9.1.0 ELECTRICAL PRINCIPLES

9.1.01 INTRODUCTION

This module unit is intended to equip the trainee with knowledge, skills and attitudes of electrical principles. The purpose of this module unit is to enable the trainee enhance their understanding of other areas of study in this course. Trainees need the knowledge of basic mathematics to facilitate their understanding of this module.

9.1.02 GENERAL OBJECTIVES

By the end of the module unit, the trainee should be able to;

a) understand the principles of direct current circuits.
b) acquire knowledge in the care and maintenance of chemical cells.
c) understand concepts in electrostatics.
d) understand the theory of magnetism and electromagnetism.
e) Understand the principles of operation transformers.

9.1.023 MODULE SUMMARY AND TIME ALLOCATION

ELECTRICAL PRINCIPLES

Code	Sub-Module Unit	Content	Time Hrs		
			Theory	Pract	Total
9.1.1	Direct Current Circuits	Basic electrical quantities and their units Simple circuit diagrams. Ohm's law Determination of resistance of metal conductors Effects of temperature on resistance Kirchhoff's law	2	4	6

9.1.2	Introduction To Direct (D.C.) Generators And Motors	Construction of electric machines Operation of ac/dc machines Characteristics of state machines Types of d.c windings e.m.f equation	2	6	8
9.1.3	Alternating Current Circuits	Operation of circuits Effects of passive elements in a.c. power factor in a.c. circuits	2	2	4
9.1.4	Batteries	Faraday's laws of electrolysis Construction of batteries and their characteristics Batteries connections Charging methods Care and maintenance of batteries Effects of internal resistance on terminal voltage	2	2	4
9.1.5	Electronic Components	Construction of components Operation of components Characteristics of components Application of components	2	2	4
9.1.6	Semiconductor Theory	Atomic theory Classification of materials Intrinsic semiconductors Extrinsic semiconductors The p-n junction	2	2	4

9.1.7	Electrostatics	Electric fields Construction of capacitors Definitions of electrostatic quantities and units Determination of total capacitance Energy stored in a capacitor	2	4	6
9.1.8	Magnetism and Electromagnetism	Magnetic and non-magnetic materials Magnetic field patterns Force on current carrying conductor Magnetic circuit quantities Magnetism curve and hysteresis loop Electromagnetic induction Inductance in materials Total inductance	2	4	6
9.1.9	Transformers	Principle of operation of transformers Types of transformers and their applications Construction of different types of transformers Simple calculations on single phase transformers	2	8	10
9.1.10	Amplifiers	Transistor configuration Transistor characteristics Biasing methods Coupling methods Classes of amplifiers Distortion and noise in amplifiers Operational amplifiers	2	4	6

9.1.11	Power Supplies	Power regulation and stabilization Rectification Smoothing Processes methods Voltage multipliers and dividers Methods of power supply and protection	2	6	8
Total Time			**22**	**44**	**66**

9.1.1 **DIRECT CURRENT CIRCUITS**

Theory

9.1.1T0 *Specific Objectives*

By the end of the sub-module unit, the trainee should be able to:

a) explain the basic electrical quantities and their units
b) draw and interpret simple circuit diagrams
c) state Ohm's law to solve given electrical circuit problems
d) determine the resistance of metal conductors
e) explain the effects of temperature on resistance
f) apply Kirchhoff's laws to solve given electrical circuit problems

Content

9.1.1T1 Basic electrical quantities and their units
- i) E.M.F in volts
- ii) Current in amperes
- iii) Resistance in ohms
- iv) Power in watts
- v) Energy in joules

9.1.1T2 Simple circuit diagrams.
- i) The simple electric circuit
- ii) Resistor in parallel
- iii) Series – parallel connection
- iv) Resistors in series

9.1.1T3 Ohm's law
- i) Statement
- ii) Verification
- iii) Resistance circuit calculations
- iv) Power and energy calculations

9.1.1T4 Determination of resistance of metal conductors
- i) Resistivity
- ii) Conductivity
- iii) Length
- iv) Cross – sectional area

9.1.1T5 Effects of temperature on resistance
- i) Definition of temperature coefficient of resistance
- ii) Positive and negative temperature coefficient
- iii) Simple calculations to any base temperature

9.1.1T6 Kirchhoff's laws

- Current law
- Voltage law
- Calculations

Practice

9.1.1P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) connect simple electrical circuits and measure various electrical quantities
b) verify Ohm's law
c) demonstrate that the resistance of material depends on area, length and resistivity
d) verify Kirchhoff's law

