

WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION
PHYSICS

PREAMBLE

This syllabus is evolved from the Senior Secondary School teaching syllabus and is intended to indicate the scope of the course for Physics examination.

It is structured with the conceptual approach. The broad concepts of Matter, Position, Motion and Time; Energy; Waves; Fields; Atomic and Nuclear Physics, Electronics are considered and each concept forms a part on which other sub-concepts are further based.

AIMS

The aims of the syllabus are to:

- (1) acquire proper understanding of the basic principles and applications of Physics;
- (2) develop scientific skills and attitudes as pre-requisites for further scientific activities;
- (3) recognise the usefulness, and limitations of scientific method to appreciate its applicability in other disciplines and in everyday life;
- (4) develop abilities, attitudes and skills that encourage efficient and safe practice;
- (5) develop attitudes relevant to science such as concern for accuracy and precision, objectivity, integrity, initiative and inventiveness.

ASSESSMENT OBJECTIVES

The following skills appropriate to Physics will be tested:

- (1) Knowledge and understanding:

Candidates should be able to demonstrate knowledge and understanding of:

- (a) scientific phenomena, facts, laws, definitions, concepts and theories;
- (b) scientific vocabulary, terminology and conventions (including symbols, quantities and units);
- (c) the use of scientific apparatus, including techniques of operation and aspects of safety;
- (d) scientific quantities and their determinations;
- (e) scientific and technological applications with their social, economic and environmental implications.

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(2) Information Handling and Problem-solving

Candidates should be able, using visual, oral, aural and written (including symbolic, diagrammatic, graphical and numerical) information to:

- (a) locate, select, organise and present information from a variety of sources, including everyday experience;
- (b) translate information from one form to another;
- (c) analyse and evaluate information and other data;
- (d) use information to identify patterns, report trends and draw inferences;
- (e) present reasonable explanations for natural occurrences, patterns and relationships;
- (f) make predictions from data.

(3) Experimental and Problem-Solving Techniques

Candidates should be able to:

- (a) follow instructions;
- (b) carry out experimental procedures using apparatus;
- (c) make and record observations, measurements and estimates with due regard to precision, accuracy and units;
- (d) interpret, evaluate and report on observations and experimental data;
- (e) identify problems, plan and carry out investigations, including the selection of techniques, apparatus, measuring devices and materials;
- (f) evaluate methods and suggest possible improvements;
- (g) state and explain the necessary precautions taken in experiments to obtain accurate results.

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SCHEME OF EXAMINATION

There will be two papers both of which must be taken for a total mark of 160. Candidates will be allowed an extra 15 minutes for reading Paper 1 during which they are not expected to write anything.

PAPER 1: will be a practical test lasting $2\frac{3}{4}$ hours comprising **three** questions out of which candidates will answer any two to score a total mark of 50. The paper will be taken by school candidates only. Each question of this paper will have two Parts: A and B.

- (1) Part A will be an experiment for 21 marks. Candidates will be required to state the precautions taken during the experiments and reasons for such precautions.
- (2) Part B will consist of **two** short-answer questions that are related to the experiment for 4 marks.

PAPER 2: will consist of two sections: A and B which will last for $2\frac{3}{4}$ hours.

Section A will comprise 50 multiple-choice objective questions drawn from the common areas of the syllabus. It will last for $1\frac{1}{4}$ hours for 50 marks.

Section B will last for $1\frac{1}{2}$ hours and will comprise of two parts: I and II.

Part I will comprise **ten** (10) short-structured questions drawn from the portions of the syllabus peculiar to the different countries such that candidates from each member country will be able to answer **five** (5) questions for 15 marks.

Part II will comprise **five** (5) essay-type questions drawn from the common areas of the syllabus. Candidates will be required to answer **three** (3) questions for 45 marks..

PAPER 3: will be an alternative test to Paper 1 for private candidates only. It will be a Test-of-Practical work lasting $2\frac{3}{4}$ hours for 50 marks.

PRACTICAL PHYSICS

This will be tested by a practical examination based on the syllabus. The objective of the practical examination is to test how well the candidates understand the nature of scientific investigation and their capability in handling simple apparatus in an experiment to determine an answer to a practical question. It is also to determine their competence in demonstrating their understanding of some of the principles involved in a small-scale laboratory experiment.

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The practical test will contain enough instructions to enable candidates to carry out the experiment. Even when standard experiments, such as the determination of focal lengths or specific heat capacities are set, candidates will be told what readings to take and how to calculate the result. Therefore, it should not be necessary for candidates to learn by heart how to perform any experiment.

In addition to experiments on the topics in the syllabus, candidates may be asked to carry out with the aid of full instructions, variants of standard experiments.

