of the function of resistors in circuits** **- use a given colour code for resistance values** **- show an appreciation of the need to choose components with suitable power ratings** **- describe the action of a variable potential divider (potentiometer)** **- describe the action of thermistors and light-dependent resistors and show understanding of their use as input transducers** **- describe the action of a capacitor as an energy store and show understanding of its use in time delay circuits** **- describe the action of a reed switch and reed relay** **- show understanding of the use of reed relays in switching circuits** **- recognise and show understanding of circuits operating as light sensitive switches and temperature operated alarms (using a reed relay or other circuits)**

	understand the action and use of diodes in electrical circuits	**- describe the action of a diode as a unidirectional conductor of electricity** **- *describe the use of diodes as rectifiers in a circuit***

Electronic systems	**acquire basic knowledge on electronic systems**	- ***describe the action of a bipolar transistor as an electrically operated switch and show understanding of its use in switching circuits*** - ***state in words and in truth table form, the action of the following logic gates: AND, OR, NAND, NOR, NOT (inverter)*** - ***recognise the symbols for the above mentioned logic gates (NB American ANSI Y 32.14 symbols will be used)*** - ***recognise the use of cross-coupled logic gates as a bistable circuit*** - ***show appreciation of the fact that bistable circuits exhibit the property of 'memory'*** - ***recognise the use of cross-coupled logic gates as an astable circuit (pulse generator)*** - ***relate qualitatively the frequency of an astable circuit to the values of the resistive and capacitative components***

ATOMIC PHYSICS

Topic	General Objective	Specific Objective
	Students should be able to:	**Students should be able to:**
Radioactivity	**appreciate the existence of radioactive emissions**	**- describe the process of radioactivity.** **- give examples of radioactive materials** **- state the dangers of exposure to radioactive emissions** **- describe the safe handling and storage of radioactive material in a laboratory** **- state that alpha, beta and gamma emissions can be emitted during the process of radioactivity** **- describe methods of detection of these emissions by Geiger-Muller tubes** **- show awareness of the existence of background radiation**

understand the characteristics of the three emissions	**- show understanding that radioactive emissions occur randomly over space and time** **- state, for each radioactive emission:** **(i) its nature** **(ii) its relative ionising effect** **(iii) its relative penetrating power** **- describe their deflection in electric and magnetic fields** ***- interpret their relative ionising effects***
describe the composition of the nucleus	**- describe the composition of the nucleus in terms of protons and neutrons** **- use and explain the terms** **i) proton number = atomic number (Z)** **ii) nucleon number = mass number (A)** **- use the term nuclide and the nuclide notation** $^{A}_{Z}X$ **- describe an isotope as nuclide with same Z but different A** **- give examples of isotopes and their uses**

	understand nuclear reactions	**- state the meaning of radioactive decay as a process by which a heavy nuclide breaks down to smaller and more stable nuclides** ***- use equations (involving symbols) to represent changes in the composition of the nucleus when particles are emitted*** **- distinguish between fission and fusion** ***- describe chain reactions as applied in nuclear reactors*** **- relate fusion to energy production in the sun** **- discuss the advantages and disadvantages of using these processes to provide energy** ***- use the equation $E=mc^2$ in simple calculations***
	understand the term half-life	**- define half-life as the time for half the original number of radioactive particles to decay** **- use half-life in simple calculations.** ***- plot and interpret decay curves.***

	appreciate the uses and dangers of radioactive materials	**- state the uses of radioactive materials in industries, agriculture, medicine and production of electricity.** **- describe the dangers of waste products of radioactive materials and give suggestions on safer disposal of these waste products**