9.1.1C *Competence*
The trainee should have the ability to:
i)Measure electrical quantities
ii)Determine conductor resistance

Content

9.1.1P1 Measurement of electrical quantities
- Current
- Voltage
- Resistance
- Power

9.1.1P2 Verification of Ohm's law

9.1.1P3 Determination of conductor resistance
i) Resistance
ii) Receptivity
iii) length
iv) Area

9.1.1P4 Verification of Kirchhoff's laws
- current law
- voltage law

Suggested Learning Resources
- Dc power source
- Assorted resistance
- Measuring instruments
- Bread boards

9.1.2 **INTRODUCTION TO DIRECT CURRENT (D.C.) GENERATORS AND MOTORS**

Theory

9.1.2T0 *Specific Objectives*
By the end of the topic, the trainee should be able to:
a) explain the construction of electric machines
b) describe the principle of

operation of d.c./ac machines
c) explain characteristics of state machines and typical applications
d) describe different types of d.c. windings
e) derive e.m.f equation

9.1.2C *Competence*
The trainee should have the ability to:
i)operate d.c. machines
ii)carry out maintenance of d.c. machines

Content

9.1.2T1 Construction of electric machines armature
i.Commutator
ii.Windings
iii.Electromagnetic induction
iv.Armature reaction
v.Excitation

9.1.2T2 operation of d.c./a.c machines

9.1.2T3 characteristics of state machines

9.1.2T4 types of d.c. windings

9.1.2T5 Compound wound
- Starting resistors
- Speed characteristics
- Torque

9.1.2T6 e.m.f equation

Practice

9.1.2P0 *Specific Objectives*
By the end of the topic, the trainee should be able to:
a) Operate d.c. machines
b) Carry out maintenance of d.c. machines

Content

9.1.2P1 Operation of d.c. machines
- Starting methods
- Voltage regulation
- Speed control

9.1.2P2 Maintenance of d.c. machines

Suggested Learning Resources
- Lab equipment and tools
- D.C. motor
- Ac motor
- Electrical instruments
- D.C. generators
- D.C. conductors
- Electronic d.c. motor starters
- Face plate starters
- Drum starters

- Workshop tools

9.1.3 **ALTERNATING CURRENT CIRCUIT**

Theory

9.1.3T0 *Specific Objectives*
By the end of the topic the trainee should be able to:
a) explain the principle of operation of a.c. circuits
b) explain the effects of various passive elements in a current
c) Determine power factor in a.c. circuits

9.1.3C Competence
The Trainee should have the ability to:
i) Determine power factor.
ii) Calculate power in ac currents
iii) Explain the
iv) principle of
v) operation of ac generation
vi) Perform power factor improvement
vii) Install power factor correction equipment
viii) Operate ac generator

Content

9.1.3T1 Operation of a.c. circuits

9.1.3T2 Effects of passive elements in a.c circuits
i) Wave forms
ii) Amplitude
iii) Phase angle
iv) Period
v) Roof mean square valve
vi) Average valve
vii) Frequency

9.1.3T3 Power factor in a.c. circuits

Practice

9.1.3P0 *Specific Objectives*
By the end of the topic the trainee should be able to:
a) generate a series wave
b) establish the feature of an a.c. wave form.
c) perform experiment to show effect of power factor

d) identify components of an a.c. generator
e) verify the effects of passive elements in a.c. circuits

Content

9.1.3T1 Wave generation
9.1.3T2 Features of an a.c. waveform
9.1.3T3 Power factor
9.1.3T4 Components of an a.c. generator
9.1.3T5 Passive elements in a.c. circuits

Suggested Learning Resources

Charts
- Graph
- Calculations
- Cathode Ray Oscilloscope
- Multimeter
- a.c. generator kit
- a.c. generator

9.1.4 **BATTERIES**

Theory

9.1.4T0 Specific Objectives
By the end of the sub-module unit, the trainee should be able to:
a) State Faraday's laws of electrolysis
b) Explain the construction of cells and their characteristics
c) state methods of cell connections
d) explain charging methods of batteries
e) explain care and maintenance of batteries
f) explain the effects of internal resistance on terminal voltage

9.1.4C *Competence*
The trainee should have the ability to:
i) Charge batteries
ii) Maintain batteries

Content

9.1.4T1 Faraday's laws of electrolysis
-1st law
-2nd law

9.1.4T2 Construction of cells and their characteristics
- Primary – Lec lanche
- batteries
- Secondary – lead Acid
- batteries