Candidates should be trained to take as varied a set of readings as possible and to set out the actual observed readings systematically on the answer sheet. The experiments may require a repetition of readings and an exhibition of results graphically and their interpretation.

DETAILED SYLLABUS

It is important that candidates are involved in practical activities in covering this syllabus. Candidates will be expected to answer questions on the topics set out in the column headed 'TOPICS'. The 'NOTES' are intended to indicate the scope of the questions which will be set but they are not to be considered as an exhaustive list of limitations and illustrations.

N.B. Questions will be set in S.I. units. However, multiples or sub-multiples of the units may be used.

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SECTION A
FOR CANDIDATES IN ALL MEMBER COUNTRIES

PART I
MATTER, POSITION, MOTION AND TIME

| TOPICS | NOTES |
|---|---|
| 1. Concepts of matter | Simple structure of matter should be discussed. The three states of matter, namely solid, liquid and gas. Evidence of the particle nature of matter e.g. Brownian motion experiment, Kinetic theory of matter. Use of the theory to explain: states of matter (solid, liquid and gas), pressure in a gas, evaporation and boiling; cohesion, adhesion, capillarity. Crystalline and amorphous substances to be compared (Arrangement of atoms in crystalline structure not required.) |
| 2. Fundamental and derived quantities and units | |
| (a) Fundamental quantities and units | Length, mass, and time as examples of fundamental quantities and m, kg and s as their respective units. |
| (b) Derived quantities and unit | Volume, density and speed as derived quantities and m^3 , kgm^{-3} and ms^{-1} as their respective units. |
| 3. Position, distance and displacement. | |
| (a) Concept of position as a location of point – rectangular coordinates. | Position of objects in space using the X,Y,Z axes can be mentioned. |
| (b) Measurement of distance | Use of string, metre rule, vernier callipers and micrometer screw gauge. Degree of accuracy should be noted. Metre (m) as unit of distance. |
| (c) Concept of direction as a way of locating a point – bearing | Use of compass and a protractor. |
| (d) Distinction between distance and displacement | Graphical location and directions by axes to be stressed. |

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| TOPICS | NOTES |
|---|--|
| 4. Mass and weight | Use of lever balance and chemical/beam balance to measure mass and spring balance to measure weight. |
| Distinction between mass and weight | Kilogram (kg) as unit of mass and newton (N) as unit of weight. |
| 5. Time | |
| (a) Concept of time as interval between physical events | The use of heart-beat, sand-clock, ticker-timer, pendulum and stopwatch/clock. |
| (b) Measurement of time | Seconds (s) as units of time. |
| 6. Fluids at rest | |
| (a) Volume, density and relative density | Experimental determination for solids and liquids. |
| (b) Pressure in fluids | Concept and definition of pressure. Pascal's principle, application of principle to hydraulic press and car brakes. Dependence of pressure on the depth of a point below a liquid surface. Atmospheric pressure. Simple barometer, manometer, siphon, syringes and pumps, determination of the relative density of liquids with U-tube and Hare's apparatus. |
| (c) Equilibrium of bodies | Identification of the forces acting on a body partially or completely immersed in a fluid. |
| (i) Archmedes' principle | Use of the principle to determine the relative densities of solids and liquids. |
| (ii) Law of flotation | Establishing the conditions for a body to float in a fluid. Applications in hydrometer, balloons, boats, ships, submarines etc. |

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| TOPICS | NOTES |
|--|---|
| 7. Motion | |
| (a) Types of motion: Random, rectilinear, translational, rotational, circular, orbital, spin, oscillatory | Only qualitative treatment is required. Illustration should be given for the various types of motion. |
| (b) Relative motion | Numerical problems on co-linear motion may be set. |
| (c) Cause of motion | Force as cause of motion. |
| (d) Types of force: | |
| (i) Contact force | Push and pull |
| (ii) Force Field | Electric and magnetic attractions and repulsion; gravitational pull. |
| (e) Solid friction | Frictional force between two stationary bodies (static) and between two bodies in relative motion (dynamic). Coefficients of limiting friction and their determination. Advantages of friction e.g. in locomotion, friction belt, grindstone. Disadvantages of friction e.g. reduction of efficiency, wear and tear of machines. Methods of reducing friction. Use of ball bearings, rollers and lubrication. |
| (f) Friction in fluids (Viscosity) | Definition and effects. Simple explanation as extension of friction in fluids. Fluid friction and its application in lubrication should be treated qualitatively. Terminal velocity and its determination. |
| (g) Simple ideas of circular motion | Experiments with a string tied to a stone at one end and whirled around should be carried out to |
| | (i) demonstrate motion in a vertical/horizontal circle. |

