ECE 360 Spring 2008

Electromagnetic Fields and Waves

Overview

Course Catalog Description: Maxwell's equations, plane wave propagation, waveguides and transmission lines, transient pulse propagation, and elementary dipole antenna.
Prerequisites: C- or better in 213, Physics 161, and Math 264L
Textbook: F. Ulaby, *Fundamentals of Applied Electromagnetics*, 5th edition (2006), Prentice Hall.
Optional Textbook: F. J. Edminister, *Schaum's Outline of Theory and Problems of Electromagnetics*, McGraw-Hill.
Class Goals: For the students to acquire a comprehensive understanding of electric and magnetic fields, their origins, as well as there interactions with various materials and boundaries.
Course Coordinator: Jamesina Simpson

Table 1: Objectives, Implementation, and Assessment

Outcomes		Implementation	Assessment	A	B	C	D	E	F	G	H	I	J	K
1	To understand the fundamental scalar and vector field quantities with their associated units, and to understand the fundamental constants encountered in electromagnetics.	EECE 360: This point is addressed in nearly every single lecture. Many of the homework problems require the students have knowledge of this.	Problem #1 in Exam 1, Exam 2, and the Final Exam.	**X**				**X**						
2	To understand how to characterize materials in terms of their electric and magnetic properties, and to assess how this characterization depends on the frequency of the field.	EECE 360: addressed in class lectures and class assignments.	One problem on Exam 2 and the Final Exam.	**X**				**X**						
3	To understand the difference between phasor form and the time-instantaneous representation of an electromagnetic wave.	EECE 360: addressed in class lectures and class assignments.	One problem on Exam 2 and the Final Exam.	**X**				**X**						
4	To understand how to describe an electromagnetic wave mathematically for a given set of coordinate axes, direction of wave polarization, and direction of wave propagation. The ability to describe a wave should also be consistent with the presence of nearby surfaces.	EECE 360: addressed in class lectures and class assignments.	One problem on Exam 2 and the Final Exam.	**X**				**X**						

5	To be able to take a problem in electromagnetics that is stated in words; draw an appropriate sketch that depicts the problem; set-up the problem with respect to an appropriate coordinate system, source and observation points; use the approprate physical law or principle in the context of the coordinate system with proper unit vectors; and complete the mathematics to demonstrate an analytically closed form solution that properly addresses the problem statement.	EECE 360: addressed extensively in class lectures and problem sets.	Problem #5 in Exam 1, Exam 2, and the Final Exam.					**X**		**X**				**X**
6	Communicate effectively in written technical English.	EECE 360: In class it is emphasized that solutions to problem sets and exam problems be written in a lucid technical English.	An informal grade will be assigned to the Final Exam that assess's the students' composition of the problem solutions.							**X**				
7	Be knowledgeable of electromagnetics in a global and social context.	EECE 360: In lectures I often discuss examples of how electromagnetics impacts us globally and socially through, *e.g.*, communications, unexpected consequences of technologies, *etc.*	If students attend my lectures, they will be aware of this. So, attendance.								**X**			
8	Appreciate the fact that their education does not end upon completing their B.S. degree.	EECE 360: In lectures I often emphasize to students the nature in which electromagnetics problems were solved in the past (sometimes using mechanical analogies), and how we can solve them today through the use of computer tools (MatLab, for instance).	If students attend my lectures, they will be aware of this. So, attendance.									**X**		

9	Have an awareness of contemporary issues.	EECE 360: In lectures I often discuss technical issues that are raised in the public media (print, television, internet) during the time frame that I teach the class. I highlight these when electromagnetics is involved.	If students attend my lectures, they will be aware of this. So, attendance.										**X**	
10	Utilize modern engineering tools for engineering practice.	EECE 360: Encourage the use of MatLab or other similar software tool to evaluate integrals that are faced in problem sets.	Problem Sets.											**X**

Table II: Expectation and Assessment Outcome
Spring 2008, Assistant Professor Jamesina Simpson

General expectation: By end of semester, 75% of the students will have scored 70% or better on the final exam problems pertaining to the outcomes listed.

Homework: Assignments will be given on a weekly basis. Worth 20% of final grade. Expectation is that all students will submit a completed assignment each week and will receive at least partial credit.

Projects: N/A

Quizzes: N/A

Exams: Two exams (each, 20% of final grade) and one final, comprehensive exam (40% of final grade) will be administered. Expect 75% of students to complete exams with a grade of 70% or better.