-Alkaline batteries

9.1.4T3 batteries connections
- i) series connection
- ii) parallel connection
- iii) series – parallel
- iv) connections
- v) simple calculations

9.1.4T4 Charging methods
- i) constant current
- ii) constant voltage
- iii) trickle charge
- iv) booster charge
- v) battery ratings
- vi) simple calculations

9.1.4T5 Care and maintenance of batteries
- i) specific gravity
- ii) electrolyte level
- iii) terminal voltage
- iv) safety precautions
- v) storage

9.1.4T6 Effects of internal resistance on terminal voltage – simple calculations

Practice

9.1.4P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) measure total voltage and current of batteries connected in series and parallel
b) demonstrate various charging methods
c) determine the internal resistance of batteries and show its effect on
d) terminal voltage
e) carry out light maintenance on a battery

Content

9.1.4P1 Measurements of total voltage and current in series and parallel connected batteries

9.1.4P2 Demonstration of various charging methods

9.1.4P3 Effects of internal resistance on terminal voltage of batteries

9.1.4P4 Maintenance of batteries

Suggested Learning Resources
- Various batteries
- Sulphuric acid
- Distilled water
- Battery chargers
- Test instruments

9.1.5 **ELECTRONIC COMPONENTS**

Practice

9.1.5T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) explain the construction of various components
b) explain the operation of various electronic components
c) explain characteristics of various electronic components
d) state the application of various electronic component

9.1.5C *Competence*
The trainee should have the ability to:
a) identify electronic components
b) test electronic components
c) determine component value and rating

Content

9.1.5T1 Construction of electronics components
i) Resistors
ii) Capacitors
iii) Inductors
iv) Diodes
v) Bi polar transistor (BJT)
vi) Field effect transistors (FETS)
vii) Triacs
viii) Thyristors (SCR)
ix) Photo conductive cells
x) Photo diodes
xi) Photo transistors
xii) Light emitting diodes
xiii) (LED)
xiv) Liquid crystal display (LCD)
xv) Integrated circuits
xvi) (ICS)

9.1.5T2 Operation of electronic components

9.1.5T3 Characteristics of electronic components

9.1.5T4 Applications of electronic components

Practice

9.1.5P0 Specific Objectives
By the end of the sub-module unit, the trainee should be able to:
a) identify various electronic components
b) determine values and ratings of electronic components

c) test various electronic components

Content

9.1.5P1 Identification of various electronic components

9.1.5P2 Values and ratings of electronic components
- Component size
- Colour code
- Component Data

9.1.5P3 Testing of electronic component
i) Short circuit
ii) Open circuit
iii) Change in value
iv) leakage

Suggested Learning Resources
- various components
- breadboard
- measuring instruments
- various electronic tools
- connecting leads

9.1.6 **SEMICONDUCTORS**

Practice

9.1.6T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) explain atomic theory
b) classify materials using the energy band diagram
c) explain extrinsic semiconductors
d) explain the p-n junction

9.1.6C *Competence*
The trainee should have the ability to:
i) identify diodes terminals
ii) connect a diode in a circuit
iii) determine diode characteristics

Content

9.1.6T 1 Atomic theory
i) Element
ii) Compound
iii) Periodic table
iv) Protons
v) Neutrons
vi) Electrons
vii) Orbit

9.1.6T 2 Classification of materials
-Conductor
-Semiconductors
-Insulators

9.1.6T 3 Intrinsic semiconductors
i) Silicon
ii) Germanium
iii) Covalent bonds
iv) Electron hole pair
v) generation/
vi) recombination

vii) Intrinsic conduction

9.1.6T4 Extrinsic semiconductors
i) Doping
ii) N- type semiconductor
iii) P- type semiconductor
iv) Extrinsic conduction

9.1.6T 5 The P-N junction
-Formation of the -junction
-Depletion layer
-Forward bias

Practice

9.1.6P0 Specific Objectives
By the end of the sub-module unit the trainee should be able to:
a) identify the terminals of a p-n junction diode
b) connect the P-N junction diode circuit
c) determine the characteristics of the P-N junction diode

Content

9.1.6P1 Identification of the terminals of a P-N junction diode
-Anode
-Cathode

9.1.6P2 Connection of a diode in a circuit
Polarity
- Voltage levels
- establish transistor
- configuration

9.1.6P3 Characteristics of p-n junction diode
-Forward
-Reverse

Suggested Learning Resources
- Junction diodes
- Measuring instruments
- Connecting leads
- Power supply units
- Accessories
- Electronic tool kit
- Bread boards

