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:

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

9.1.3 Module Unit Summary and Time Allocation

Code	Sub module	Content	,	Time Hrs	
	unit		Theory	Pract	Total
9.1.01	Electrical Principles	 Electrical quantities and their units Electric circuits Circuit laws and theorems Resistance of metal conductors and resistors Wheatstone bridge Detention of the second sec	4	4	8
9.1.02	Magnetism and Electromagn etism	 Terminologies Types of magnets Magnetic fields Magnetic circuits Electromagnetic induction 	4	2	6

ELECTRICAL AND ELECTRONIC PRINCIPLES

		 Classification of magnetic and non- magnetic materials Verification of the existence of magnetic field 			
9.1.03	Introduction to (D.C) Generators And Motors	 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	 AC circuits Wave forms Amplitude Phase angle Period Roof mean square valve 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	 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

Total Ti	ne		36	30	66
		• Tests and measurements			
		supply regulators			
		• Construction of power			
		multiplication			
		• Voltage division and			
		Supply protection			
	• • •	Methods of power			
		Voltage multipliers			
		• Smoothing			
	Rectification	rectification			
9.1.08	Power	• Methods of power	4	4	8
		electronics components			
		• Application of			
		components			
	Components	Operation of electronics	-		
9.1.07	Electronic	Electronics Components	2	4	6
		 resis on semiconductor components 			
		semiconductor devices			
		Connection of			
		conductor devices			
		• Identification of semi			
		semiconductor devices			
		Applications of			
		Characteristics of semi- conductor devices			
		conductor devices			
		• Operation of semi			
		devices			
	or Devices	of semiconductor			
9.1.06	Semiconduct	Construction and symbol	4	4	8

9.1.01 ELECTRICAL PRINCIPLES

Theory

Specific Objectives		quantities
By the end of the sub-		v) Verify Ohm's and
module the trainee		Kirchoff's laws
should be able to:		
a) state the basic		Content
electrical	9.1.01T1	Electrical quantities
quantities and		and their units
their units.		- In volts
b) draw electric		- Current in amperes
circuits		- Resistance in Ohms
c) apply electric		- Power in watts
circuits laws and	9101T2	Electric circuits
theorems to solve	2.1.0112	- simple electric
problems on	~	circuits
electrics circuits		- resistors in parallel
d) determine	CO.	- resistors in parallel
resistance of	X	- Tesisions in series
conductor 🔍	0101T3	Circuit laws and
e) explain the	9.1.0115	theorems
principle of a <i>solution</i>		Ohme low
wheatstone bridge.		- Official and the second
f) explain the	0 1 01774	- KIRCHOITS LAWS
principle of	9.1.0114	Resistance of metal
operation of a		conductors and
potentiometer		resistors
		- Length
Competence		- cross-sectional
The trainee should		area
have the ability to:		- resistivity
i) Derive formulae		- conductivity
for various d. c.		- effects of
circuits		temperature
ii) Determine	9.1.01T5	Wheatstone Bridge
resistance of	9.1.01T6	Potentiometer
conductors and		- operation
resistors in various		- derive formula
circuit		
arrangement		Practice
	 Specific Objectives By the end of the submodule 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 e) explain the principle of a wheatstone bridge. f) explain the principle of a potentiometer Competence 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 	Specific ObjectivesBy the end of the sub-module the traineeshould be able to:a) state the basicelectricalquantities andtheir units.b) draw electriccircuitsc) apply electriccircuits laws andproblems onelectrics circuitsd) determineresistance ofconductore) explain theprinciple of awheatstone bridge.f) explain theprinciple of aoperation of apotentiometerCompetenceThe trainee shouldhave the ability to:i) Derive formulaefor various d. c.circuitsii) Determine9.1.01T5resistance ofconductors andresistors in variouscircuitarrangement

