12.1.0 ELECTRICAL ENGINEERING PRINCIPLES

12.1.01 Introduction

This module unit is intended to equip the trainee with knowledge, skills and attitude required to understand the basic electrical engineering principles necessary for training in the area of trade.

12.1.02 General Objectives

At the end of the module unit, the trainee should be able to:

a) Understand the concepts of electrical quantities
b) Perform basic calculations on dc and ac circuits
c) Explain the behaviour of magnetic materials, magnetism and electromagnetism
d) Describe the construction and operation of dc sources
e) Explain the basic concepts of ac generation
f) Describe the theory of dielectrics, principles and characteristics of capacitors
g) Analyze analogue ac and dc meters

12.1.03 Module Unit Summary and Time Allocation

Electrical Engineering Principles

Code	Sub Module Unit	Content	Time Hrs
12.1.1	Electrical quantities and application	• Basic SI units • Derived units • Units of electrical quantities • Calculations	8
12.1.2	Cells and Batteries	• Electrolysis and applications • Definition of electricity • Construction of simple cell • Determination of E.m.f in cells • Differentiation of primary and secondary • Construction and applications	6

		of cells • Calculations • Charging methods	
12.1.3	Electrical Instruments	• Analogue instruments • Repulsion and attraction moving coil instruments • Shunts and multipliers • Multimeters	10
12.1.4	DC Circuit Theory	• Definition of resistivity • Ohms law • Series circuits • Parallel circuits • Series-parallel networks • Kirchhoff's Laws, • Superposition theorem • Calculations • Chemical effects due to electric current	8
12.1.5	Magnetism & Electromagnetism	• Electromagnetic fields • Leakage and flux fringing • Laws of Electromagnetic induction • Inductance • Hysteresis • Calculations	8
12.1.6	Electrostatics	• Definitions • Types of capacitors • Concept of charge and electrostatic field • Dielectric field • Calculations	8
12.1.7	AC Theory	• Simple ac generator • Terminologies applied to ac generators • Unidirectional and directional waveforms • Passive elements in ac circuits • Calculations	8
	Single Phase	• Constructional features • Principles of operation	10

12.1.8	Transformers	• Tests for single phase transformers • Applications of single phase transformers	
Total Time			**66**

12.1.1 ELECTRICAL QUANTITIES AND APPLICATION

Theory

12.1.1T0 *Specific Objectives*

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

a) state the basic SI units.
b) recognize derived SI units.
c) state various units of electrical quantities
d) perform simple calculations

Content

12.1.1T1 Basic SI unit quantities
- i) Length
- ii) Mass
- iii) Time

12.1.1T2 Derived SI units

12.1.1T3 Electrical quantities
- i) Coulomb
- ii) Newton
- iii) Joule
- iv) Volt
- v) Ohm
- vi) Siemens
- vii) Watt

12.1.1T4 Simple calculations

12.1.2 CELLS AND BATTERIES

Theory

12.1.2T0 *Specific Objectives*

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

a) describe electrolysis and its applications
b) define the term electricity
c) describe the construction and operation of a simple cell
d) determine the total e.m.f and internal resistance of cells connected in series and in parallel
e) distinguish between primary and secondary cells
f) explain the applications and construction of different types of cells
g) perform calculations on secondary cells
h) describe charging methods of batteries

Content

12.1.2T1 Description of electrolysis and its applications

12.1.2T2 Definition of electricity

12.1.2T3 Construction and operation of a simple cell

12.1.2T4 Determination of total internal resistance of cells connected in series and in parallel, and hence the E.m.f

12.1.2T5 Distinguishing between and secondary cells

12.1.2T6 Construction and applications of different types of cells

12.1.2T7 Calculations
- i) E.m.f
- ii) Internal resistance

12.1.2T8 Charging methods
- i) Constant current
- ii) Constant voltage
- iii) Trickle charge
- iv) Booster charge
- v) Battery ratings
- vi) Simple calculations

