



# Electromagnetic Fields & Waves I – EEE 341

## Department of Electrical & Electronics Engineering

### Faculty of Engineering

#### 1. Basic Details

**Programme:** B.ENG

**Year:** 2014/2015

**Total Units:** 2

**Level:** 300L

**Taught Semester:** First Semester

**Instructor:**

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**Office Hours:**

**Mondays** (12 – 4pm); and **Thursdays** (11am – 1pm, 5 – 6pm); or By Appointment

**Reading Materials:**

**Departments:** EEE & MEE

**Prerequisite Courses:** PHY 101, PHY 103 (General Physics I & II), MTH 104 (Elementary Mathematics III) & ENG 301(Engineering Analysis III), OR Equiv. **Prior Knowledge:**

- Elementary knowledge of Vector Analysis – geometric representation of vectors in 1-3 dimensions, components, Direction Cosines, Differentiation & Integration of vectors, Cross Product, Dot Product, Vector, Scalar, Gradient, Divergence, Curl,
- Basic knowledge of the physics of Kinematics of a particle
- Basic understanding of Geometry, Dynamics & Co-ordinate Systems
- Fundamental knowledge of Electrostatics, Magnetics fields & induction, Maxwell's Equation, Wave Theory, etc.

**Lecture Time:** Thurs: 2-4pm

**Total Learning Hours:** 20

**Course Delivery:** Blended/Face to Face

**Lecturers:** Engr. G.K. Ijemaru & Engr. A.S. Oluwole

#### 2. Course Overview

Electromagnetics (EM) is a branch of physics or electrical engineering that studies the interactions between electrical and magnetic phenomena. It entails the analysis, synthesis, physical interpretation, and application of electrical & magnetic fields. Maxwell's equations represent a fundamental unification of electric and magnetic fields predicting electromagnetic wave phenomena by which all wireless (and guided) telecommunication systems operate.

EEE 341 provides the background for many continuing specialist courses that implement the results of this course e.g. microwave components, photonics, fiber optics, radar, antennas, etc.

### 3. Course Objectives

The purpose of this course is to introduce electromagnetics from a wave viewpoint and give a unifying description both qualitatively and quantitatively of the subject demonstrating how it impacts on all specialties within electrical engineering.

### 4. Intended Learning Outcomes (ILO)

On successful completion of the course, the students will be able to:

- Understand the mathematical techniques of vector analysis
- Use vector calculus to solve Maxwell's Equations describing the electromagnetic static and dynamic fields in a variety of geometries and coordinate systems.
- Understand, analyze and apply some of the EM principles and concepts using vector analysis
- Analyze electromagnetic wave propagation in free space and in different materials.
- Analyze electromagnetic wave propagation through guiding structures (metal & dielectric waveguides and transmission lines) under various loading conditions, and design impedance matching circuits for optimum power transfer.
- Analyze and design wire antennas, arrays & dishes.

### 5. Course Content

- **Vector Analysis (Review)**
  - ✓ Vector Algebra (Elementary vector operator, unit vector, components of a vector, etc.)
  - ✓ Vector Calculus (gradient, divergent, curl, etc.)
  - ✓ Coordinate systems (Vectors in Cartesian, Circular and Cylindrical)
- **Electrostatics**
  - ✓ Electric charge & the law of electronics, electric field and lines of force, electrostatic induction, electric field intensity, electric flux density, electric potential energy, dielectric materials and their properties, Poisson's and Laplace equations,
  - ✓ Capacitor, insulation, resistance of a cable, energy stored in a capacitor,
- **Magneto-statics**
  - ✓ Electromagnetism, electromagnetic induction,
  - ✓ Ampere's law and Faraday's law
  - ✓ Energy stored in a magnetic circuit
  - ✓ Magnetic properties of matter

### 6. Course Schedule

Week	Topics	Reading Assignment
1.	▪ <b>Topic 1: Vector Algebra (Review)</b>	
2.	▪ <b>Topic 2: Vector Calculus (Review)</b>	
3.	▪ <b>Topic 3: Vectors in Cartesian Coordinate (Review)</b>	
4.	▪ <b>Topic 4: Review of EM laws in integral forms, Gauss's law, Ampere's law and Faraday's law</b>	
5.	▪ <b>Topic 5: Magnetic fields in and around current carrying conductors; conduction and displacement current</b>	
6.	▪ <b>Quiz 1</b>	
7.	▪ <b>Topic 6: Derivation of Maxwell's equation in curl form from Faraday's and Ampere's laws</b>	
8.	▪ <b>Time-varying electric and magnetic fields in free space</b>	