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| TOPICS | NOTES |
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| | (ii) show the difference between angular speed and velocity. |
| | (iii) show centripetal force. Banking of roads in reducing sideways friction should be qualitatively discussed. |
| 8. Speed and velocity | |
| (a) Concept of speed as change of distance with time | |
| (b) Concept of velocity as change of displacement with time | Metre per second (ms^{-1}) as unit of speed/velocity. |
| (c) Uniform/non-uniform speed/velocity | Ticker-timer or similar devices should be used to determine speed/velocity. Definition of velocity as ds/dt . |
| (d) Distance/displacement-time graph | Determination of instantaneous speed/velocity from distance/displacement-time graph and by calculation. |
| 9. Rectilinear acceleration | |
| (a) Concept of acceleration as change of velocity with time. | Unit of acceleration as ms^{-2} |
| (b) Uniform/non-uniform acceleration | Ticker timer or similar devices should be used to determine acceleration. Definition of acceleration as dv/dt . |
| (c) Velocity-time graph, | Determination of acceleration and displacement from velocity-time graph |
| (d) Equations of motion with constant acceleration; Gravitational acceleration as a special case. | Use of equations to solve numerical problems. |

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| TOPICS | NOTES |
|--|---|
| 10. Scalars and vectors | |
| (a) concept of scalars as physical quantities with magnitude and no direction | Mass, distance, speed and time as examples of scalars. |
| (b) concept of vectors as physical quantities with both magnitude and direction. | Weight, displacement, velocity, and acceleration as examples of vectors. |
| (c) Vector representation | |
| (d) Addition of vectors | Use of force board to determine the resultant of two forces |
| (e) Resolution of vectors | |
| (f) Resultant velocity using vector representation. | Obtain the resultant of two velocities analytically and graphically. |
| 11. Equilibrium of forces | |
| (a) Principle of moments | Moment of force/Torque. Simple treatment of a couple, e.g. turning of water tap, corkscrew, etc. |
| (b) Conditions for equilibrium of rigid bodies under the action of parallel and non-parallel forces. | Use of force board to determine resultant and equilibrant forces. Treatment should include resolution of forces into two perpendicular directions and composition of forces. Parallelogram of forces. Triangle of forces. |
| (c) Centre of gravity and stability | Should be treated experimentally. Treatment should include stable, unstable and neutral equilibria. |
| 12. Simple harmonic motion | |
| (a) Illustration, explanation and definition of simple harmonic motion (S.H.M.) | Use of a loaded test-tube oscillating vertically in a liquid, simple pendulum, spiral spring and bifilar suspension to demonstrate simple harmonic motion. |

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| TOPICS | NOTES |
|--|---|
| (b) Speed and acceleration of S.H.M. | Relate linear and angular speeds, linear and angular accelerations. |
| (c) Period, frequency and amplitude of a body executing S.H.M. | Experimental determination of 'g' with the simple pendulum and helical spring. The theory of the principles should be treated but derivation of the formula for 'g' is not required. |
| (d) Energy of S.H.M. | |
| (e) Forced vibration and resonance | Simple problems may be set on simple harmonic motion. Mathematical proof of simple harmonic motion in respect of spiral spring, bililar suspension and loaded test-tube is not required. |
| 13. Newton's laws of motion: | |
| (a) First Law: Inertia of rest and inertia of motion | Distinction between inertial mass and weight |
| (b) Second Law: Force, acceleration, momentum and impulse | Use of timing devices e.g. ticker-timer to determine the acceleration of a falling body and the relationship when the accelerating force is constant. Linear momentum and its conservation. Collision of elastic bodies in a straight line. |
| (c) Third Law: Action and reaction | Applications: recoil of a gun, jet and rocket propulsions. |

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PART II

ENERGY: Mechanical and Heat

| TOPICS | NOTES |
|---|--|
| 14. Energy: | |
| (a) Forms of energy | Examples of various forms of energy should be mentioned e.g. mechanical (potential and kinetic), heat, chemical, electrical, light, sound, nuclear etc. |
| (b) World energy resources | Renewable (e.g. solar, wind, tides, hydro, ocean waves) and non-renewable (e.g. petroleum, coal, nuclear, Biomass). Sources of energy should be discussed briefly. |
| (c) Conservation of energy | Statement of the principle of conservation of energy and its use in explaining energy transformations. |
| 15. Work, Energy and Power | |
| (a) Concept of work as a measure of energy transfer | Unit of work as the joule (J) |
| (b) Concept of energy as capability to do work | Unit of energy as the joule (J) while unit of electrical consumption is kWh. |
| (c) Work done in a gravitational field. | Work done in lifting a body and by falling bodies. |
| (d) Types of mechanical energy | Derivation of P.E. and K.E. are expected to be known. Identification of types of energy possessed by a body under given conditions. |
| (i) Potential energy (P.E.) | |
| (ii) Kinetic energy (K.E.) | |
| (e) Conservation of mechanical energy | Verification of the principle |