9.1.7 **ELECTROSTATICS**

Practice

9.1.7T0 Specific Objectives
By the end of the sub-module unit, the trainee should be able to:
a) explain the concept of electric fields
b) explain the construction of capacitors and their applications

c) define the electrostatic quantities
d) determine the total capacitance for various capacitor connections
e) derive and apply the formula for energy stored in a capacitor

9.1.7C *Competence*

The trainee should have the ability to:

i) Identify capacitors
ii) Measure capacitance
iii) Test capacitance
iv) Apply capacitors in electrical circuits

Content

9.1.7T1 Electric fields
Electric flux
Charge
Potential gradient

9.1.7T2 Construction of capacitors and applications
Paper capacitors
Electrolytic capacitors
Ceramic capacitors
Aluminium foil capacitor
Polyester capacitor
Tantalum capacitor
Multiplate capacitor
Variable capacitor
Applications

9.1.7T3 Definitions of electrostatic quantities and units
(i) Electric flux
(ii) Electric flux density
(iii) Electric field intensity
(iv) Permittivity
(v) Capacitance
(vi) Charge

9.1.7T4 Determination of total capacitance
Series connection
Parallel
Series-parallel connection
Calculations

9.1.7T5 Energy stored in a capacitor
E = ½ CV2 joules
calculations

Practice

9.1.7P0 *Specific Objectives*

By the end of the sub-module unit, the trainee should be able to:

a) identify various types of capacitors
b) measure capacitance in various connections
c) test a capacitor

Content

9.1.7P0 Identification of capacitors

9.1.7P1 Measurement of capacitance

9.1.7P2 Testing of capacitance

Suggested Learning Resources

- Assorted capacitors
- Test instruments
- Bread boards

9.1.8 **MAGNETISM AND ELECTROMAGNETISM**

Practice

9.1.8T0 *Specific Objectives*

By the end of the sub-module unit, the trainee should be able to:

a) distinguish between magnetic and non-magnetic materials explain the
b) concepts of magnetic field
c) explain the concept of force on a current carrying conductor in a magnetic field and its applications
d) define the magnetic circuit quantities and their electric circuit equivalents
e) explain the magnetization curve and hysteresis loop
f) explain the concept of electromagnetic induction
g) explain inductance in materials
h) determine total inductance

9.1.8C *Competence*

The trainee should have the ability to:

i. construct an electromagnet
ii. apply magnets in the engineering field

Content

9.1.8T1 Magnetic and non-magnetic materials

- Molecular arrangements
- Field patterns

9.1.8T 2 Magnetic field patterns

i) Permanent magnets
ii) Electromagnets
iii) Single wire
iv) Loop of wire
v) Solenoid

9.1.8T3 Force on current carrying conductor
F = BIL
Practical applications

9.1.8T4 Magnetic circuit quantities and their electrical equivalents
i) Magnetic flux
ii) Magneto motive force (m.m.f)
iii) Reluctance
iv) Permeability
v) Series
vi) Parallel

9.1.8T5 Magnetization curve and hysteresis loop
B –H curve
Hysteresis loop
Remnant flux
Coercive force
Saturation
Energy

9.1.8T6 Electromagnetic induction
Self induction
Mutual induction
Faraday's Laws
Lenz's Laws
Direction of induced e.m.f

9.1.8T7 Inductance in materials
Definition
Unit of inductance
Inductors in series aiding
Energy stored in inductance
Calculations

9.1.8T8 Total inductance

Practice

9.1.8P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to;
a) construct electromagnets
b) use magnets in engineering applications
c) plot a B-H curve
d) verify the principle of electromagnetic induction

Content

9.1.8P1 Construction of electromagnets
Ferrous materials
Wire
Power source

9.1.8P2 Use of magnets
Bells
Speakers
Solenoids

9.1.8P 3 Plotting of B-H curve

9.1.8P 4 Verification of the principle of electromagnetic induction.

