## 9.1.0 ELECTRICAL AND ELECTRONICS PRINCIPLES

### 9.1.01 Introduction:

Most machines in mechanical engineering use electricity as source of power and use electrical/electronic controls. The understanding of electrical and electronics principles on which they operate is necessary.
The assessment mode shall be mainly practical. Some reference materials for this module unit are listed by the end of the module and it should be noted that this list is not exhaustive.

### 9.1.02 General Objectives

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

a) understand the general working of various electrical and electronic components.
b) select and use special electrical and electronic tool and equipment
c) diagnose, service, maintain and repair faults in electrical and electronic systems
d) service and maintain electrical and electronic systems



### 9.1.03 Module Summary and Time Allocation

**Electrical and Electronics Principles**

| Code | Sub Module Unit | Content | Time Hrs | | |
|---|---|---|---|---|---|
| | | | Th. | Prac. | Total |
| 9.1.1 | Direct Current Circuits | • State the basic electrical quantities and their units.<br>• draw electric circuits<br>• apply electric circuits laws and theorems to solve problems on electrics circuits<br>• Determine resistance of conductor of a Wheatstone bridge. | 4 | 2 | 6 |

| | | | | | |
|---|---|---|---|---|---|
| | | • Explain the principle of operation of a potentiometer | | | |
| 9.1.2 | Magnetism and Electromagnetism | • Terminologies<br>• Types of magnets<br>• Magnetic fields<br>• Magnetic circuits<br>• Electromagnetic induction<br>• Classification of magnetic and non-magnetic materials<br>• Verification of the existence of magnetic field | 4 | 2 | 6 |
| 9.1.3 | Introduction to Direct (D.C.) Generators and Motors | • DC machines<br>• Separately excited generators<br>• Shunt wound generators<br>• Series wound<br>• Compound wound<br>• Starting methods<br>• Voltage regulation<br>• Speed control<br>• Maintenance of DC machines | 6 | 4 | 10 |
| 9.1.4 | Alternating Current Circuits | • AC circuits<br>• Wave forms<br>• Amplitude<br>• Phase angle<br>• Period<br>• Root mean square value<br>• Average value<br>• Frequency<br>• Identification of components of an ac generator<br>• Sine wave generation | 8 | 4 | 12 |

| | | | | | |
|---|---|---|---|---|---|
| | | • Experiment of power factor | | | |
| 9.1.5 | Battery (chemical cells ) | • Types of batteries<br>• Construction<br>• Principles of operation | 2 | 4 | 6 |
| 9.1.6 | Electron Theory | • Atomic and molecular structure<br>• Semiconductor materials<br>• Intrinsic and extrinsic conduction<br>• Crystal structure of semiconductor<br>• Crystal structure of semiconductor<br>• Formation of P- and N-type semiconductor | 4 | 2 | 6 |
| 9.1.7 | Semiconductor Devices | • Construction and symbol of semiconductor devices<br>• Operation of semi conductor devices<br>• Characteristics of semi-conductor devices<br>• Applications of semiconductor devices<br>• Identification of semi conductor devices<br>• Connection of semiconductor devices<br>• Tests on semiconductor components | 4 | 4 | 8 |
| 9.1.8 | Electronic Components | • Electronics Components | 2 | 4 | 6 |

| | | | | | |
|---|---|---|---|---|---|
| 9.1.9 | Power Rectification | • Methods of power rectification<br>• Smoothing<br>• Regulation<br>• Voltage multipliers<br>• Methods of power Supply protection<br>• Voltage division and multiplication<br>• Construction of power supply regulators<br>• Tests and measurements | 4 | 2 | 6 |
| **Total Time** | | | **38** | **28** | **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) state the basic electrical quantities and their units.
b) draw electric circuits
c) apply electric circuits laws and theorems to solve problems on electrics circuits
d) determine resistance of conductor of a Wheatstone bridge.
e) explain the principle of operation of a potentiometer

**9.1.1C Competence**

The trainee should have the ability to:

i) Derive formulae for various direct current circuits
ii) Determine resistance of conductors and resistors in various circuit
iii) arrangement
iv) Connect various electrical circuits
v) Perform measurement of electrical quantities
vi) Verify Ohm's and Kirchoff's laws

*Content*

9.1.1T1 Electrical quantities and their units
- i) voltage in volts
- ii) Current in amperes
- iii) Resistance in Ohms
- iv) Power in watts

9.1.1T2 Electric circuits
- i) Simple electric circuits
- ii) Resistors in parallel
- iii) Resistors in series parallel

