33.3.0 ELECTROMAGNETIC FIELDS THEORY

33.3.01 Introduction

The module unit is designed to impart knowledge skills and attitudes necessary to understand the application of electromagnetic fields in practical situations and in general design of electrical, magnetic and electromagnetic circuits

33.3.02 General Objectives

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

a) Analyse the concepts of electromagnetic field theory
b) Appreciate the need for electromagnetic field theory in electrical and magnetic circuits
c) Apply electromagnetic fields theory in solving electromagnetic circuits

33.3.03 Module Unit Summary and Time Allocation

Electromagnetic Fields Theory

Code	Sub-Module Unit	Content	Time Hrs
33.3.1	Introduction to Electromagnetic Waves	• Sources of Electromagnetic radiation • Electromagnetic Detectors • Application of electromagnetic waves	2
33.3.2	Electrodynamics	• Terms used in electrostatics • Electric field about an infinitely long line • Terms used in Magnetostatics • Magnetic field about an infinitely long line	8
33.3.3	Maxwell's Equation	• Maxwell's equation • Instantaneous vector equations • Properties of electromagnetic waves • Displacement current density	12
33.3.4	Properties Of Electromagnetic Waves	• Electromagnetic waves terms • Properties of an electromagnetic wave • Properties of an electromagnetic wave in various media • Electromagnetic Shielding	10

		• Skin Effect of electromagnetic waves	
33.3.5	Energy and Momentum in the Electromagnetic Field	• The Energy Conservation Theorem - Poyntings' Theorem • Momentum Flux • Electromagnetic Energy Flow	12
Total Time			**44**

33.3.1 **INTRODUCTION TO ELECTRO -MAGNETIC WAVES**

Theory

33.3.1T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) explain sources of electromagnetic radiation
b) analyse the detectors used in electromagnetic radiations
c) explain the application of electromagnetic waves

Content
33.3.1T1 Sources of Electromagnetic radiation
i) Long wavelengths
ii) Visible light
iii) Short wavelengths
33.3.1T2 Detectors of Electromagnetic radiation radiations
33.3.1T3 Applications of electromagnetic waves

Practice

33.3.1P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) determine electromagnetic radiation
b) use detectors to determine electromagnetic wavelengths

Content
33.3.1P1 Electromagnetic radiation
i) Long wave lengths
ii) Visible light
iii) Short wavelengths
33.3.1P2 Determination of electromagnetic wavelengths
- Photometric/radiometric detection

33.3.2 **ELECTRODYNAMICS**

Theory

33.3.2T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) explain terms used in electrostatics
b) analyse the electric field intensity about an infinitely long line
c) explain terms used in magnetostatics
d) analyse the magnetic field intensity about an infinitely long line

Content
33.3.2T1 Terms used in electrostatics
i) Electric field Intensity , E
ii) Electric flux ψ
iii) Electric flux density, D
33.3.2T2 Electric field about an infinitely long line using
i) Coulombs Law
ii) Gauss' Law

33.3.2T3 Terms used in Magnetostatics
- i) Magnetic field strength, B
- ii) Magnetic flux density, H
- iii) Magnetic flux, Φ

33.3.2T4 Magnetic field about an infinitely long line using
- i) Ampere's circuit law
- ii) Biot-Savart Law
- iii) Faraday's Law

33.3.2T5 Faraday's Law and its significance in time varying magnetic field

Practice

33.3.2P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
- a) Measure magnetic circuit parameters
- b) Plot the B-H curve and hence draw the Hysteresis loop
- c) Verify the laws associated with magnetic field intensity about infinitely long line
- d) Verify the laws associated with electric field intensity about an infinitely long line

Content

33.3.2P1 Measurement of magnetic circuit parameters

33.3.2P2 Determination of B-H curve
- i) The Hysteresis Loop
- Reversal method
- Step by step method

33.3.2P3 Verification of the Laws associated with magnetic field intensity
- i) Ampere circuit Law
- ii) Blot Sawart law
- iii) Faraday's law