iii) Connect various electrical circuits

electrical

measurement of

iv) Perform

Specific Objectives		By the end of the sub-
By the end of the sub-		module the trainee
module the trainee		should be able to:
should be able to:		a) define
a) connect electrical		terminologies used
d.c. circuits		in magnetic.
b) measure electrical		b) state types of
quantities		magnetic materials
c) verify given		c) describe magnetic
electric laws		field patterns
d) use a Wheatstone		d) describe magnetic
bridge to measure		circuit
resistance		e) explain the
e) use a potentiometer		principle of
to measure voltage		electromagnetic
Content		induction
Circuit connections		
- Series	9.1.02C	Competence
- Parallel	~	The trainee should
- Series/parallel	S.	have the ability to:
Electrical quantities	C	i) explain the
- current		principle of
- voltage		operation of
- resistance		electromagnetic
- power		induction
Electrical laws		ii) verify the existence
- Ohm		of existence of
- Kirchhoff		magnetic field
Measurement of		~
resistance using the		Content
Wheatstone bridge	9.1.0211	Terminologies
Measurement of		- magnetic flux
resistance using the		 magnetic field
potentiometer		strength
		 magnetic flux
MAGNETISM AND		density
ELECTRO		 magnetic motive
MAGNETISM		force
		- reluctance
Theory		- permeability
-		- hysteresis
Specific Objectives	9.1.02T2	Types of magnetic
Specific Objectives	9.1.02T2	Types of magnetic materials
	Specific Objectives By the end of the sub- module the trainee should be able to: 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 <i>Content</i> Circuit connections - Series - Parallel Electrical quantities - current - voltage - resistance - power Electrical laws - Ohm - Kirchhoff Measurement of resistance using the Wheatstone bridge Measurement of resistance using the potentiometer MAGNETISM AND ELECTRO MAGNETISM AND ELECTRO MAGNETISM AND	Specific Objectives By the end of the sub- module the trainee should be able to: 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 <i>Content</i> Circuit connections - Series 9.1.02C - Parallel - Series/parallel Electrical quantities - current - voltage - resistance - power Electrical laws - Ohm - Kirchhoff Measurement of resistance using the potentiometer MAGNETISM AND ELECTRO MAGNETISM AND ELECTRO MAGNETISM

9.1.02T3	Magnetic field pattern - Bar magnets	
9.1.02T4 9.1.02T5	 Current conductors Magnetic circuits Introduction Laws Inductance Energy stored in an inductor Calculation Principle of 	9.1.03
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	Electromagnetic induction	9.1.03T0
9.1.02P0	 Practice Specific Objectives By the end of the sub- module 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. 	L.com
9.1.02P1 9.1.02P2	<i>Content</i> Identification of various magnetic materials Classification of	9.1.03C
9.1.02P3	magnetic and non- magnetic materials Verification of the existence of magnetic field	

Permanent

Electromagnets

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- Bar magnet
- Horse shoe magnet
- Combination of magnets
- Current carrying conductor
- 3 **INTRODUCTION** TO D.C. **GENERATORS AND MOTORS**

Theory

- Specific Objectives By the end of the submodule the trainee should be able: 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
- 3C Competence The trainee should have the ability to: i) Operate DC machines

	ii) Carry out	0 1 0 4	
	DC machines	9.1.04	CURRENT (AC) CIRCUITS
9.1.03T1	<i>Content</i> DC machines		Theory
	- armature		
	- Commutator	9.1.04T0	Specific Objectives
	- Windings		By the end of the topic
	- Electromagnetic		the trainee should be
	induction		able to:
	- Armature reaction		a) explain the
	- Excitation		principle of
9.1.03T2	Separately excited		operation of AC
	generators		circuits
9.1.03T3	Shunt wound		b) explain the effects
	generators		of various passive
9.1.03T4	Series wound		elements in a
9.1.03T5	Compound wound	\sim	current.
	 Starting resistors 	~0`	factor in AC
	- Speed 🔪	0	circuits
	characteristics 🛛 🖉	•-	circuits
	- Torque	9.1.04C	Competence
	Practice		The trainee should
			have the ability to:
9 1 03P0	Specific Objectives		i) Determine power
2.1.051 0	By the end of the sub-		factor.
	module the trainee		ii) Calculate power in
	should be able:		AC currents
	a) Operate DC		111) Explain the
	machines		principle of
	b) Carry out		operation of AC
	maintenance of		generation
	DC machines		factor improvement
			u) Install power factor
	Content		v) Instan power factor
9.1.03P1	Operation of DC		equipment
	machines		Operate ac
	- Starting methods		generator
	- Voltage regulation		Content
	- Speed control	9.1.04T1	Operation of AC
9.1.03P2	Maintenance of DC	,	circuits
	machines		511

- 9.1.04T2 Effects of passive elements in AC circuits
 - Wave forms
 - Amplitude
 - Phase angle
 - Period
 - Roof mean square valve
 - Average valve

- Frequency

9.1.04T3 Determination of Power factor in AC circuits

Practice

- 9.1.04P0 *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 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

- 9.1.04P1 Wave generation 9.1.04P2 Features of an AC
- waveform
- 9.1.04P3 Power factor