Practice

12.1.2P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
- a) perform experiments on electrolysis
- b) determine internal resistance of cells connected in series and in parallel
- c) perform experiments on charging of batteries

Content

12.1.2P1 Electrolysis

12.1.2P2 Internal resistance of cells connected in series and in parallel

12.1.2P3 Battery charging

12.1.2C Competence
The trainee should have the ability to:
- i) Perform experiments on electrolysis
- ii) Determine internal resistance of cells connected in series and in parallel
- iii) Charge batteries

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

12.1.3 ELECTRICAL INSTRUMENTS

Theory

12.1.3T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
- a) describe the construction and operation of electrical instruments
- b) describe the construction and operation of the thermocouple
- c) extend the range of meters using shunts and multipliers
- d) explain the operation of a multimeter

Content

12.1.3T1 Construction and operation of electrical instruments

i) Moving iron
ii) Moving coil

12.1.3T2 Thermocouple
i) Advantages and disadvantages
ii) Applications

12.1.3T3 Extension of range of instruments
i) Shunts
ii) Multipliers
iii) Operation of multimeter
iv)Ammeter
v) Voltmeter
vi)Ohmmeter

Practice

12.1.3P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) identify different types of instruments
b) perform measurements using instruments
c) repair and maintain instruments

Content

12.1.3P1 Types of instruments (analogue/digital)
i) Voltmeters
ii) Ammeters
iii) Ohmmeters
iv) Frequency meters
v) Wattmeter
vi) Multimeters
vii) Cathode – Ray Oscilloscope

12.1.3P2 Measurements of electrical quantities
i) Voltage or potential drop
ii) Current
iii) Resistance or continuity
iv)Frequency
v) Power
vi)Time and period of waveforms
vii) Testing components

12.1.3T3 Repair and Maintenance of instruments
i) Voltmeters
ii) Ammeters
iii) Ohmmeters
iv)Frequency meters
v) Wattmeter's
vi)Multimeters
vii) Cathode – ray oscilloscope
viii) Safe use of instruments

12.1.3C Competence
The trainee should have the ability to:
i) identify various measuring instruments
ii) perform electrical measurements using the instruments
iii) repair and maintain electrical measuring instruments

Suggested Learning Resources
i) Voltmeters
ii) Ammeters
iii) Ohmmeters

iv) Frequency meters
v) Wattmeter's
vi) Multimeters
vii) Cathode – ray oscilloscope
viii) Conductors

12.1.4 DC CIRCUIT THEORY

Theory

12.1.4T0 *Specific Objectives*

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

a) define resistivity
b) define Ohm's
c) calculate voltage, current and resistance in a series circuit
d) calculate voltage, current and resistance in a parallel circuit
e) calculate voltage, current and resistance in a series-parallel circuit
f) state Kirchoff's laws
g) state the superposition theorem
h) solve simple circuit problems using Kirchoff's and superposition theorems
i) explain chemical effects due to electric current

Content

12.1.4T1 Definition of:
i) Resistivity
ii) Conductors
iii) Conductivity
iv) Effect of temperature change in the value of resistance
v) Effect of positive temperature coefficient
vi) Alloyed resistance temperature coefficient
vii) Heat energy released by current

12.1.4T2 Ohm's Law

12.1.4T3 Voltage, current and resistance in a series circuit

12.1.4T4 Voltage, current and resistance in a parallel circuit

12.1.4T5 Voltage, current and resistance in a Series-parallel circuit

12.1.4T6 Statement of Kirchhoff's theorems

12.1.4T7 Superposition theorem

12.1.4T8 Solving circuit problems using Kirchhoff's and Superposition theorems

12.1.4T9 Chemical effects due to electric current
i) Electrolysis
ii) Faraday's Laws of electrolysis
iii) Practical use of electrolytic action
iv) Electro-plating
v) Electrolytic corrosion
vi) Practice

12.1.4P0 *Specific Objectives*

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

a) connect simple electrical circuits
b) measure various electrical quantities
c) verify Ohm's law
d) verify that the resistance of a material depends on area, length and resistivity
e) verify Kirchhoff's law