9.	▪ Plane waves in vacuum, dielectric, skin effect polarization & waves	
10.	▪ Poynting's vector & Energy propagation in free space, Boundary conditions	
11.	▪ Plane waves in unbounded dielectric media, Reflection and transmission of plane waves	
12.	▪ Quiz 2	
13.	▪ Revision	

## 7. Course Learning & Teaching Methods

- Lecture: 2hrs (Thurs: 2 – 4pm)
- Formative phase tests and Group tutorials/discussions

## 8. Learning & Teaching Activities

Activity Type	Percentage	Hours
Lectures & Class Exercises	17%	20
Group Tutorials/Discussions	13%	15
Guided independent study	70%	80
<b>Total</b>	<b>100%</b>	<b>115</b>

## 9. Course Assessment Method

<b>Requirement:</b>	2 Hours Exam
<b>Status:</b>	Compulsory/Elective
<b>Written Examination:</b>	60%
<b>Quiz/Test:</b>	20% (two quizzes)
<b>Homework:</b>	10%
<b>Attendance:</b>	10%

Level of Performance	Grade	Rating (credit points per unit)
70-100%	A = Excellent	5.0
60-69%	B = Very Good	4.0
50-59%	C = Good	3.0
45-49%	D = Satisfactory	2.0
40-44%	E = Poor	1.0
0-39%	F = Failure	0.0

## 10. Industry Relevance

- Microwaves, Antennas, Electric Machines, Satellite Communications, Bio electromagnetics,
- Plasmas, Nuclear research, Fiber optics, Electromagnetic interference and compatibility,
- Electrochemical energy conversion, Radar meteorology, Remote sensing
- Motion of Nano-robots
- Sensors and actuators,
- Induction Heating, Tomography
- Motors and generators, Transformers, Relays, Electric Bells and Buzzers
- Loudspeakers and earphones, Magnetic locks
- Magnetic recording and data storage equipment (tape recorders, VCRs, hard disks)
- Radio/TV, Telephone, Transmission lines, Waveguides, Lasers,

## 11. Required Text

1. Principles of Electromagnetics by Matthew N.O Sadiku

## 12. Recommended Texts

1. Principles & applications of electromagnetic fields by Robert Plonsey
2. Electromagnetic fields, Energy and Waves by Leonard M. Magod
3. Engineering Electromagnetics by William H. Hayt, JR

## 13. Attendance Policy

Attendance is strictly mandatory. The University policy stipulates that in order to be eligible for a course examination, a student shall be expected to attend a minimum of 65% of the lecture, tutorials, practical and classes for the course in which he/she is registered [**Ref. Students' Handbook of Information, pg. 52**]. Any student, therefore, whose attendance rating falls below the required 65% shall not be eligible to write the course exam. In this regard, students will be notified of their eligibility status for a course examination prior to the exam.

## 14. Calculator Policy

Programmable calculators will not be allowed in the quizzes or final exam. The University policy prohibits the use of mobile phone, electronic programmable calculator, information storage devices, etc. in the quizzes or final exam [**Ref. Students' Handbook of Information, Pg. 49**]. A “programmable calculator” is one that can store program steps or text at any level of sophistication and the rule applies irrespective of whether or not there appears to be anything stored. If you are in any doubt as to the eligibility of your calculator, please see me well before the quiz/exam.

## 15. Exemption from Quizzes/Exam

Dated medical documentation is required for exemption from a quiz; in this case the weighting will be moved to the final. Makeup quizzes will not be offered under any circumstances. The University policy prohibits a student from absenting from exam except on acceptable medical grounds, and in consultation with the HOD and the Dean of the faculty. Any student absent on the ground of illness must produce a certified medical report, and students who absent from quizzes/exams for reasons other than illness, accident or some exceptional circumstances shall be deemed to have failed the course [**Ref. Students' Handbook of Information, Pg. 52**].

## 16. Ethical and Unethical Conduct

The preliminary purpose of Homework is to help students learn and gain practical experience in the subject matter. Allowing and encouraging collaborations with fellow students best serves this purpose. Modern engineering is, after all, almost exclusively a team effort. However, fairness requires us to be able to assess your *own* contribution. Therefore, the written material that you hand in *must* be your *own work*, and any discussions or collaborations with fellow students must be identified in writing on your solution (e.g. noting “the solution to problem #5 was worked out together with Mark Davison”, or “the solution to problem #2 was benefited from discussions with Ruth Peters”). Nearly identical solutions from different students who do not cross-reference each other will be viewed as statistically “unlikely”, thus worthy of further examination.

This policy is intended to help you make the most out of the course by allowing you to freely work with your classmates. If you are in any doubt as to what constitutes ethical or unethical conduct, please see any member of staff for assistance. Violations of this policy will be handled with maximum severity.