9.1.1T3 Circuit laws and theorems
- i) Ohms law
- ii) Kirchhoff's laws

9.1.1T4 Resistance of metal conductors and resistors
- i) Length
- ii) cross-sectional area
- iii) resistivity
- iv) conductivity
- v) effects of temperature

9.1.1T5 Potentiometer
- i) operation
- ii) derive formula
- iii) Wheatstone bridge

*Practice*

9.1.1P0 *Specific Objectives*

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

a) connect electrical direct current circuits
b) measure electrical quantities

c) verify given electric laws
d) use a Wheatstone bridge to measure resistance
e) use a potentiometer to measure voltage

*Content*

9.1.1P1 Circuit connections
i) Series
ii) Parallel
iii) Series/parallel

9.1.1P2 Electrical quantities
i) Current
ii) Voltage
iii) Resistance
iv) Power

9.1.1P3 Verification of Electrical laws
i) Ohm
ii) Kirchoff

9.1.1P4 Measurement of resistance using Whetstone's bridge

9.1.1P5 Measurement of resistance using a Potentiometer

*Suggested Learning Resources*

- Text book
- Hand out
- Charts
- Multimeter
- Capacitors
- Resistors
- Circuit
- Test modules
- Simulation software
- Computer system

## 9.1.2 MAGNETISM AND ELECTROMAGNETISM

*Theory*

9.1.2T0 *Specific Objectives*

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

a) define terminologies used in magnetic.
b) state types of magnetic materials
c) list types of magnets
d) describe magnetic fields patterns
e) describe magnetic circuits
f) explain the principle of electromagnetic induction

**9.1.2C Competence**

The trainee should have the ability to:

i) explain the principle of operation of electromagnetic induction
ii) verify the existence of existence of magnetic field

*Content*

9.1.2T1 Terminologies
i) Magnetic flux
ii) Magnetic field strength
iii) Magnetic flux density
iv) Magnetic motive force
v) Reluctance
vi) Permeability
vii) Hysteresis

9.1.2T2 Types of magnetic materials

9.1.2T3 Types of magnets

i) Permanent
ii) Electromagnets

9.1.2T3 Magnetic fields patterns
i) Bar magnets
ii) Current conductors

9.1.2T4 Magnetic circuits
i) Introduction
ii) Laws
iii) Inductance
iv) Energy stored in an inductor
v) Calculation

9.1.2T5 The principle of electromagnetic induction

*Practice*

9.1.2P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able:
a) identify various types of magnetic materials.
b) classify different types of magnets and non-magnetic material
c) verify the existence of magnetic field.

*Content*

9.1.2P1 Identification of various magnetic materials

9.1.2P2 Classification of magnetic and non-magnetic materials

9.1.2P3 Verification of the existence of magnetic field
i) Bar magnet
ii) Horse shoe magnet
iii) Combination of magnets
iv) Current carrying conductor

*Suggested Learning Resources*
i) Text book
ii) Hand out
iii) Magnets
iv) Iron filings

## 9.1.3 INTRODUCTION TO DIRECT CURRENT MACHINES

*Theory*

9.1.3T0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able:
a) explain the construction of electric machines
b) explain characteristics of electrical machines and their typical applications
c) describe different types of DC windings
d) derive e.m.f equation for Ac and DC machines

**9.1.3C Competence**
The trainee should have the ability to:
i) Operate DC machines
ii) Carry out

maintenance of DC machines

*Content*

9.1.3T1 The construction of electric machines
- i) DC machines
- ii) Principle of operation
- iii) Commutator
- iv) Windings
- v) Electromagnetic induction
- vi) Armature reaction
- vii) Excitation
- viii) Ac machines
- ix) Principle of operation
- x) armature
- xi) Commutator
- xii) Windings
- xiii) Electromagnetic induction
- xiv) Armature reaction
- xv) Excitation

9.1.3T2 Characteristics of electrical machines
- i) Typical applications

9.1.3T3 Types of DC windings

9.1.3T4 Derivation of the e.m.f equation
- i) Ac machines
- ii) Motors
- iii) Generators
- iv) DC Machines
- v) Generators
- vi) Motors

*Practice*

9.1.3P0 *Specific Objectives*

By the end of the sub module unit, the trainee should be able:
- a) operate DC machines
- b) carry out maintenance of DC machines

*Content*

9.1.3P1 Operation of DC machines
- i) Starting methods
- ii) Voltage regulation
- iii) Speed control

