

9.1.0 ELECTRICAL AND ELECTRONIC PRINCIPLES

9.1.1 Introduction

Most machines in mechanical engineering use electricity as source of power are operated using electrical and electronic control systems. The module unit is designed to equip the trainees with the necessary knowledge and skills in electrical and electronics principles to enable him/her understand the operation of mechatronics systems and carry out machine operations, maintenance and repair. The module is also meant for prepare the trainee for other module units in this course and future training.

The unit has both theoretical and practical concepts and thus theory and practical tests are recommended as the main mode of assessment.

9.1.2 General Objectives

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

- understand the general working of various electrical and electronic components.
- select and use special electrical and electronic tools and equipment
- diagnose, service, maintain and repair faults in machine electrical and electronic systems

9.1.3 Module Unit Summary and Time Allocation

ELECTRICAL AND ELECTRONIC PRINCIPLES

Code	Sub module unit	Content	Time Hrs		
			Theory	Pract	Total
9.1.01	Electrical Principles	<ul style="list-style-type: none">• Electrical quantities and their units• Electric circuits• Circuit laws and theorems• Resistance of metal conductors and resistors• Wheatstone bridge• Potentiometer	4	4	8
9.1.02	Magnetism and Electromagnetism	<ul style="list-style-type: none">• Terminologies• Types of magnets• Magnetic fields• Magnetic circuits• Electromagnetic induction	4	2	6

		<ul style="list-style-type: none"> • Classification of magnetic and non-magnetic materials • Verification of the existence of magnetic field 			
9.1.03	Introduction to (D.C) Generators And Motors	<ul style="list-style-type: none"> • DC machines • Separately excited generators • Shunt wound generators • Series wound • Compound wound • Starting methods • Voltage regulation • Speed control • Maintenance of dc machines 	6	4	10
9.1.04	Alternating Current Circuits	<ul style="list-style-type: none"> • AC circuits • Wave forms • Amplitude • Phase angle • Period • Root mean square value • Average value • Frequency • Identification of components of an ac generator. • Sine wave generation • Experiment of power factor 	8	4	12
9.1.05	Electron Theory	<ul style="list-style-type: none"> • Atomic and molecular structure • Semiconductor materials • Intrinsic and extrinsic conduction • Crystal structure of semiconductor • Crystal structure of semiconductor • Formation of P- and N-type semiconductor 	4	4	8

9.1.06	Semiconductor Devices	<ul style="list-style-type: none"> • Construction and symbol of semiconductor devices • Operation of semiconductor devices • Characteristics of semiconductor devices • Applications of semiconductor devices • Identification of semiconductor devices • Connection of semiconductor devices • Tests on semiconductor components 	4	4	8
9.1.07	Electronic Components	<ul style="list-style-type: none"> • Electronics Components • Operation of electronics components • Application of electronics components 	2	4	6
9.1.08	Power Rectification	<ul style="list-style-type: none"> • Methods of power rectification • Smoothing • Regulation • Voltage multipliers • Methods of power Supply protection • Voltage division and multiplication • Construction of power supply regulators • Tests and measurements 	4	4	8
Total Time			36	30	66

9.1.01	ELECTRICAL PRINCIPLES		iii) Connect various electrical circuits iv) Perform measurement of electrical quantities v) Verify Ohm's and Kirchoff's laws
	Theory		
9.1.01T0	<i>Specific Objectives</i> By the end of the sub-module the trainee should be able to:		
	a) state the basic electrical quantities and their units.	9.1.01T1	<i>Content</i> Electrical quantities and their units - In volts - Current in amperes - Resistance in Ohms - Power in watts
	b) draw electric circuits		
	c) apply electric circuits laws and theorems to solve problems on electric circuits	9.1.01T2	Electric circuits - simple electric circuits - resistors in parallel - resistors in series
	d) determine resistance of conductor		
	e) explain the principle of a wheatstone bridge.	9.1.01T3	Circuit laws and theorems - Ohms law - Kirchoffs laws
	f) explain the principle of operation of a potentiometer	9.1.01T4	Resistance of metal conductors and resistors - Length - cross-sectional area - resistivity - conductivity - effects of temperature
9.1.01C	<i>Competence</i> The trainee should have the ability to:		
	i) Derive formulae for various d. c. circuits		
	ii) Determine resistance of conductors and resistors in various circuit arrangement	9.1.01T5 9.1.01T6	Wheatstone Bridge Potentiometer - operation - derive formula
			Practice