Outcomes	Outcomes Assessment	Evaluation
0. Homework:	63% of the students submitted solutions to all of the problem sets.	Expectation was not met. The expectation is stringent (all must submit at least a partially completed assignment each week).
1. To understand the fundamental scalar and vector field quantities with their associated units, and to understand the fundamental constants encountered in electromagnetics.	100% of the students scored 70% or better on problem 1 on the final.	Expectation was met. Note: since the format of the final was changed at the last minute to accommodate changing the order of presentation of some materials, only the first part of problem 1 could be used to assess this.
2. To understand how to characterize materials in terms of their electric and magnetic properties, and to assess how this characterization depends on the frequency of the field.	100% of the students scored 70% or better on problem 3 on the final. [Note, problem 3 used instead of problem 2.]	Expectation was met.
3. To understand the difference between phasor form and the time-instantaneous representation of an electromagnetic wave.	62% of the students scored 70% or better on problem 3 on the final. [Note, problem 6 used instead of problem 3.]	Expectation was not met. Maybe those students that did not regularly attend class missed out on the concepts.
4. To understand how to describe an electromagnetic wave mathematically for a given set of coordinate axes, direction of wave polarization, and direction of wave propagation. The ability to describe a wave should also be consistent	62% of the students scored 70% or better on problem 4 on the final. [Note, problem 6 used instead of problem 4.]	Expectation was not met. Maybe those students that did not regularly attend class missed out on the concepts.

with the presence of nearby surfaces.		
5. To be able to take a problem in electromagnetics that is stated in words; draw an appropriate sketch that depicts the problem; set-up the problem with respect to an appropriate coordinate system, source and observation points; use the approprate physical law or principle in the context of the coordinate system with proper unit vectors; and complete the mathematics to demonstrate an analytically closed form solution that properly addresses the problem statement.	85% of the students scored 70% or better on problem 4 on the final. [Note, problem 5 used instead of problem 4.]	Expectation was met
6. Communicate effectively in written technical English.	100% of the students received a satisfactory score for their writing on the final.	Expectation was met.
7. Be knowledgeable of electromagnetics in a global and social context.	I touch upon this in occasional lectures as warranted. However, I do not have attendance data.	Unquantified.
8. Appreciate the fact that their education does not end upon completing their B.S. degree.	I touch upon this oin occasional lectures as warranted. However, I do not have attendance data.	Unquantified.
9. Have an awareness of contemporary issues.	I touch upon this in lectures as warranted. However, I do not have attendance data.	Unquantified.
10. Utilize modern engineering tools for engineering practice.	63% of the students submitted solutions to all of the problem sets. At least one of the problems included construction of a Matlab code.	Expectation was met.

Sample Course Schedule from Spring 2008

ECE 360: Electromagnetic Fields and Waves

Spring 2008 Overview:

Introduction to electromagnetic waves in electrical engineering. Concepts of transmission lines, electrostatics and magnetostatics; Maxwell's equations for time-varying fields; plane-wave propagation, reflection, and transmission; introduction to fiber optics and other special topics.

Required Textbook: F. Ulaby, *Fundamentals of Applied Electromagnetics*, 5th edition (2006), Prentice Hall.

Optional Textbook: F. J. Edminister, *Schaum's Outline of Theory and Problems of Electromagnetics*, McGraw-Hill.

Instructor: Jamesina Simpson, Assist. Professor, ECE
Office: ECE building 318a
Office Hours: Mon. 11:00-12:00, Tues. 3:00 – 4:00
Phone: 277-1904; Email: simpson@ece.unm.edu

Goals: To provide the electrical engineering student with the necessary foundation to appreciate exactly how electromagnetic fields and waves impact modern technology such as high-speed digital circuits and fiber optics.

Organization: Three lectures per week; no labs. Weekly homework assignment due on Wed.

Grading: Two Midterms, 20% each; Final 40%; Homework 20%.

Final Exam: Friday, May 16th, 7:30 – 9:30 am

Course Outline:

Week 1 Why study electromagnetics? Introduction to transmission lines. (Chpt. 1, 2)

Week 2 Transmission lines, continued: Lumped-element model, transmission line differential equations, impulsive wave propagation and reflection, bounce diagram, sinusoidal excitation, input impedance. (Chpt. 2)

Week 3 Smith Chart, impedance transformation and matching. Review of vector algebra, line and surface integrals, coordinate systems. (Chpt. 2, 3)

Week 4 Central forces. Electrostatics: Coulomb's Law, electric potential, electrostatic flux, Gauss' Law. (Chpt. 4)

Week 5 Electrostatics, continued: Electric field boundary conditions, electrical properties of materials, conductors and dielectrics, capacitance, electrostatic field energy. (Chpt. 4)

