

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 of *non-programmable* calculators are permitted in the examination.

WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION
APPLIED ELECTRICITY

ALTERNATIVE A
DETAILED SYLLABUS

TOPICS	NOTES
<p>1. DIRECT CURRENT CIRCUIT THEORY</p> <p>Nature of electricity Insulators and conductors Circuit theory, Ohm's Law, Kirchhoff's Laws Resistors</p> <p>Resistivity and Conductivity Power and energy</p>	<p>Qualitative treatment only.</p> <p>Series and parallel circuits. Colour coding, ratings and types of resistors.</p> <p>Quantitative treatment. Treatment should include calculations.</p>
<p>2. MAGNETIC FIELD</p> <p>Fundamentals of magnetism</p> <p>Comparison between magnetic and electric circuits</p> <p>Description of magnetizing curve and hysteresis loop</p>	<p>Treatment should include magnetic flux, magnetic flux density, permeability, magnetomotive force, magnetizing force and reluctance.</p> <p>Calculations involving series magnetic circuits should be expected.</p> <p>Qualitative treatment only.</p>
<p>3. ELECTRIC FIELD</p> <p>Concept of Electric field</p> <p>Definition of capacitance</p> <p>Structure, type, coding and applications of capacitors</p> <p>Capacitance in terms of dimensions.</p>	<p>Electric flux, electric flux density, electric field strength, permittivity and dielectric constant, potential gradient.</p> <p>Explanation of the formula</p> $C = \frac{Q}{V}$ <p>Types should include: air, paper, mica, ceramic, polyester and electrolytic capacitors</p> $C = \epsilon_0 \epsilon_r \frac{A}{d}$

WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION
APPLIED ELECTRICITY

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	Self induction, mutual induction. Treatment of Fleming's Right Hand Rule. Lenz's Law and Faraday's Law.
(ii) flux change	
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 milliammeter 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.

WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION
APPLIED ELECTRICITY

TOPICS	NOTES
<p>7. THERMIONIC DEVICES</p> <p style="padding-left: 40px;">Diode, triode, tetrode and pentode</p>	<p>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.</p>
<p>8. DIGITAL ELECTRONICS</p> <p style="padding-left: 40px;">Binary numbers</p> <p style="padding-left: 40px;">Logic gates</p>	<p>Conversion of denary to binary and vice versa. Addition and subtraction of binary numbers.</p> <p>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.</p>
<p>9. ALTERNATING CURRENT CIRCUIT THEORY</p> <p style="padding-left: 40px;">Generation of e.m.f. in a single turn coil.</p> <p style="padding-left: 40px;">Definition of period, cycle, frequency, peak, average and r.m.s. values including calculations</p> <p style="padding-left: 40px;">Waveform plotting from rotating phasors</p> <p style="padding-left: 40px;">Circuits</p> <p style="padding-left: 40px;">Series resonance</p> <p style="padding-left: 40px;">Power in a.c. circuit</p> <p style="padding-left: 40px;">Star and delta connections</p>	<p>Plotting of labelled sinusoidal wave for a cycle.</p> <p>Addition, subtraction of sine waves. Effect of phase shift.</p> <p>Resistive, inductive, capacitive. Series RL, RC, RLC circuits.</p> <p>Quantitative treatment Frequency-response curve.</p> <p>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.</p> <p>Using diagrams to show the differences between star and delta connections The following should be explained.</p> <p style="padding-left: 40px;">(a) relationship between phase and line quantities (voltage and current for both connections).</p>

WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION
APPLIED ELECTRICITY

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

WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION
APPLIED ELECTRICITY

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

WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION
APPLIED ELECTRICITY

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

WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION
APPLIED ELECTRICITY

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

WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION
APPLIED ELECTRICITY

ALTERNATIVE B – DETAILED SYLLABUS

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

WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION
APPLIED ELECTRICITY

TOPICS	NOTES
<p>Energy stored in charged capacitors Electromagnetic induction</p> <p>Laws of electromagnetic induction Applications of electromagnetism</p>	<p>Treatment should include capacitors in series and parallel combinations. Concepts and definitions of self and mutual induction.</p> <p>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.</p>
<p>4. ELECTRICAL ENERGY SUPPLY</p> <p>Sources of d.c.</p> <p>Sources of a.c.</p> <p>Basic electrical power system</p> <p>Generating stations</p> <p>Transmissions</p> <p>Faults</p>	<p>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.</p> <p>Alternators (single-phase and three-phase). Treatment should include description, characteristics and ratings.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p>

WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION
APPLIED ELECTRICITY

TOPICS	NOTES
D.C. motors	Principles of operation. Main features (field armature, sources of e.m.f.) Contents should be treated quantitatively. Use of $E = V - I_a R_a$ 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.

WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION
APPLIED ELECTRICITY

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: <ul style="list-style-type: none"> (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. <p>Preparation of cable ends for connection should be treated.</p>
Surface wiring Power socket outlet – radial, ring mains, final subcircuit and spur Conduit, conduit run and fittings.	Wiring regulations, series and parallel. Types – light gauge, heavy gauge, flexible (metallic and non-metallic). 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).

WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION
APPLIED ELECTRICITY

Protection	<p>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.</p> <p>Types and principles of operation of protective devices (fuses and circuits breakers) should be treated.</p>
Installation tests	<p>Types (continuity, polarity, earth leakage etc.)</p> <p>Descriptive treatment of these tests and the order in which the tests are carried out should be treated.</p>
Fault diagnosis and repairs in circuits	<p>Short circuit, open circuit (blown fuse or open miniature circuit breaker and earth faults should be treated.</p>
Earthing	<p>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.</p>