9.1.01P0	<p><i>Specific Objectives</i> By the end of the sub-module the trainee should be able to:</p> <ul style="list-style-type: none"> a) connect electrical d.c. 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 	<p>By the end of the sub-module the trainee should be able to:</p> <ul style="list-style-type: none"> a) define terminologies used in magnetic. b) state types of magnetic materials c) describe magnetic field patterns d) describe magnetic circuit e) explain the principle of electromagnetic induction 	
9.1.01P1	<p><i>Content</i> Circuit connections</p> <ul style="list-style-type: none"> - Series - Parallel - Series/parallel 	9.1.02C	<p><i>Competence</i> The trainee should have the ability to:</p> <ul style="list-style-type: none"> i) explain the principle of operation of electromagnetic induction ii) verify the existence of existence of magnetic field
9.1.01P2	<p>Electrical quantities</p> <ul style="list-style-type: none"> - current - voltage - resistance - power 		
9.1.01P3	<p>Electrical laws</p> <ul style="list-style-type: none"> - Ohm - Kirchhoff 		
9.1.01P4	<p>Measurement of resistance using the Wheatstone bridge</p>	9.1.02T1	<p><i>Content</i> Terminologies</p> <ul style="list-style-type: none"> - magnetic flux - magnetic field strength - magnetic flux density - magnetic motive force - reluctance - permeability - hysteresis
9.1.01P5	<p>Measurement of resistance using the potentiometer</p>		
9.1.02	<p>MAGNETISM AND ELECTRO MAGNETISM</p> <p>Theory</p>		
9.1.02T0	<p><i>Specific Objectives</i></p>	9.1.02T2	<p>Types of magnetic materials</p> <ul style="list-style-type: none"> - Types of magnets

9.1.02T3	<ul style="list-style-type: none"> - Permanent - Electromagnets Magnetic field pattern		<ul style="list-style-type: none"> - Bar magnet - Horse shoe magnet - Combination of magnets - Current carrying conductor
9.1.02T4	<ul style="list-style-type: none"> - Bar magnets - Current conductors Magnetic circuits		
	<ul style="list-style-type: none"> - Introduction - Laws - Inductance - Energy stored in an inductor - Calculation 	9.1.03	INTRODUCTION TO D.C. GENERATORS AND MOTORS
9.1.02T5	Principle of Electromagnetic induction		Theory
	Practice	9.1.03T0	<i>Specific Objectives</i> By the end of the sub-module the trainee should be able:
9.1.02P0	<i>Specific Objectives</i> By the end of the sub-module the trainee should be able: <ul style="list-style-type: none"> a) identify various types of magnetic materials. b) classify different types of magnets and non-magnetic material c) verify the existence of magnetic field. 		<ul style="list-style-type: none"> a) explain the construction of electric machines b) describe the principle of operation of DC/AC machines c) explain characteristics of state machines and typical applications d) describe different types of DC windings e) derive e.m.f equation
9.1.02P1	<i>Content</i> Identification of various magnetic materials		
9.1.02P2	Classification of magnetic and non-magnetic materials	9.1.03C	<i>Competence</i> The trainee should have the ability to:
9.1.02P3	Verification of the existence of magnetic field		<ul style="list-style-type: none"> i) Operate DC machines