Content

12.1.4P1 Simple electrical circuits
12.1.4P2 Measurement of electrical quantities
- i) Current
- ii) Voltage
- iii) Resistance
- iv) Power

12.1.4T3 Verification of Ohm's law
12.1.4T4 Determination of conductor resistance
- i) Resistance
- ii) Resistivity
- iii) length
- iv) Area

12.1.4T5 Verification of kirchhoff's laws
- i) Current law
- ii) Voltage law

12.1.4T3 Testing of capacitance
12.1.4T4 Experiments on charging and discharging of capacitors

12.1.4C Competence

The trainee should have the ability to:

i) Measure electrical quantities
ii) Determine conductor resistance

Suggested Learning Resources

- Dc power source
- Assorted resistance
- Measuring instruments
- Bread boards
- Connecting leads

12.1.5 MAGNETISM AND ELECTROMAGNETISM

Theory

12.1.5T0 *Specific Objectives*

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

a) describe the concept of magnetic fields and field distribution
b) explain leakage flux and fringing
c) describe the basic laws of electromagnetic induction
d) explain the concepts of inductance
e) plot and explain the hysteresis loop
f) explain and solve problems relating to magnetic circuits

Content

12.1.5T1 Description of electromagnetic fields
- i) Permanent magnet
- ii) Between a pair of poles
- iii) In a current carrying conductor
- iv) In parallel wires
- v) In a loop
- vi) In a solenoid

12.1.5T2 Leakage flux and fringing

12.1.5T3 Laws of electromagnetic induction
- i) Faraday's law
- ii) Lenz's law
- iii) Fleming's rules

12.1.5T4 Inductance
- i) Self
- ii) Mutual
- iii) Calculations
- iv) Practical applications of induced electromotive force

12.1.5T5 Hysteresis loop
- i) Plotting
- ii) Explanation

12.1.5T6 Problems relating to magnetic circuits
- i) Series
- ii) parallel

Practice

12.1.5P0 *Specific Objectives*

By the end of the sub module unit, the trainee should be able to:
- a) identity various types of magnetic materials
- b) verify the existence of magnetic field
- c) apply the principles of electromagnetism

Content

12.1.5P1 Magnetic materials
- i) Identification
- ii) Classification
- iii) Magnetic
- iv)Non magnetic

12.1.5P2 Verification of the existence of magnetic field
- i) Bar magnet
- ii) Horse shoe magnet
- iii) Combination of magnets
- iv)Current carrying conductor

12.1.5P3 Applications of electromagnetism
- Construction of electromagnet

12.1.5C Competence

The trainee should have the ability to:
- i) Construct an electromagnet
- ii) Apply magnets in the engineering field

Suggested Learning Resources
- Permanent magnets
- Electromagnet
- Power
- Wires
- Bells
- Soft iron

12.1.6 ELECTROSTATICS

Theory

12.1.6T0 *Specific Objectives*

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

a) define electrostatic quantities
b) types of capacitors
c) describe the concept of charge and electrostatic field
d) explain the dielectric effect
e) perform calculations involving capacitance

Content

12.1.6T1 Definitions of electrostatic quantities and units
i) Electric flux
ii) Electric flux density
iii) Electric field intensity
iv) Permittivity
v) Capacitance
vi) Charge
vii) Derivation of the formula

$$C = \frac{EA}{d} = \frac{Er\,Eo\,A}{d}$$

12.1.6T2 Types of capacitors
i) Paper capacitors
ii) Electrolytic capacitors
iii) Ceramic capacitors
iv) Alluminium foil capacitor
v) Polyester capacitor
vi) Tantalum capacitor
vii) Multiplate capacitor
viii) Variable capacitor
ix) Applications
x) Description of charge concept

12.1.6T3 Charge
i) Electric field strength
ii) Capacitance and its units

12.1.6T4 Dielectric field effect

12.1.6T5 Calculations
i) Capacitors in series
ii) Capacitors in parallel
iii) Energy stored in a capacitor