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| TOPICS | NOTES |
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| (f) Concept of power as time rate of doing work. | Unit of power as the watt (W). |
| (g) Application of mechanical energy – machines. Levers, pulleys, inclined plane, wedge, screw, wheel and axle, gears. | The force ratio (F.R.), mechanical advantage (M.A.), velocity ratio (V.R.) and efficiency of each machine should be treated. Identification of simple machines that make up a given complicated machine e.g. bicycle. Effects of friction on machines. Reduction of friction in machines. |
| 16. Heat Energy | |
| (a) Temperature and its measurement | Concept of temperature as degree of hotness or coldness of a body. Construction and graduation of a simple thermometer. Properties of thermometric liquids. The following thermometers should be treated: Constant – volume gas thermometer, resistance thermometer, thermocouple, liquid-in-glass thermometer including maximum and minimum thermometer and clinical thermometer. Pyrometer should be mentioned. Celsius and Absolute scales of temperature. Kelvin and degree Celsius as units of temperature. |
| (b) Effects of heat on matter e.g. | Use of the Kinetic theory to explain effects of heat. |
| (i) Rise in temperature (ii) Change of state (iii) Expansion (iv) Change of resistance | |
| (c) Thermal expansion – Linear, area and volume expansivities | Qualitative and quantitative treatment. Consequences and applications of expansions. Expansion in buildings and bridges, bimetallic strips, thermostat, over-head cables causing sagging and in railway lines causing buckling. Real and apparent expansion of liquids. Anomalous expansion of water. |

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|--|---|
| | Per kelvin (K^{-1}) as the unit of expansivity. |
| (d) Heat transfer – Conduction, convection and radiation | Use of the kinetic theory to explain the modes of heat transfer. Simple experimental illustrations. Treatment should include the explanation of land and sea breezes, ventilation and applications in cooling devices. The vacuum flask. |
| (e) The gas laws-Boyle’s law, Charles’ law, pressure law and general gas law | The laws should be verified using simple apparatus. Use of the kinetic theory to explain the laws. Simple problems may be set. |
| (f) Measurement of heat energy: (i) Concept of heat capacity (ii) Specific heat capacity | Use of the method of mixtures and the electrical method to determine the specific heat capacities of solids and liquids. Land and sea breezes related to the specific heat capacity of water and land, $Jkg^{-1} K^{-1}$ as unit of specific heat capacity. |
| (g) Latent heat | Explanation and types of latent heat. |
| (i) Concept of latent heat | |
| (ii) Melting point and boiling point | Determination of the melting point of a solid and the boiling point of a liquid. Effects of impurities and pressure on melting and boiling points. Application in pressure cooker. |
| (iii) Specific latent heat of fusion and of vaporization | Use of the method of mixtures and the electrical method to determine the specific latent heat of fusion of ice and of vaporization of steam. Applications in refrigerators and air conditioners. |
| | Jkg^{-1} as unit of specific latent heat. |

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| (h) Evaporation and boiling | Effect of temperature, humidity, surface area and draught on evaporation to be discussed. |
| (i) Vapour and vapour pressure | Explanation of vapour and vapour pressure. Demonstration of vapour pressure using simple experiments. Saturated vapour pressure and its relation to boiling. |
| (j) Humidity, relative humidity and dew point | Measurement of dew point and relative humidity. Estimation of humidity of the atmosphere using wet and dry-bulb hygrometer. |
| (k) Humidity and the weather | Formation of dew, fog and rain. |

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PART III

WAVES

| TOPICS | NOTES |
|--|--|
| 17. Production and propagation of waves | |
| (a) Production and propagation of mechanical waves | Use of ropes and springs (slinky) to generate mechanical waves. |
| (b) Pulsating system: Energy transmitted with definite speed, frequency and wavelength | Use of ripple tank to show water waves and to demonstrate energy propagation by waves. Hertz (Hz) as unit of frequency. |
| (c) Waveform | Description and graphical representation. Amplitude, wavelength, frequency and period. Sound and light as wave phenomena. |
| (d) Mathematical relationship connecting frequency (f), wavelength (λ), period (T) and velocity (v) | $v = f\lambda$ and $T = \frac{1}{f}$. Simple problems may be set. |
| 18. Types of waves | |
| (a) Transverse, longitudinal and stationary waves | Examples to be given. |
| (b) Mathematical representation of wave motion. | Equation $y = A \sin \left(\omega t \pm \frac{2\pi x}{\lambda} \right)$ to be explained Questions on phase difference will not be set. |
| 19. Properties of waves: Reflection, refraction, diffraction, interference, superposition of progressive waves producing standing/stationary waves. | Ripple tank should be extensively used to demonstrate these properties with plane and circular waves. Explanation of the properties. |
| 20. Light waves | |
| (a) Sources of light | Natural and artificial. Luminous and non-luminous bodies. |