9.1.3P2 maintenance of DC machines

*Suggested Learning Resources*
- i) Lab equipment and tools
- ii) DC motor
- iii) Ac motor
- iv) Electrical instruments
- v) DC generators
- vi) DC conductors
- vii) Electronic DC motor starters
- viii) Face plate starters
- ix) Drum starters
- x) Workshop tools



## 9.1.4 ALTERNATING CURRENT CIRCUITS

*Theory*

9.1.4T0 *Specific Objectives*

By the end of the sub module unit, the trainee should be able to:
- a) explain the principle of operation of Ac circuits
- b) explain the effects of various passive elements in a current.
- c) Determine power factor in Ac circuits

**9.1.4C Competence**

The trainee should have the ability to:

i) Determine power factor.
ii) Calculate power in ac currents
iii) Explain the principle of operation of ac generation
iv) Perform power factor improvement
v) Install power factor correction equipment
vi) Operate ac generator

*Content*

9.1.4T1 Operation of Ac circuits
9.1.4T2 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
9.1.4T3 Power factor

*Practice*

9.1.4P0 *Specific Objectives*

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

a) generate a series wave
b) establish the features of an Ac wave form
c) perform experiment to show effect of power factor
d) identify components of an Ac generator
e) verify the effects of passive elements in ac circuits

*Content*

9.1.4T1 Wave generation
9.1.4T2 Features of an Ac waveform
9.1.4T3 Verification of Power factor
9.1.4T4 Components of an Ac generator
9.1.4T5 Effects of Passive elements in Ac circuits

*Suggested Learning Resources*

i) Charts
ii) Graph
iii) Calculations
iv) Cathode Ray Oscilloscope
v) Multimeter
vi) Ac generator kit
vii) Ac generator



**9.1.5 BATTERY**

*Theory*

9.1.5T0 *Specific Objectives*

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

a) explain the principles of operation of different types of batteries.
b) describe the construction of different types of batteries
c) state advantages and disadvantages of both lead-acid and nickel alkaline

9.1.5C *Competence*

The trainee should have the ability to:

i) Service and maintain various types of batteries

*Content*

9.1.5T1 Principles of operation:
- Chemistry of charge and discharge

9.1.5T2 Construction
i) Casing
ii) Separators
iii) Plates
iv) Electrolyte

9.1.5T3 Types of batteries
i) Lead-acid high maintenance
ii) Lead Acid Maintenance free
iii) Lead Low maintenance
iv) Nickel alkaline
v) Small batteries

*Practice*

9.1.5P0 *Specific Objectives*

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

a) service and maintain different types batteries
b) replace different types of batteries
c) use battery service and maintenance tools/equipment
d) charge batteries

*Content*

9.1.5P1 Service and maintenance
i) Battery charging
ii) Battery charger
iii) Battery testing
iv) Battery replacement
v) Safety

9.1.5P2 Battery replacement

9.1.5P3 Battery maintenance tools and equipment

9.1.5P4 Battery charging

*Suggested Learning Resources*
- Text books
- Charts
- Voltmeter
- Battery
- Charger
- Hydrometer
- Funnel
- Electrolyte
- Distilled water
- Workshop tools
- Jumper cables



## 9.1.6 ELECTRON THEORY

*Theory*

9.1.6T0 *Specific Objectives*

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

a) describe the atomic and molecular structure of semi conductors
b) state the types of semiconductor materials
c) explain intrinsic and

extrinsic conduction
d) explain the crystal structure of a semiconductor
e) describe the formation of P- and N -type semiconductors

*Content*

9.1.6T1 Atomic and molecular structure
i) neutron
ii) proton
iii) electrons
iv) orbit

9.1.6T2 Semiconductor materials
i) silicon
ii) germanium
iii) periodic table

9.1.6T3 Intrinsic and extrinsic conduction
i) electrons
ii) holes
iii) influence of external field
iv) generation and recombination of charge carriers

9.1.6T4 Crystal structure of semiconductor
i) covalent bond
ii) energy levels
iii) lattice

9.1.6T5 Formation of P and N-type semiconductor
i) donor and acceptor atoms
ii) doping
iii) trivalent and pentavalent atoms
iv) free electrons and holes
v) diffusion and drift currents

## 9.1.7 SEMI CONDUCTOR DEVICES

*Theory*

9.1.7T0 *Specific Objectives*

By the end of sub-module unit, the trainee should be able to:
a) describe the construction of semi conductor devices
b) explain the operations of semi conductor devices
c) explain and plot the characteristics of semi- conductor devices
d) state application of semiconductor devices

**9.1.7C Competence**

The trainee should have the ability to:
i) Construct electronic circuits using semiconductor devices
ii) Test semiconductor devices
iii) Explain and plot the characteristics of semiconductor devices
iv) Select and use various semiconductor devices