- 9.1.04P4 Components of an AC generator
 9.1.04P5 Passive elements in AC, circuits
- 9.1.05 ELECTRON THEORY

Theory

- 9.1.05T0 Specific Objectives By the end of the submodule 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
 - 9.1.04C *Competence* The trainee should have the ability to describe the formation of P- and
 - N-type semiconductors

Content 9.1.05T1 Atomic and molecular structure

- neutron
- proton
- electrons

9.1.05T2 9.1.05T3	 orbit Semiconductor materials silicon germanium periodic table Intrinsic and extrinsic conduction electrons holes 		a) b) c)	describe the construction of semi conductor devices explain the operations of semi conductor devices explain and plot the characteristics of semi- conductor
	 influence of external field generation and recombination of charge carriers 		d)	devices state application of semiconductor devices
9.1.05T4	Crystal structure of semiconductor - covalent bond - energy levels - lattice	9.1.06C	Con The have i) (<i>npetence</i> trainee should e the ability to: Construct electronic circuits
9.1.05T5	 Formation of P and N-type semiconductor donor and acceptor atoms doping trivalent and pentavalent atoms free electrons and holes diffusion and drift currents 	ç	ii) T iii) T iii) I t iv) S s	using semiconductor devices Test semiconductor devices Explain and plot he characteristics of semiconductor devices Select and use various semiconductor devices
9.1.00	CONDUCTOR DEVICES	9.1.06T1	Con sym	<i>Content</i> Istruction and Ibol of
9.1.06T0	Specific Objectives By the end of the sub- module unit, the trainee should be able to:		sem devi - 1 - 1 - 1	iconductor ices Diode Bipolar junction transistor (BJT) Field effect transistors (FETs)

	- Zener diode		- LCD
	- Light emitting		Ducation
			Practice
	 Silicon controlled rectifier (SCR) Liquid crystal 	9.1.06P0	Specific Objectives By the end of the sub
0.1.0.000	display LCD)		should be able to
9.1.0612	Operation of semi		a) Identify types of
	conductor devices		semiconductor
	- Diode		devices
	transistor (BIT)		b) Connect and
	- Field effect		operate
	transistors		semiconductor
	(FET/MOSFET)		devices
	- Zener diodes		c) Test the
	- Silicon controlled		semiconductor
	rectifier (SCR)		devices
	- Liquid Crystal	\sim	~
	display (LCD)		Content
	- Light emitting	9.1.0611	Identification of semi
	diodes (LEDs)	0.1.06T2	Conductor devices
9.1.06T3	Characteristics of	9.1.0012	connection of
	semi-conductor		devices
	devices	9 1 06T3	Tests on
	- Diode	2.1.0013	semiconductor
	- BJT		components
	- FET/MOSFET		components
	- Zener diode	9.1.07	ELECTRONIC
	- Light emitting		COMPONENTS
	diode (LED)		
	- Liquid crystal		Theory
	CD _a		
0.1.0674	- SCRS	9.1.07T0	Specific Objectives
9.1.0014	Applications of		By the end of the
	devices		module unit, the
	- Diode		trainee should be able
	- BIT		to
	- FFT		a) describe the
	- Zener diode		features of various
	- IFD		components
	- SCR		components
	DUK		

	b) describe the operation of		- Integrated circuits (ICS)
	various electronic	9.1.07T 2	Operation of
	components	211071 2	electronics
	c) state the		components
	application of	9 1 07T3	Applications of
	various electronic	2.1.0715	electronics
	component		components
	•••mp •m•m		components
9.1.07C	Competence		Practice
	The trainee should		
	have the ability to;	9.1.07P0	Specific Objectives
	i) Select and use	,	By the end of the sub
	various electronic		module unit. the
	components		trainee should be able
	ii) Test electronic		to:
	components		a) identify various
	iii) Determine		electronic
	component value	~	components
	and rating	A.	b) determine values
	6	·0.	and ratings of
	Content	.×	electronic
9.1.07T1	Electronics	-	components
	Components		c) test various
	- Resistors		electronic
	- Capacitors		components
	- Inductors		1
	- Diodes		Content
	- Bi polar transistor	9.1.07P1	Identification of
	(BIT)		various electronic
	- Field effect		components
	transistors	9.1.07P2	Values and rating
	(FFTS)		- Component size
	Trioco		- Colour code
	- Thuristors (SCD)		- Component
	- Thynsiols (SCR)		Data
	- Photo conductive	9.1.07P3	Testing of electronic
			component
	- Photo diodes		- Short circuit
	- Photo transistors		- Open circuit
	- Light emitting		- Change in velue
	diodes (LED)		- Change in value
	- Liquid crystal		- leakage
	display (LCD)		

