WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION
APPLIED ELECTRICITY

PREAMBLE

This examination syllabus has been evolved from the Senior Secondary School Applied Electricity curriculum. The examination syllabus does not replace the curriculum.

The two major concepts that permeate the entire syllabus are electricity production and utilization.

There are two alternative syllabuses for this subject. Candidates in Ghana are required to opt for Alt. A and other candidates for Alt. B

OBJECTIVE

The objective of the syllabus is to test the candidates' knowledge and understanding of

(1) the basic concepts and principles of Applied Electricity;

(2) safe working procedures and safety precautions in domestic and industrial environment;

(3) the basic skills in electrical installation, fault tracing and simple electrical repairs;

(4) the principles of operation and the application of simple electronic devices.

EXAMINATION SCHEME

There will be two papers both of which must be taken.

Paper 1: Practical Test (3hours)

This paper will consist of two experiments to be carried out by candidates in 3 hours for 100 marks.

Questions for the practical paper will be taken from the following areas common to the two alternative syllabuses viz:

(1) d.c and a.c. circuit theories

(2) measuring instruments

(3) d.c and a.c machines

(4) electromagnetic induction

Paper 2: Theory (2¼ hours)

Section A – will comprise 60 multiple choice objective questions to be attempted in 1¼ hours. The section carries 60 marks.

Section B – will comprise 6 structured/short answer questions, out of which candidates will be expected to attempt 5 questions in 1 hour.

This section carries 40 marks.

The use o*f non-programmable* calculators are permitted in the examination.

WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION
APPLIED ELECTRICITY

ALTERNATIVE A

DETAILED SYLLABUS

TOPICS	NOTES
1. DIRECT CURRENT CIRCUIT THEORY	
Nature of electricity	
Insulators and conductors	
Circuit theory, Ohm's Law, Kirchhoff's Laws	Qualitative treatment only.
Resistors	Series and parallel circuits. Colour coding, ratings and types of resistors.
Resistivity and Conductivity	Quantitative treatment.
Power and energy	Treatment should include calculations.
2. MAGNETIC FIELD	
Fundamentals of magnetism	Treatment should include magnetic flux, magnetic flux density, permeability, magnetomotive force, magnetizing force and reluctance.
Comparison between magnetic and electric circuits	Calculations involving series magnetic circuits should be expected.
Description of magnetizing curve and hysteresis loop	Qualitative treatment only.
3. ELECTRIC FIELD	
Concept of Electric field	Electric flux, electric flux density, electric field strength, permittivity and dielectric constant, potential gradient.
Definition of capacitance	Explanation of the formula $C = \frac{Q}{V}$
Structure, type, coding and applications of capacitors	Types should include: air, paper, mica, ceramic, polyester and electrolytic capacitors
Capacitance in terms of dimensions.	$C = \epsilon_o \epsilon_r \frac{A}{d}$

TOPICS	NOTES
Capacitors in series and in parallel	Treatment should include charge and energy stored. ($E=\frac{1}{2}QV=\frac{1}{2}CV^2$)
4. ELECTROMAGNETIC INDUCTION	
Magnetic field around a current-carrying conductor and a solenoid	Qualitative treatment only, making mention of Screw rule or Right Hand grip rule.
Force on a current-carrying conductor in a magnetic field.	Quantitative treatment, expected use of the formula $F = BIL\sin\theta$
Quantitative treatment of emf induced in a coil due to:	Fleming's Left Hand Rule $E = BLV\sin\theta$
(i) velocity (ii) flux change	Self induction, mutual induction. Treatment of Fleming's Right Hand Rule. Lenz's Law and Faraday's Law.
Energy stored in a coil	$E=\frac{1}{2}LI^2$
Applications of electromagnetism	No derivation is required. Applications, should include electric bell, solenoid, loudspeaker, buzzer, moving-coil instruments.
5. MEASURING INSTRUMENTS	
Principles of operation, application and protection of measuring instruments.	Moving coil, moving iron, ohmmeter, multimeter, voltmeter, ammeter, cathode ray oscilloscope; comparison of moving coil and moving iron instruments.
Conversion of milliameter into ammeter, voltmeter and ohmmeter.	Quantitative treatment required.
6. EMISSION OF ELECTRONS Thermionic emission, photo emission	Qualitative treatment only.
Secondary emission	Qualitative treatment only.
Field emission	Qualitative treatment only.