Suggested Learning Resources
- Permanent magnets
- Electromagnets
- Power

- Wires
- Bells

9.1.9 **TRANSFORMERS**

Theory

9.1.9T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) explain the principle of operation of a transformer
b) explain the various types of transformers
c) explain the construction of different types of transformers
d) explain applications of transformers

9.1.9C *Competence*
The trainee should have the ability to:
i) Test transformers
ii) Construct a single phase transformer

Content

9.1.9T1 Principle of operation of a transformer
Electromagnetic induction
Magnetic circuit
Inductance
Coupling efficiency
Losses

9.1.9T2 Types of transformers and their applications
Single – Phase transformers
Power transformers
Audio transformers
R.F
Auto transformers
Three phase transformers
Isolating transformers

9.1.9T3 Construction of different types of transformers
Core type
Shell type
Windings

9.1.9T4 Simple calculations on single phase transformers
Transformers ratios
Efficiency
Applications of transforms

Practice

9.1.9P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) carry out transformer tests
b) construct a ingle phase transformer

Content

9.1.9P1 Transformer tests

9.1.9P2 Transformer construction

Suggested Teaching/learning resources
- Various types of transformers
- Wires
- Electrical measuring instruments
- Electrical tools

9.1.10 **AMPLIFIERS**

Practice

9.1.10T0 *Specific objectives*

By the end of the sub-module unit, this trainee should be able to:
a) state the types of transistor configurations
b) explain the various characteristics of transistors
c) explain biasing methods of transistor
d) explain various coupling methods
e) explain distortion and noise in amplifiers
f) explain different classes of amplifier operations
g) explain the operation of operational amplifiers

9.1.10C *Competence*

The trainee should have the ability to:
i) Connect and operate various amplifiers circuits
ii) Measure various amplifier parameters
iii) Construct various amplifiers

Content

9.1.10T1 Transistor configuration
- common base
- common emitter
- common collector

9.1.10T2 Characteristics of transistors
- Input characteristics
- Output characteristics
- transfer characteristics

9.1.10T3 Biasing methods
-Fixed bias
-Collector base bias
-Potential divider bias
-Emitter bias

9.1.10T4 Coupling methods

- R.C coupling
- Transformer coupling
- direct coupling
- matching

9.1.10T5 Distortion and noise in amplifiers

i) Harmonic distortion
ii) Frequency distortion
iii) Inter modulation distortion
iv) Amplitude distortion
v) Transistor noise

9.1.10T6 Classes of amplifiers

-Class A
-Class B
-Class C

9.1.10T7 Operational amplifiers definitions and terminology

- Characteristics of op-amps
- Applications of op-amps

Practice

9.1.10P0 Specific Objectives

By the end of the sub-module unit, the trainee should be able to:

a) connect and operate various circuits
b) perform various measurements and tests on an amplifier
c) construct various amplifiers

Content

9.1.10P1 Connection and operation of amplifiers

i) Different biasing methods
ii) Different coupling methods
iii) Different classes of operation

9.1.10P2 Measurements and tests

Input signal levels
Output signal levels
Distortion
Bias voltage
Bias current
Waveforms
Power

9.1.10P3 Construction of amplifiers

Suggested Learning Resources

- Transistors
- Op-amps

Measuring instruments
Catalogue and data books
Power supply units
Connecting leads
Electronic tool kit

Training kits
Bread boards

9.1.11 **POWER SUPPLY CIRCUITS**

Practice

9.1.11T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:

a) explain the principles of power regulation and stabilization
b) explain the rectification processes
c) explain different methods of smoothing
d) explain the operation of voltage multipliers and dividers
e) explain the methods of power supply protection.

9.1.11C *Competence*
The trainee should have ability to:

i) Construct basic power supply circuits
ii) Test and measure power supply parameters

Content

9.1.11T1 Power regulation and stabilization
- Zener diode regulator
- Transistor regulator
- IC regulator

9.1.11T2 Methods of power rectification
- Half wave
- Full wave
- Methods of smoothing
- Full wave bridge

9.1.11T3 Smoothing methods
- Reservoir capacitor
  R – C filter
- Pie filter

9.1.11T4 Voltage multipliers and dividers
- Double
- Triplex
- quadruple

9.1.11T5 Methods of power supply protection
Fuses
Current limiting

Practice

9.1.11P0 Specific Objectives
By the end of the sub-module unit, the

	trainee should be able to: a) construct half and full wave rectifier circuits b) construct filter network circuits c) build simple regulator circuit d) test and measure various supply parameters	D.C. out put on load Load current Ripple *Suggested Learning Resources* - Transformers - Rectifiers - Filters - Regulators - Instruments - Charts
	Content	
9.1.11P1	Construction of rectifier circuit Half wave Full wave Full wave bridge	
9.1.11P2	Construction of smoothing circuits Reservoir capacitor R – C filter Pie filter	
9.1.11P3	Construction of power supply regulators Zener diode regulator Transistor regulator IC regulator Construction of voltage multipliers Double Triplex Quadrupler	
9.1.11P4	Tests and measurements of supply parameters D.C .out put on no load	