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| (b) Rectilinear propagation of light | Formation of shadows and eclipse. Pinhole camera. Simple numerical problems may be set. |
| (c) Reflection of light at plane surface: plane mirror | Regular and irregular reflection. Verification of laws of reflection. Formation of images. Inclined plane mirrors. Rotation of mirrors. Applications in periscope, sextant and kaleidoscope. |
| (d) Reflection of light at curved surfaces: concave and convex mirrors | <p>Laws of reflection. Formation of images. Characteristics of images. Use of mirror formulae:</p> $\frac{1}{u} + \frac{1}{v} = \frac{1}{f} \text{ and magnification } m = \frac{v}{u}$ <p>to solve numerical problems (Derivation of formulae is not required)</p> <p>Experimental determination of the focal length of concave mirror. Applications in searchlight, parabolic and driving mirrors, car headlamps, etc.</p> |
| (e) Refraction of light at plane surfaces: rectangular glass prism (block) and triangular prism. | <p>Laws of refraction. Formation of images, Real and Apparent depth. Critical angle and total internal reflection. Lateral displacement and angle of deviation. Use of minimum deviation equation:</p> $\mu = \frac{\sin(A + D_m)}{2 \sin A/2}$ <p>(Derivation of the formula is not required)</p> <p>Applications: periscope, prism binoculars, optical fibres. The mirage.</p> |
| (f) Refraction of light at curved surfaces: Converging and diverging lenses | <p>Formation of images. Use of lens formulae</p> $\frac{1}{u} + \frac{1}{v} = \frac{1}{f} \text{ and magnification } \frac{v}{u}$ <p>to solve numerical problems.</p> |

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| | (Derivation of the formulae not required). Experimental determination of the focal length of converging lens. Power of lens in dioptries D. |
| (g) Application of lenses in optical instruments. | Simple camera, the human eye, film projector, simple and compound microscopes, terrestrial and astronomical telescopes. Angular magnification. Prism binoculars. The structure and function of the camera and the human eye should be compared. Defects of the human eye and their corrections. |
| (h) Dispersion of white light by a triangular glass prism. | Production of pure spectrum of a white light. Recombination of the components of the spectrum. Colour of objects. Mixing coloured lights. |
| 21. Electromagnetic waves: Types of radiation in electromagnetic spectrum | Elementary description and uses of various types of radiation: Radio, infrared, visible light, ultra-violet, X-rays, gamma rays. |
| 22. Sound Waves | |
| (a) Sources of sound | |
| (b) Transmission of sound waves | Experiment to show that a material medium is required. |
| (c) Speed of sound in solid, liquid and air | To be compared. Dependence of velocity of sound on temperature and pressure to be considered. |
| (d) Echoes and reverberation | Use of echoes in mineral exploration, and determination of ocean depth. Thunder and multiple reflections in a large room as examples of reverberation. |
| (e) Noise and music | |
| (f) Characteristics of sound | Pitch, loudness and quality |

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| (g) Vibration in strings | <p>The use of sonometer to demonstrate the dependence of frequency (f) on length (l), tension (T) and linear density (m) of string should be treated. Use of the formula:</p> $f_o = \frac{1}{2l} \sqrt{\frac{T}{m}}$ <p>in solving simple numerical problems. Applications in stringed instruments e.g. guitar, piano, harp, violin etc.</p> |
| (h) Forced vibration | Use of resonance boxes and sonometer to illustrate forced vibration. |
| (i) Resonance (ii) Harmonics and overtones | Use of overtones to explain the quality of a musical note. Applications in percussion instruments e.g. drum, bell, cymbals, xylophone, etc. |
| (i) Vibration of air in pipe – open and closed pipes | Measurement of velocity of sound in air or frequency of tuning fork using the resonance tube. Use of the relationship $v = f\lambda$ in solving numerical problems. End correction is expected. Applications in wind instruments e.g. organ, flute, trumpet, horn, clarinet, saxophone, etc. |