TOPICS	NOTES
7. THERMIONIC DEVICES Diode, triode, tetrode and pentode	Qualitative treatment of devices and their characteristics. In the case of the triode, parameters must be defined, used as an amplifier must be stressed and typical values must be mentioned.
8. DIGITAL ELECTRONICS Binary numbers	Conversion of denary to binary and vice versa. Addition and subtraction of binary numbers.
Logic gates	Qualitative treatment of AND, OR, NOT, NAND, NOR, Exclusive OR using switches, diodes, transistors and logic gates. For each gate, the symbol, truth table and Boolean expression are required.
9. ALTERNATING CURRENT CIRCUIT THEORY Generation of e.m.f. in a single turn coil.	Plotting of labelled sinusoidal wave for a cycle.
Definition of period, cycle, frequency, peak, average and r.m.s. values including calculations Waveform plotting from rotating phasors	Addition, subtraction of sine waves. Effect of phase shift.
Circuits	Resistive, inductive, capacitive. Series RL, RC, RLC circuits.
Series resonance	Quantitative treatment Frequency-response curve.
Power in a.c. circuit	Quantitative treatment Single-phase and three-phase. Difference between active and reactive power using phasor diagrams. Power factor and the effect of low power factor.
Star and delta connections	Using diagrams to show the differences between star and delta connections The following should be explained. (a) relationship between phase and line quantities (voltage and current for both connections).

TOPICS	NOTES
	(b) Power factor concept (c) Effect of low power factor Simple problems excluding those of power factor improvement.
10. TRANSFORMERS	
Types, construction, action and transformation ratio	Shell and core types, single-phase, three-phase. The use of laminations should be explained. The circuit diagram of only single-phase transformer is required.
Transformer action	Quantitative treatment of the transformer: (a) induced e.m.f. (b) conservation of energy.
Losses and efficiency	Open circuit test to determine iron losses, short circuit test to determine copper losses Quantitative treatment Efficiency = $\frac{\text{input} - \text{losses}}{\text{input}} \times 100\%$
Losses and temperature rise in transformers.	Losses should include copper losses, iron losses and stray losses. Methods of minimizing the losses.
11. SEMI-CONDUCTORS DEVICES AND POWER SUPPLY Semiconductor theory	Qualitative treatment of energy band theory, intrinsic and extrinsic semiconductors, doping Qualitative treatment only.
Diodes	I-V characteristics to show forward and reverse biasing. Types, rating and applications. Applications should include: rectification, clamping, detection, clipping and d.c. rectification.
Rectification	Half and full wave, including filtering (smoothing) central and doubling.

TOPICS	NOTES
Bipolar transistors configuration Characteristics of common-emitter only	Qualitative treatment of p-n-p and n-p-n transistors. Qualitative treatment with simple problems on the common-emitter amplifier.
Deficiencies in transistors	Thermal runaway and beta spread. The need for heat sinking must be emphasized.
Other semiconductor devices- Field effect transistor, thermistor, diac, triac and thyristor.	Circuit symbols, switching operation and application of each device.
Integrated circuits	Formation, functions and limitations.
12. AMPLIFIERS	
A.F. amplifier	Biasing and loadline Output characteristics and power gain.
Power amplifier	Qualitative treatment only for power amplifier. Prevention of distortion. Types should include A,B,C, and their operation and application.
Operational amplifiers; Inverting and non-inverting.	Properties and their applications.
13. COMMUNICATION	
Characteristics of radio waves.	Relationship between velocity, wavelength and frequency. $\lambda = \frac{v}{f}$ Qualitative treatment of amplitude and frequency modulation. Advantages and disadvantages of a.m. and f.m.

TOPICS	NOTES
14. ALTERNATING CURRENT MACHINES	
Alternator: main features, principles of operation and application of alternators.	Descriptive treatment of single-phase alternator and comparison with d.c. generator. Generators in vehicles and small portable power supply.
Relationship between speed, poles and frequency.	Simple problems involving the formula $N = \frac{60f}{p}$
A.C. Motors: main features, principles of operation, and application of single-phase and three-phase motors.	Descriptive treatment of single-phase motors such as capacitor start and run, universal or series, repulsion and hysteresis motors.
Methods of starting induction three-phase motors.	Direct-on-line, star/delta auto-transformer
15. DIRECT CURRENT MACHINES	
D.C. Generators: main features principles of operation, methods of connecting the field circuits and applications	Qualitative treatment Use of $E=V + I_aR_a$ Use of d.c. generators in bicycles, cars and lorries should be emphasized.
D.C. Motors: main features, principles of operation, types, characteristics, methods of starting and applications.	Should be treated quantitatively E=V – IaRa For method of starting use face-plate starter and d.c. power supply.
Voltage regulation	Quantitative treatment, percentage voltage regulation.
Methods of cooling.	Air, oil, oil and air, oil and fan or forced cooling.