	ii) Carry out maintenance of DC machines	9.1.04 ALTERNATING CURRENT (AC) CIRCUITS	
	<i>Content</i>		
9.1.03T1	DC machines	Theory	
	- armature		
	- Commutator	9.1.04T0	<i>Specific Objectives</i>
	- Windings		By the end of the topic the trainee should be able to:
	- Electromagnetic induction		a) explain the principle of operation of AC circuits
	- Armature reaction		b) explain the effects of various passive elements in a current.
	- Excitation		c) Determine power factor in AC circuits
9.1.03T2	Separately excited generators		
9.1.03T3	Shunt wound generators		
9.1.03T4	Series wound		
9.1.03T5	Compound wound		
	- Starting resistors		
	- Speed characteristics		
	- Torque	9.1.04C	<i>Competence</i>
			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
			Operate ac generator
			<i>Content</i>
		9.1.04T1	Operation of AC circuits
	Practice		
9.1.03P0	<i>Specific Objectives</i>		
	By the end of the sub-module the trainee should be able:		
	a) Operate DC machines		
	b) Carry out maintenance of DC machines		
	<i>Content</i>		
9.1.03P1	Operation of DC machines		
	- Starting methods		
	- Voltage regulation		
	- Speed control		
9.1.03P2	Maintenance of DC machines		

9.1.04T2	Effects of passive elements in AC circuits <ul style="list-style-type: none"> - Wave forms - Amplitude - Phase angle - Period - Roof mean square valve - Average valve - Frequency 	9.1.04P4	Components of an AC generator
		9.1.04P5	Passive elements in AC. circuits
		9.1.05	ELECTRON THEORY
			Theory
9.1.04T3	Determination of Power factor in AC circuits	9.1.05T0	<i>Specific Objectives</i> By the end of the sub-module unit the trainee should be able to: <ol style="list-style-type: none"> 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
	Practice		
9.1.04P0	<i>Specific Objectives</i> By the end of the topic the trainee should be able to: <ol style="list-style-type: none"> a) Generate a series wave b) Establish the feature 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 	9.1.04C	<i>Competence</i> The trainee should have the ability to describe the formation of P- and N-type semiconductors
	<i>Content</i>		<i>Content</i>
9.1.04P1	Wave generation	9.1.05T1	Atomic and molecular structure <ul style="list-style-type: none"> - neutron - proton - electrons
9.1.04P2	Features of an AC waveform		
9.1.04P3	Power factor		

9.1.05T2	- orbit Semiconductor materials		a) describe the construction of semi conductor devices
	- silicon		b) explain the operations of semi conductor devices
	- germanium		c) explain and plot the characteristics of semi- conductor devices
	- periodic table		d) state application of semiconductor devices
9.1.05T3	Intrinsic and extrinsic conduction		
	- electrons		
	- holes		
	- influence of external field		
	- generation and recombination of charge carriers		
9.1.05T4	Crystal structure of semiconductor	9.1.06C	<i>Competence</i> The trainee should have the ability to:
	- covalent bond		i) Construct electronic circuits using semiconductor devices
	- energy levels		ii) Test semiconductor devices
	- lattice		iii) Explain and plot the characteristics of semiconductor devices
9.1.05T5	Formation of P and N-type semiconductor		iv) Select and use various semiconductor devices
	- donor and acceptor atoms		
	- doping		
	- trivalent and pentavalent atoms		
	- free electrons and holes		
	- diffusion and drift currents		
9.1.06	SEMI CONDUCTOR DEVICES		
	Theory		
9.1.06T0	<i>Specific Objectives</i> By the end of the sub-module unit, the trainee should be able to:	9.1.06T1	<i>Content</i> Construction and symbol of semiconductor devices
			- Diode
			- Bipolar junction transistor (BJT)
			- Field effect transistors (FETs)

	<ul style="list-style-type: none"> - Zener diode - Light emitting diode - Silicon controlled rectifier (SCR) - Liquid crystal display LCD) 		<ul style="list-style-type: none"> - LCD
9.1.06T2	Operation of semi conductor devices <ul style="list-style-type: none"> - Diode - Bipolar junction transistor (BJT) - Field effect transistors (FET/MOSFET) - Zener diodes - Silicon controlled rectifier (SCR) - Liquid Crystal display (LCD) - Light emitting diodes (LEDs) 	9.1.06P0	<p>Practice</p> <p><i>Specific Objectives</i> By the end of the sub module unit the trainee should be able to</p> <ol style="list-style-type: none"> a) Identify types of semiconductor devices b) Connect and operate semiconductor devices c) Test the semiconductor devices
9.1.06T3	Characteristics of semi-conductor devices <ul style="list-style-type: none"> - Diode - BJT - FET/MOSFET - Zener diode - Light emitting diode (LED) - Liquid crystal display (LCD) - SCRs 	9.1.06T1 9.1.06T2 9.1.06T3	<p><i>Content</i></p> <p>9.1.06T1 Identification of semi conductor devices</p> <p>9.1.06T2 Connection of semiconductor devices</p> <p>9.1.06T3 Tests on semiconductor components</p>
9.1.06T4	Applications of semiconductor devices <ul style="list-style-type: none"> - Diode - BJT - FET - Zener diode - LED - SCR 	9.1.07T0	<p>9.1.07 ELECTRONIC COMPONENTS</p> <p>Theory</p> <p><i>Specific Objectives</i> By the end of the module unit, the trainee should be able to</p> <ol style="list-style-type: none"> a) describe the constructional features of various components