9.1.08	POWER		- Full wave
	RECTIFICATION		- Full wave bridge
		9.1.08T2	Smoothing
	Theory		- Reservoir
0.1.00700			- capacitor
9.1.0810	Specific Objectives		- $R - C$ filter
	By the end of the sub		- Pie filter
	module unit, the	9.1.08T3	Regulation
	trainee should be able		- Zener diode
	to:		regulator
	a) explain the		- Transistor regulator
	principles of power		- IC regulator
	regulation and	9.1.08T4	Voltage multipliers
	stabilization		- Double
	b) describe the		- Triplex
	rectification		- Quadrupler
	processes	9.1.08T5	Methods of power
	c) describe different		Supply protection
	methods of	\sim	- Circuit breakers
	smootning	-01	- Switches
	d) explain the	6	- Fuses
	voltage multipliere		
	and dividers		Practice
	e) explain the	0.1.0000	
	methods of power	9.1.08P0	Specific Objectives
			By the end of the sub
	supply protection.		1 1 1
	supply protection.		module unit, the
9.1.08C	supply protection.		module unit, the trainee should be
9.1.08C	supply protection. <i>Competence</i> The trainee should		module unit, the trainee should be able to:
9.1.08C	supply protection. <i>Competence</i> The trainee should have the ability to		module unit, the trainee should be able to: a) build simple
9.1.08C	supply protection. <i>Competence</i> The trainee should have the ability to i) demonstrate		 module unit, the trainee should be able to: a) build simple regulator circuit
9.1.08C	supply protection. <i>Competence</i> The trainee should have the ability to i) demonstrate rectification		 module unit, the trainee should be able to: a) build simple regulator circuit b) test and measure unities outputs
9.1.08C	supply protection. <i>Competence</i> The trainee should have the ability to i) demonstrate rectification ii) demonstrate		 module unit, the trainee should be able to: a) build simple regulator circuit b) test and measure various supply normators
9.1.08C	supply protection. <i>Competence</i> The trainee should have the ability to i) demonstrate rectification ii) demonstrate different methods		 module unit, the trainee should be able to: a) build simple regulator circuit b) test and measure various supply parameters
9.1.08C	supply protection. <i>Competence</i> The trainee should have the ability to i) demonstrate rectification ii) demonstrate different methods of smoothing		 module unit, the trainee should be able to: a) build simple regulator circuit b) test and measure various supply parameters
9.1.08C	supply protection. <i>Competence</i> The trainee should have the ability to i) demonstrate rectification ii) demonstrate different methods of smoothing iii) verify voltage	0.1.09D1	 module unit, the trainee should be able to: a) build simple regulator circuit b) test and measure various supply parameters
9.1.08C	supply protection. <i>Competence</i> The trainee should have the ability to i) demonstrate rectification ii) demonstrate different methods of smoothing iii) verify voltage multiplication and	9.1.08P1	 module unit, the trainee should be able to: a) build simple regulator circuit b) test and measure various supply parameters <i>Content</i> Construction of power supply
9.1.08C	supply protection. <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	 module unit, the trainee should be able to: a) build simple regulator circuit b) test and measure various supply parameters <i>Content</i> Construction of power supply regulators
9.1.08C	supply protection. <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	 module unit, the trainee should be able to: a) build simple regulator circuit b) test and measure various supply parameters <i>Content</i> Construction of power supply regulators Zener diode
9.1.08C	supply protection. <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 <i>Content</i>	9.1.08P1	 module unit, the trainee should be able to: a) build simple regulator circuit b) test and measure various supply parameters <i>Content</i> Construction of power supply regulators Zener diode regulator
9.1.08C 9.1.08T1	supply protection. <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 <i>Content</i> Methods of power	9.1.08P1	 module unit, the trainee should be able to: a) build simple regulator circuit b) test and measure various supply parameters <i>Content</i> Construction of power supply regulators Zener diode regulator Transistor regulator
9.1.08C 9.1.08T1	supply protection. <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 <i>Content</i> Methods of power rectification	9.1.08P1	 module unit, the trainee should be able to: a) build simple regulator circuit b) test and measure various supply parameters <i>Content</i> Construction of power supply regulators Zener diode regulator Transistor regulator

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 semiconduct devices
- Test instruments
- Circuit trainer kits
- chats
- 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

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