TOPICS	NOTES
16. ELECTRICAL POWER SUPPLY, WIRING AND ACCESSORIES Generating systems	Brief mention of power generating systems, e.g., diesel, steam, hydroelectric, nuclear, geothermal, tidal, gas turbine and solar plant systems.
Switchgear and protection	Qualitative treatment of industrial and domestic protective devices such as circuit breakers, cartridge fuses and rewirable fuses.
Earthing of electrical appliances	Qualitative treatment.
Control of lighting by switches, grouping lamps, socket outlets and final sub-circuit	Qualitative treatment.
Ring circuit and spur, cables.	Qualitative treatment.
Maintenance and repairs of various electrical appliances	Electrical appliances should include fluorescent lamp, refrigerator. The use of circuit diagrams should be stressed.

WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION
APPLIED ELECTRICITY

ALTERNATIVE B – DETAILED SYLLABUS

TOPICS	NOTES
1. DIRECT CURRENT CIRCUIT THEORY	
Insulators and conductors; resistivity and conductivity Colour coding and ratings of resistors, series and parallel circuits, power in d.c circuits	Concepts, definitions and calculations involving all topics.
2. ALTERNATING CURRENT CIRCUIT THEORY	
Waveform plotting from rotating phasor.	Addition and subtraction of sine waves, effect of phase shift.
Phasor diagrams	Sketching and analysis of phasor diagrams
Circuits	Resistive, inductive, capacitive, RL, RC, LC and RLC in series. Characteristics and calculations involving each circuit.
Inductive reactance, Capacitive reactance.	Concepts, definitions, symbols, unit of measurement and simple calculations.
Series resonance	Simple calculations involving resonant circuits.
Bandwidth	Concepts and applications.
Power in a.c. circuits	Treatment should include single-phase; real, reactive and apparent power. Power factor.
3. ELECTROMAGNETIC FIELD	
Basic concepts of electromagnetism	Concepts, definitions, symbols and units of measurement involving magnetic flux, flux density, magnetomotive force, magnetising force, reluctance and permeability. Analysis of e.m.f. induced in a conductor cutting magnetic flux.
Magnetic circuits	Calculations involving homogenous cores.
Capacitor	Coding, ratings and applications. Concepts and definitions. Relationship between capacitance and dimensions.

TOPICS	NOTES
Energy stored in charged capacitors Electromagnetic induction	Treatment should include capacitors in series and parallel combinations. Concepts and definitions of self and mutual induction.
Laws of electromagnetic induction Applications of electromagnetism	Lenz's Law and Faraday's Law. Principles of operation and applications of induction in electric bells, buzzers, telephones, receivers, loudspeakers and relays. Treatment should include construction of electric bells, transformers and buzzers.
4. ELECTRICAL ENERGY SUPPLY Sources of d.c.	Batteries (primary and secondary cells); description and characteristics of the cells. Qualitative treatment of d.c. generators and solar cells as sources of d.c. supply.
Sources of a.c.	Alternators (single-phase and three-phase). Treatment should include description, characteristics and ratings.
Basic electrical power system	Layout diagram of a simple power system. Treatment should include standard symbolic representation and functions of basic electrical power system components like transmission lines, circuit breakers, transmission substations, distribution system and loads.
Generating stations	Treatment of generating stations should cover hydro, steam (coal, oil, gas), nuclear and diesel power stations. Basic operating principles. Main components and their functions. Block diagram representation showing prime mover and generator.
Transmissions	Layout diagram of high voltage overhead transmission system. Treatment of main components (towers, insulators and conductors) and functions. Exhaustive treatment of components not required. Operating voltage levels for transmission lines (132kV and 330kV) and the need for high voltage system should be highlighted.
Faults	Types of faults – Three-phase faults, single-line to ground faults, line-to-line faults. Effects of the faults. Detailed treatment of fault is not required.