	b) describe the operation of various electronic components		- Integrated circuits (ICS)
	c) state the application of various electronic component	9.1.07T 2	Operation of electronics components
		9.1.07T3	Applications of electronics components
9.1.07C	<i>Competence</i> The trainee should have the ability to;		Practice
	i) Select and use various electronic components	9.1.07P0	<i>Specific Objectives</i> By the end of the sub module unit, the trainee should be able to:
	ii) Test electronic components		a) identify various electronic components
	iii) Determine component value and rating		b) determine values and ratings of electronic components
9.1.07T1	<i>Content</i> Electronics Components		c) test various electronic components
	- Resistors		
	- Capacitors		
	- Inductors		
	- Diodes	9.1.07P1	<i>Content</i> Identification of various electronic components
	- Bi polar transistor (BJT)		
	- Field effect transistors (FETS)	9.1.07P2	Values and rating
	- Triacs		- Component size
	- Thyristors (SCR)		- Colour code
	- Photo conductive cells	9.1.07P3	- Component Data
	- Photo diodes		Testing of electronic component
	- Photo transistors		- Short circuit
	- Light emitting diodes (LED)		- Open circuit
	- Liquid crystal display (LCD)		- Change in value
			- leakage

9.1.08	POWER RECTIFICATION		- Full wave - Full wave bridge
	Theory	9.1.08T2	Smoothing - Reservoir - capacitor - R – C filter - Pie filter
9.1.08T0	<i>Specific Objectives</i> By the end of the sub module unit, the trainee should be able to:	9.1.08T3	Regulation - Zener diode regulator - Transistor regulator - IC regulator
	a) explain the principles of power regulation and stabilization	9.1.08T4	Voltage multipliers - Double - Triplex - Quadrupler
	b) describe the rectification processes	9.1.08T5	Methods of power Supply protection - Circuit breakers - Switches - Fuses
	c) describe different methods of smoothing		
	d) explain the operation of voltage multipliers and dividers		Practice
	e) explain the methods of power supply protection.	9.1.08P0	<i>Specific Objectives</i> 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
9.1.08C	<i>Competence</i> The trainee should have the ability to		
	i) demonstrate rectification		
	ii) demonstrate different methods of smoothing		
	iii) verify voltage multiplication and division	9.1.08P1	<i>Content</i> Construction of power supply regulators - Zener diode regulator - Transistor regulator - IC regulator
9.1.08T1	<i>Content</i> Methods of power rectification - Half wave		

9.1.08P2

Tests and measurements

- D.c. out put on no load
- D.c. out put on load
- Load current
- Ripple

Suggested Learning Resources

- Selected semi-conduct devices
- Test instruments
- Circuit trainer kits
- charts
- handouts
- textbooks
- Reservoir
- capacitor
- R – C filter
- Pie filter
- Zener diode regulator
- Transistor regulator
- IC regulator
- Double
- Triplex
- Quadrupler
- Circuit breakers
- switches
- Fuses
- Electrical workshop tools
- Data books
- Charts
- Assorted electronics components
- Assorted electronics components

- Reliance
- Catalogue
- Handouts Test instruments
- Circuit trainer kits
- Charts
- Graph
- Calculations
- Cathode Ray Oscilloscope
- Multimeter
- AC generator kit
- AC generator
- 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
- magnets
- iron filings
- Charts
- Multimeter
- Capacitors
- Resistors
- Circuit
- Test modules
- Simulation software
- Computer system