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PART IV

FIELDS

| TOPICS | NOTES |
|--|---|
| <p>23. Description and property of fields.</p> <p>(a) Concept of fields: Gravitational, electric and magnetic</p> <p>(b) Properties of a force field</p> | <p>Use of compass needle and iron filings to show magnetic field lines.</p> |
| <p>24. Gravitational field</p> <p>(a) Acceleration due to gravity, (g)</p> <p>(b) Gravitational force between two masses: Newton's law of gravitation</p> <p>(c) Gravitational potential and escape velocity.</p> | <p>g as gravitational field intensity should be mentioned, $g = F/m$.</p> <p>Masses include protons, electrons and planets</p> <p>Universal gravitational constant (G). Relationship between 'G' and 'g'</p> <p>Calculation of the escape velocity of a rocket from the earth's gravitational field.</p> |
| <p>25. Electric Field</p> <p>(1) Electrostatics</p> <p>(a) Production of electric charges</p> <p>(b) Types of distribution of charges</p> <p>(c) Storage of charges</p> <p>(d) Electric lines of force</p> | <p>Production by friction, induction and contact.</p> <p>A simple electroscope should be used to detect and compare charges on differently-shaped bodies.</p> <p>Application in light conductors.</p> <p>Determination, properties and field patterns of charges.</p> |

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| (e) Electric force between point charges: Coulomb's law | Permittivity of a medium. |
| (f) Concepts of electric field, electric field intensity (potential gradient) and electric potential. | Calculation of electric field intensity and electric potential of simple systems. |
| (g) Capacitance – Definition, arrangement and application | Factors affecting the capacitance of a parallel – plate capacitor. The farad (F) as unit of capacitance. Capacitors in series and in parallel. Energy stored in a charged capacitor. Uses of capacitors e.g. in radio, T.V. etc. (Derivation of formulae for capacitance is not required) |
| (2) Current electricity | |
| (a) Production of electric current from primary and secondary cells | Simple cell and its defects. Daniell cell, Leclanché cell (wet and dry). Lead-acid accumulator, Alkaline-cadium cell. E.m.f. of a cell, the volt (V) as unit of e.m.f. |
| (b) Potential difference and electric current | Ohm's law and resistance. Verification of Ohm's law. The volt (V), ampere (A) and ohm (Ω) as units of p.d., current and resistance respectively. |
| (c) Electric circuit | Series and parallel arrangements of cells and resistors. Lost volt and internal resistance of batteries. |
| (d) Electric conduction through materials | Ohmic and non ohmic conductors. Examples should be given. |
| (e) Electric energy and power | Quantitative definition of electrical energy and power. Heating effect of electrical energy and its application. Conversion of electrical energy to mechanical energy e.g. electric motors. Conversion of solar energy to electrical and heat energies e.g. solar cells, solar heaters, etc. |

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| (f) Shunt and multiplier | Use in conversion of a galvanometer into an ammeter or a voltmeter. |
| (g) Resistivity and Conductivity | Factors affecting the electrical resistance of a material should be treated. Simple problems may be set. |
| (h) Measurement of electric current, potential difference, resistance, e.m.f. and internal resistance of a cell. | Principle of operation and use of ammeter, voltmeter, potentiometer, metre bridge, and wheatstone bridge. |
| 26. Magnetic field | |
| (a) Properties of magnets; Magnetic materials. | Practical examples such as soft iron, steel and alloys. |
| (b) Magnetization and de-magnetization | Temporary and permanent magnets. Comparison of iron and steel as magnetic materials. |
| (c) Concept of magnetic field | Magnetic flux and magnetic flux density. Magnetic field around a permanent magnet, a current-carrying conductor and a solenoid. Plotting of lines of force to locate neutral points. Units of magnetic flux and magnetic flux density as weber (Wb) and tesla (T) respectively |
| (d) Force on a current-carrying conductor placed in a magnetic field and between two parallel current-carrying conductors | Qualitative treatment only. Applications: electric motor and moving-coil galvanometer. |
| (e) Use of electromagnets | Examples in electric, bell telephone earpiece etc. |
| (f) Earth's magnetic field | Mariner's compass. Angles of dip and declination. |
| (g) Magnetic force on a moving charged particle | Solving simple problems involving the motion of a charged particle in a magnetic field |
| 27. Electromagnetic field | |
| (a) Concept of electromagnetic field | Identifying the directions of current, magnetic field and force in an electromagnetic field (Fleming's left-hand rule). |