*Content*

9.1.7T1 Construction and symbol of semiconductor

devices
i) Diode
ii) Bipolar junction transistor (BJT)
iii) Field effect transistors (FETs)
iv) Zener diode
v) Light emitting diode
vi) Silicon controlled rectifier (SCR)
vii) Liquid crystal display LCD)

9.1.7T2 Operation of semi conductor devices
i) Diode
ii) Bipolar junction transistor (BJT)
iii) Field effect transistors (FET/MOSFET)
iv) Zener diodes
v) Silicon controlled rectifier (SCR)
vi) Liquid Crystal display (LCD)
vii) Light emitting diodes (LEDs)

9.1.7T3 Characteristics of semi-conductor devices
i) Diode
ii) BJT
iii) FET/MOSFET
iv) Zener diode
v) Light emitting diode (LED)
vi) Liquid crystal display (LCD)
vii) SCRs

9.1.7T4 Applications of semiconductor devices
i) Diode
ii) BJT
iii) FET
iv) Zener diode
v) LED
vi) SCR
vii) LCD

*Practice*

9.1.7P0 *Specific Objectives*
By the end of the sub module unit the trainee should be able to
a) Identify types of semiconductor devices
b) Connect and operate semiconductor devices
c) Test the semiconductor devices

*Content*

9.1.7P1 Identification of semi conductor devices

9.1.7P2 Connection of semiconductor devices

9.1.7P3 Tests on semiconductor components

*Suggested Learning Resources*
i) Charts
ii) Selected textbooks
iii) Reliance
iv) Catalogue
v) Handouts Test instruments
vi) Charts
vii) Circuit trainer kits

## 9.1.8 ELECTRONIC COMPONENTS

*Theory*

9.1.7T0 *Specific Objectives*

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

a) describe the constructional features of various components
b) describe the operation of various electronic components
c) state the application of various electronic component

**9.1.7C Competence**

The trainee should have the ability to;

i) Select and use various electronic components
ii) Test electronic components
iii) Determine component value and rating

*Content*

9.1.7T1 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 (LED)
xiii) Liquid crystal display (LCD)
xiv) Integrated circuits (ICS)

9.1.7T2 Operation of electronics components

9.1.7T3 Applications of electronics components

*Practice*

*9.1.7P0 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*

9.1.7P1 Identification of various electronic components

9.1.7P2 Values and rating

i) Component size
ii) Colour code
iii) Component Data

9.1.7P3 Testing of electronic component

i) Short circuit

ii) Open circuit
iii) Change in value
iv) leakage

*Suggested Learning Resources*
i) Text books
ii) Data books
iii) Charts
iv) Assorted electronics components
v) Assorted electronics components

## 9.1.8 POWER RECTIFICATION

*Theory*

9.1.8T0 *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) describe the rectification processes
c) describe different methods of smoothing
d) explain the operation of voltage multipliers and dividers
e) explain the methods of power supply protection.

9.1.8C *Competence*
The trainee should have the ability to:
- Rectify voltage rectification
- Apply different methods of smoothing

*Content*

9.1.8T1 Methods of power rectification
i) Half wave
ii) Full wave
iii) Full wave bridge

9.1.8T2 Smoothing
i) Reservoir
ii) capacitor
iii) R – C filter
iv) Pie filter

9.1.8T3 Regulation
i) Zener diode regulator
ii) Transistor regulator
iii) IC regulator

9.1.8T4 Voltage multipliers
i) Double
ii) Triplex
iii) Quadrupler

9.1.8T5 Methods of power Supply protection
i) Circuit breakers
ii) Switches
iii) Fuses

*Practice*

9.1.8P0 *Specific Objectives*
By the end of the sub module unit, the trainee should be able to:
a) build simple regulator circuit
b) test and measure various supply parameters

*Content*

9.1.8P1 Construction of power supply regulators
i) Zener diode regulator

ii) Transistor regulator
iii) IC regulator

9.1.8P2 Tests and measurements
i) DC out put on no load
ii) DC out put on load
iii) Load current
iv) Ripple

*Suggested Learning Resources*
i) Chats
ii) Handouts
iii) Textbooks
iv) Reservoir
v) Capacitor
vi) R – c filter
vii) Pie filter
viii) Zener diode regulator
ix) Transistor regulator
x) Ic regulator
xi) Double
xii) Triplex
xiii) Quadrupler
xiv) Circuit breakers
xv) Switches
xvi) Fuses
xvii) Electrical workshop tools