TOPICS	NOTES
Substations	Types of substations (main and distribution) and their functions. Layout and functions of component (distribution transformers, isolators, fuses).
Distribution system	Treatment of distribution transformers should include types and name plate ratings. Layout and main components (overhead distribution lines, underground cables and loads). Types of distribution system (radial and ring). Distribution feeder voltages – 3.3kV, 6.6kV, 11kV and 33kV Low voltage levels: 415V and 240V. Types of load (residential, industrial and commercial loads).
Construction of underground distribution cables	Constructing materials should only be treated (conductors, insulators and outer servicings).
5. MEASURING INSTRUMENTS Measuring Instruments	Basic components (operating devices, controlling device (gravity and spring), damping device (air-dashpot and eddy current) and measuring scale. Types (moving iron and moving coil). Advantages and disadvantages of each instrument type should be highlighted.
Conversion of milliammeter to voltmeter and ammeter	Quantitative treatment required.
Applications of measuring Instruments	Use of ammeters, voltmeters, multimeters, insulation resistance tester, ohmmeter, wattmeter, watt-hour meter (energy meter).
6. ELECTRICAL MACHINES (D.C.)	Principles of operation. Main features (exciter, stationary magnetic field, armature, commutator). Quantitative treatment essential. Use of $E = V + Ia\,Ra$ necessary.
D.C. generators	
Field Circuits	Methods of connecting field circuits (series, shunt, and compound). Characteristics of each method should be treated.
Applications of d.c. generators	Use of d.c. generators in bicycles, vehicles, laboratories and industries should be emphasized.

TOPICS	NOTES
D.C. motors	Principles of operation. Main features (field armature, sources of e.m.f.) Contents should be treated quantitatively. Use of E=V-Ia Ra essential.
Method of starting	Characteristics of d.c. motors (speed, torque, load and their relationship) Manual and automatic. Qualitative treatment
Application of d.c. motors	Use of d.c. motors in traction, trams, cranes and toys should be emphasized.
7. ELECTRICAL MACHINES (A.C.)	
A.C. generators	Main features (exciter, starter, rotor, slip rings and brush gear). Principle of operation and application of single-phase alternators. Relationship between speed, poles and frequency should be treated. Problems involving $N = (120f)/p$ should be expected.
A.C. motors	Principle of operation. Descriptive treatment of various types – single-phase (induction and repulsion motors); three-phase (induction and synchronous motors).
Application of A.C. motors	(1) Use of single-phase motors in the household: water pump, refrigerators, grinding machines, table fans and ceiling fans should be emphasized. (2) Use of three-phase motors in lifts, conveyors, industrial air conditioners and industrial drives should be emphasized.
Transformers	Basic principle (mutual inductance and conservation of energy)
Types of transformers	Single-phase and three-phase (star and delta connections).
Operation of transformers	Magnetic circuit (core), primary windings, secondary windings, turns ratio and transformation ratio.

TOPICS	NOTES
Losses and efficiency	Treatment should include types and characteristics of losses. Tests to determine losses (open circuit test for iron losses, short circuit test for copper losses). Calculations involving efficiency.
Methods of cooling	Air, oil, oil and air, oil and fan or forced cooling.
Applications of transformers	Applications in stepping up and stepping down of voltages, measurement of currents, protection of instruments and welding.
8. ELECTRICAL WIRING Layout Planning	In planning electrical wiring layout the following should be emphasized: (1) Types of materials – cables, wiring pins, clips, woodblocks and conduit pipes. (2) Types & selection of accessories – joint boxes, ceiling roses, sockets, lamp holders. (3) Types of cable jointing – married or tee joints, mechanical soldered joints (4) Types of wiring methods – surface, conduit (surface concealed), trunking; ducting and control of lighting by switches. Preparation of cable ends for connection should be treated.
Surface wiring	Wiring regulations, series and parallel.
Power socket outlet – radial, ring mains, final subcircuit and spur	Types – light gauge, heavy gauge, flexible (metallic and non-metallic).
Conduit, conduit run and fittings.	Junction boxes (circular, angle, twin, through) adaptor, elbow bend, inspection tee, inspection bend, brass bushings – male and female, coupler.
Trunking and ducting	Types (tap-on and busbar trunking, concrete and steel under floor ducts and fittings).

Protection	Emphasis should be placed on need for and methods of protection against fire, excess current, over voltage, under voltage, shock, corrosion, leakage and mechanical damage. Types and principles of operation of protective devices (fuses and circuits breakers) should be treated.
Installation tests	Types (continuity, polarity, earth leakage etc.) Descriptive treatment of these tests and the order in which the tests are carried out should be treated.
Fault diagnosis and repairs in circuits	Short circuit, open circuit (blown fuse or open miniature circuit breaker and earth faults should be treated.
Earthing	The need, methods and tests should be treated. Measuring of earth continuity conductor and earth fault loop impedance, sizes of earthing lead should be emphasized.