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|---|---|
| (b) Electromagnetic induction Faraday's law, Lenz's law and motor-generator effect | Applications: Generator (d.c. and a.c.), induction coil and transformer. The principles underlying the production of direct and alternating currents should be treated. Equation $E = E_0 \sin \omega t$ should be explained. |
| (c) Inductance | Explanation of inductance. Henry as unit of inductance. Energy stored in an inductor $(E = \frac{1}{2} LI^2)$ Application in radio, T.V., transformer. (Derivation of formula is not required). |
| (d) Eddy current | A method of reducing eddy current losses should be treated. Applications in induction furnace, speedometer, etc. |
| (e) Power transmission and distribution | Reduction of power losses in high-tension transmission lines. Household wiring system should be discussed. |
| 28. Simple a.c. circuits | |
| (a) Graphical representation of e.m.f. and current in an a.c. circuit. | Graphs of equation $I = I_0 \sin \omega t$ and $E = E_0 \sin \omega t$ should be treated. |
| (b) Peak and r.m.s. values | Phase relationship between voltage and current in the circuit elements; resistor, inductor and capacitor. |

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| TOPICS | NOTES |
|--|---|
| (c) Series circuit containing resistance, inductance and capacitance | Simple calculations involving a.c. circuit. (Derivation of formulae is not required.) |
| (d) Reactance and impedance | X_L and X_C should be treated. Simple numerical problems may be set. |
| (e) Vector diagrams | |
| (f) Resonance in an a.c. circuit | Applications in tuning of radio and T.V. should be discussed. |
| (g) Power in an a.c. circuit | |

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PART V

ATOMIC AND NUCLEAR PHYSICS

| TOPICS | NOTES |
|---|---|
| 29. Structure of the atom (a) Models of the atom (b) Energy quantization (c) Photoelectric effect (d) Thermionic emission (e) X-rays | Thomson, Rutherford, Bohr and electron-cloud (wave-mechanical) models should be discussed qualitatively. Limitations of each model. Quantization of angular momentum (Bohr) Energy levels in the atom. Colour and light frequency. Treatment should include the following: Frank-Hertz experiment, Line spectra from hot bodies, absorption spectra and spectra of discharge lamps. Explanation of photoelectric effect. Dual nature of light. Work function and threshold frequency. Einstein's photoelectric equation and its explanation. Applications in T.V., camera, etc. Simple problems may be set. Explanation and applications. Production of X-rays and structure of X-ray tube. Types, characteristics, properties, uses and hazards of X-rays. Safety precautions. |
| 30. Structure of the nucleus (a) Composition of the nucleus | Protons and neutrons. Nucleon number (A), proton number (Z), neutron number (N) and the equation: $A=Z + N$ to be treated. Nuclides and their notation. Isotopes. |

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| TOPICS | NOTES |
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| (b) Radioactivity – Natural and artificial | Radioactive elements, radioactive emissions (α , β , γ) and their properties and uses. Detection of radiations by G – M counter, photographic plates, etc. should be mentioned. Radioactive decay, half-life and decay constant. Transformation of elements. Applications of radioactivity in agriculture, medicine, industry, archaeology, etc. |
| (c) Nuclear reactions – Fusion and Fission | Distinction between fusion and fission. Binding energy, mass defect and energy equation: $E = mc^2$ Nuclear reactors. Atomic bomb. Radiation hazards and safety precautions. Peaceful uses of nuclear reactions. |
| 31. Wave-particle paradox (a) Electron diffraction (b) Duality of matter | Simple illustration of the dual nature of light. |

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SECTION B
(FOR CANDIDATES IN NIGERIA)

| TOPICS | NOTES |
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| 1. Projectiles Concept of projectiles as an object thrown/released into space | Applications of projectiles in warfare, sports etc. Simple problems involving range, maximum height and time of flight may be set. |
| 2. Properties of waves: Polarization | The mechanical analogue of polarization should be demonstrated. Application of polarization in polaroid. |
| 3. Electrical conduction through liquids | Electrolytes and non-electrolytes: conduction of charge carriers through electrolytes; voltameter, electroplating, Faraday's law of electrolysis – Calibration of the ammeter. |
| 4. Electrical conduction through gases | Discharge through gases; hot cathode emission. Application e.g. in neon signs, fluorescent tubes etc. |
| 5. Elastic properties of solids: (a) Hooke's law (b) Young's modulus (c) Work done in springs and elastic strings | Qualitative treatment of Young's modulus only. |
| 6. Structure of matter | Use of the kinetic theory of matter to explain diffusion. |
| 7. Surface tension | Definition and effects (capillarity, cohesion and adhesion). Applications e.g. in umbrellas, canvas, and in the use of grease and detergents |
| 8. Wave-particle paradox The uncertainty principle | Explain the uncertainty principle in very general terms with specific examples. |