Practice

12.1.6P0 Specific Objectives

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

a) identify various types of
b) capacitors
c) measure capacitance in
d) connections
e) test a capacitor
f) perform experiments on charging and discharging of capacitors

Content

12.1.6P1 Types of capacitors

12.1.6T2 Measurement of capacitance in various connections
Testing of capacitance

12.1.6T3 Experiments on charging and discharging of

Capacitors

12.1.6C Competence

The trainee should have the ability to:

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

Suggested Teaching Learning Resources

- Assorted capacitors
- Test instruments
- Bread boards

12.1.7 AC THEORY

Theory

12.1.7T0 *Specific Objectives*

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

a) describe the principle of ac generators
b) explain the terms used with ac generators
c) derive the e.m.f equation
d) explain the effects of various passive elements in an ac circuits
e) perform calculations related to sinusoidal waveforms

Content

12.1.7T1 Description of principles of AC generation
i) Effect of rotating a coil in a magnetic field
ii) Waveforms for unidirectional and alternating fields
iii) Graphical illustrations of AC waveforms

12.1.7T2 Terms used in generators
i) Waveforms
ii) Period
iii) Frequency
iv) Instantaneous value
v) Amplitude, average values
vi) Root mean square values and its derivation by graphical methods
vii) Graphical addition of two sinusoidal waveforms
viii) Effects of passive elements in ac circuits
- Resistance
- Capacitance
- Inductance
- Phase difference
- Vector diagrams

12.1.7T3 Derivation of the EMF equation

12.1.7T4 Effects of passive elements in an ac circuit

12.1.7T5 Calculations

Practice

12.1.7P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) identify components of an ac generator
b) generate a sine wave
c) establish the features of an ac waveform
d) verify the effects of passive elements in ac circuits
e) perform experiments to show the effect of power factor

Content
12.1.7P1 Identification of components of ac generator
12.1.7T2 Sine wave generation
12.1.7T3 Features of an ac waveform
i) Cycle
ii) Frequency
iii) Period
iv) Amplitude
12.1.7T4 Effects of R – L – C on voltage and current in ac circuit
i) Series circuits
ii) Parallel
12.1.7T5 Experiment on power factor

12.1.7C Competence
The trainee should have the ability to:
i) Perform power factor improvement
ii) Install power factor correction equipment

Suggested Learning Resources
- Resistors
- Capacitors
- Inductors

12.1.8 SINGLE PHASE TRANSFORMERS

Theory

12.1.8T1 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) describe the construction of single phase transformers
b) explain the principle of operation of single phase transformers
c) test single phase transformers
d) state applications of single phase transformers

Content
12.1.8T1 Construction of single phase transformer
12.1.8T2 Explanation of operation of single phase transformers
i) Transformer equation

ii) Voltage transformation
iii) Current transformation
iv) Impedance transformation
v) Equivalent circuit
vi) Phasor diagram
vii) Transformer efficiency

12.1.8T4 Testing of transformers
i) No load test
ii) Short circuit
iii) Transformer polarity test

12.1.8T5 State applications of single phase transformers
i) Matching
ii) Auto-transformer

Practice

12.1.8P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) test transformers for proper operation
b) connect transformers to single phase and three phase circuits
c) connect instrument transformers

Content

12.1.8P1 Transformer tests
i) Connectivity
ii) Earthing
iii) Insulation resistance
iv) Open circuit
v) Short circuit
vi) Efficiency

12.1.8P2 Connection of transformers
i) Schematic diagrams
ii) Wiring diagrams

12.1.8T3 Instrument transformers

Suggested teaching/Learning Activities
- Discussion
- Illustration
- Demonstration
- Note taking
- Practical exercise
- Calculations

Suggested teaching/Learning Resources
- Electrical measuring instruments
- Electronic tool kit
- Electrical tool kit
- Ac power supply
- Dc Power supply

Suggested Evaluation Methods
- Oral tests
- Timed written tests
- Assignments
- Timed practical tests
- Project