Week 6 Magnetostatics: Right-hand rule, Lorentz force, Biot-Savart relation, torques. (Chpt. 5)

Week 7 Magnetostatics, continued: Magnetic properties of materials, magnetic field boundary conditions, Ampere's Law, inductance, magnetostatic field energy. (Chpt. 5)

Week 8 Motional EMF, motors and generators, Lenz's Law, eddy currents. Faraday's Law voltage-current for an inductor, transformers. (Chpt. 6)

Week 9 Displacement current and the generalized Ampere's Law. Time-dependent Maxwell's equations. (Chpt. 6)

Week 10 Consequences of the time-dependent Maxwell's equations: Electromagnetic wave equation, plane-wave propagation in free space (vacuum) at the speed of light, polarization, electric and magnetic field boundary conditions. (Chpt. 7)

Week 11 Sinusoidal steady-state specialization: Helmholts equation, plane waves, propagation in lossless media. (Chpt. 7)

Week 12 Linear, circular, and elliptical electromagnetic wave polarization. Electromagnetic wave propagation in lossy materials, skin effect. (Chpt. 7)

Week 13 Poynting vector and power flow. Plane electromagnetic wave reflection and transmission at a material interface for normal incidence. (Chpt. 7, 8)

Week 14 Plane electromagnetic wave reflection and transmission at a material interface for oblique incidence. Snell's Laws. Brewster angle. Total internal reflection. Applications to fiber optics and photonics. (Chpt. 8)

Week 15 Review; special topics.

Department of Electrical and Computer Engineering

ECE 360 Knowledge Probe

This quiz is for assessment purposes only and will not be counted towards your grade in this class.
(Prerequisites to this class are: Phys. 161, Math 264, and ECE 213)

NAME:________________________________

BANNER ID ______________________

Do not write below this line.

1. ______/10
2. ______/10
3. ______/10
4. ______/10
5. ______/10
6. ______/10
7. ______/10
8. ______/10
9. ______/10
10. ______/10

Total Grade:_____/100

Probe 1 [Phys. 161]

Which one of the following phenomena should not belong on a chart of the electromagnetic spectrum?

a. Lightning triggered whistler waves in the atmosphere
b. The ability of dogs to hear at frequencies above the range of human hearing
c. Operational frequencies of cell phones
d. Submarine communications
e. *I do not know*

Probe 2 [Phys. 161]

Which of the following correctly describes a property of a static electric field?

a. A static electric field can penetrate a metal sometimes
b. A static electric field always penetrates a metal
c. A static electric field is always zero in a metal
d. A static electric field is parallel to a metal boundary
e. *I do not know*

Probe 3 [Phys. 161]

Which of the following is not a property of a vector?

a. A vector has a magnitude and a direction
b. The magnitude of a vector does not possess a direction
c. One can always generate a unit vector from any vector
d. The gradient of a vector is zero
e. *I do not know*

Probe 4 [Math 264]

Which of the following is a true statement pertaining to a unit normal?

a. The direction of the differential surface area vector $d\vec{S}$ is always determined by the unit normal to the surface
b. The unit normal is an important part of the differential volume dV
c. The unit normal is the only unit vector whose magnitude can be greater than unity
d. There is no such thing as the unit normal
e. *I do not know*

Probe 5 [Math 264]

$\iiint \nabla \cdot \vec{F} \, dV = \oint\!\!\oint \vec{F} \cdot d\vec{S}$ with $d\vec{S} = \vec{a}_n \, dS$ is a statement of the divergence theorem.

a. True
b. False
c. *I have never seen this*

Probe 6 [Math 264]

Given two vectors: $\vec{A} = \sqrt{3}\vec{a}_x + \vec{a}_y$ and $\vec{B} = 2\vec{a}_x$, find the angle between them.

a. 30°
b. 60°
c. 90°
d. 0°
e. *I do not know*

Probe 7 [Math 264]

Find the gradient of the scalar field given by $f(x, y, z) = axz + bx^3 y$

a. $(az + 3bx^2 y)\vec{a}_x + bx^3\vec{a}_y + ax\vec{a}_z$
b. $az\,\vec{a}_x + bx^3\vec{a}_y$
c. $az + bx^3$
d. 0
e. *I do not know.*

Probe 8 [ECE 213]

What is the advantage of using the Laplace Transform in solving for the transient response of a circuit?

Probe 9 [ECE 213]

The complete response to an RLC circuit is the sum of the forced response and the natural response.

a. True
b. False
c. *I have never seen this*

Probe 10 [ECE 213]

Plot the following function: $f(t) = u(t+6)$. Label your axes.