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SECTION C
(FOR CANDIDATES IN GHANA)

| TOPICS | NOTES |
|---------------------------------------|--|
| 1. Dimensions, measurements and units | Dimensional analysis: Use in determining formulae and units. |
| 2. Engines | Internal combustion engines, jet engines and rockets. Principles of operation of engines. |
| 3. Heat capacity | Use of cooling curve to determine the specific heat capacity of a liquid and also to determine the melting point of naphthalene. |
| 4. Gases | Van der Waals' equation for one mole of real gas. |
| 5. Beats | Explanation of the phenomena of beats, beat frequency uses of beats. |
| 6. Doppler effect | Explanation of Doppler effect of sound. Only qualitative treatment required. |
| 7. Electrical networks | Kirchhoff's laws. Application in electrical networks. Potential divider. |
| 8. Gravitational force | Satellites – artificial and natural. Orbits of satellites particularly geo-stationary orbits. Derivation of the expression of the period of satellites. |
| 9. Magnetic fields | Applications of magnetic force on a moving charged particle e.g. in deflection of charged particles in a T.V. and mass spectrometer. Lorentz force in crossed electric and magnetic fields. |

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| TOPICS | NOTES |
|----------------------------|---|
| 10. Electronics | |
| (a) Solid state materials | Distinction between conductors, semi-conductors and insulators in terms of conductivity and modes of conduction. Intrinsic conduction. Valence, conduction and forbidden energy bands, and how they affect the conductivity of materials. Doping of semi-conductors, p – and n – type semi-conductors. Majority and minority carriers. |
| (b) Semi-conductor devices | I – V characteristic of p – n junction diode. Rectification: half and full wave rectification. Smoothing of rectified wave forms using capacitors. Mode of operation of p-n-p and n-p-n transistors. Simple single stage amplifier. Integrated circuits should be mentioned. |

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PHYSICS

SECTION D
(FOR CANDIDATES IN SIERRA LEONE)

| TOPICS | NOTES |
|--|--|
| 1. Projectiles Concept of projectiles as an object thrown/ released into space. | Applications of projectiles in warfare, sports etc. Simple problems involving range, maximum height and time of flight may be set. |
| 2. Engines | Internal combustion engines, jet engines and rockets. Principle of operation of engines. |
| 3. Properties of wave: Polarization | The mechanical analogue of polarization should be demonstrated. Application of polarization in polaroid. |
| 4. Beats | Explanation of phenomenon of beats, beat frequency. Uses of beats. |
| 5. Electrical conduction through liquids | Electrolytes and non-electrolytes: conduction of charge carriers through electrolytes; voltammeter, electroplating, Faraday's law of electrolysis. Calibration of the ammeter. |
| 6. Electrical conduction through gases | Discharge through gases; hot cathode emission. Application e.g. in neon signs, fluorescent tubes etc. |
| 7. Satellite – Artificial and natural | Orbits of satellites particularly geo-stationary orbits. Derivation of the expression for the period of orbit of satellites required. |
| 8. Magnetic fields | Applications of magnetic force on a moving charged particle e.g. in deflection of charged particles in cathode-ray tubes. |

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PHYSICS

| TOPICS | NOTES |
|--|--|
| 9. Elastic properties of solids: (a) Hooke's law (b) Young's modulus (c) Work done in springs and elastic strings | Qualitative treatment of Young's modulus only. |
| 10. Structure of matter | Use of the kinetic theory of matter to explain diffusion. |
| 11. Surface tension | Definition and effects (capillarity, cohesion and adhesion). Applications e.g. in umbrellas, canvas, and in the use of grease and detergents. |
| 12. Electronics | Distinction between conductors, semi-conductors and insulators in terms of conductivity and modes of conduction. Semi-conductor diode: Brief and qualitative treatment of the theory of p-type and n-type. The p-n junction diode and its current/voltage characteristic. The use of a diode as a rectifier. |

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PHYSICS

SECTION E
(FOR CANDIDATES IN THE GAMBIA)

| TOPICS | NOTES |
|--|--|
| 1. Projectiles Concept of projectiles as an object thrown/released into space | Applications of projectiles in warfare, sports etc. Simple problems involving range, maximum height and time of flight may be set. |
| 2. Properties of waves: Polarization | The mechanical analogue of polarization should be demonstrated. Application of polarization in polaroid. |
| 3. Electrical conduction through liquids | Electrolytes and non-electrolytes: conduction of charge carriers through electrolytes; voltameter, electroplating, Faraday's law of electrolysis – Calibration of the ammeter. |
| 4. Electrical conduction through gases | Discharge through gases; hot cathode emission. Application e.g. in neon signs, fluorescent tubes etc. |
| 5. Elastic properties of solids | Hooke's law |
| 6. Structure of matter | Use of the kinetic theory of matter to explain diffusion. |
| 7. Surface tension | Definition and effects. Application. |