33.3.2P4 Verification of laws associated with electric field intensity
- i) Coulombs law
- ii) Gauss law

33.3.3 MAXWELL'S EQUATION

Theory

33.3.3T0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
- a) describe Maxwell's equations in differential and integral forms
- b) analyse the Maxwell's equations to derive the instantaneous vector field theorem
- c) explain the properties of electromagnetic waves
- d) describe the displacement current density of parallel plate capacity

Content

33.3.3T1 Maxwell's equations
- i) Gauss' law for the electric field
- ii) Gauss' law for the magnetic field
- iii) Ampere' law
- iv) Faraday's law

33.3.3T2 analyses of Maxwell's equation to derive the instantaneous vector equation
- Instantaneous vector equation

33.3.3T3 Properties of electromagnetic waves
i) Propagation constant **Γ**
ii) Attenuation constant **α**

33.3.3T4 Displacement current density of parallel plate capacitors
- Phase constant **β**

Practice

33.3.3P0 *Specific Objectives*
By the end of the sub-module unit, the trainee should be able to:
a) Verify the Maxwell's equation
b) Apply the Maxwell's equation to determine the instantaneous vector field theorems

Content

33.3.3P1 Verification of Maxwell's equation
i) Gauss's laws for electric and magnetic fields
ii) Amperes law
iii) Faraday's law

33.3.3P2 Determination of instantaneous vector field theorems
i) Maxwell's equation
ii) Poyting's vector theorem

33.3.4 PROPERTIES OF ELECTROMAGNETIC WAVES

Theory

33.3.4T0 *Specific Objectives*
By the end of the sub-module unit the trainee should be able to:
a) explain terms used in Electromagnetic waves
b) describe Properties of an electromagnetic waves
c) analyse the properties of electromagnetic waves in various media
d) explain the principles of Electromagnetic Shielding
e) describe the skin effect in electromagnetic waves

Content

33.3.4T1 Terms used in Electromagnetic waves
i) Plane waves
ii) Transverse electromagnetic (TEM) wave
iii) Skin depth

33.3.4T2 Properties of an electromagnetic wave
i) Velocity of propagation,
ii) Intrinsic wave impendance
iii) Frequency
iv) Wavelength,
v) Attenuation,

33.3.4T3 Wave Characteristics in various media
i) Lossy Media
ii) Lossless Media
iii) Free Space
iv) Good Conductors

33.3.4T4 Principles of electromagnetic shielding

33.3.4T5 Skin Effect

33.3.4T6 Poynting's theorem and the Poynting's vector

33.3.5 ENERGY AND MOMENTUM IN THE ELECTROMAGNETIC FIELD

Theory

33.3.5T0 *Specific Objectives*

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

a) describe the Energy Conservation Theorem
b) describe momentum flux
c) determine the electromagnetic energy flow

Content

33.3.5T1 The Energy Conservation Theorem - Poyntings' Theorem

i) Ohmic Heating
ii) Electric field Energy Density
iii) Magnetostatic Field Energy Density

33.3.5T2 Magnetostatic Momentum Flux

33.3.5T3 Electromagnetic Energy Flow

i) Energy Flow into a Resistive Wire
ii) Energy Flow out of Battery
iii) Propagation of Energy along a Wire

33.3.5C **Competence**

The trainee should have the ability to:

i) Measure magnetic circuit parameters
ii) Plot the B-H curve and determine characteristic of magnetic materials by studying the hysteresis loop.
iii) Use detectors to determine various wavelengths
iv) Apply vector field theorems to analyse wave propagation

Suggested teaching/Learning Activities

- Discussion
- Illustration
- Demonstration
- Note taking
- Practical exercise
- Calculations

Suggested teaching/Learning Resources

- Spectrum analysers
- Cathode Ray Oscilloscope
- Detectors

Suggested Evaluation Methods

- Oral tests
- Timed written tests
- Assignments
- Timed practical tests