ECE 4800 Fall 2011: Electromagnetic Fields and Waves

Instructor: Amar S. Basu  
Office: 3133 Engineering  
Email: abasu@eng.wayne.edu  
Phone: 313-577-3990

Lecture Times: M W 7:30PM - 9:20PM,  
Class Dates: 9/7/11 – 12/14/11  
Location: 218 Manoogian  
Credits: 4  
Office Hours: M 6-7:30PM, Th 2-3:30, and by appointment

WSU Catalog Description:
Prerequisites: ECE 3300. From these courses, students should be familiar with 1) Electrical quantities/waveforms, 2) Analysis of electrical circuits, 3) Resistance, and Ohms Law, 3) Nodal and mesh analysis, and 4) 1st and 2nd order systems.

Course Topics: Open only to students enrolled in professional engineering programs. Fundamentals of electromagnetic engineering, static electric and magnetic fields using vector analysis and fields of steady currents, Maxwell’s equations and boundary value problems. Basic principles of plane waves, transmission lines and radiation. (T)

Learning Objectives (5)
1. Understand and compute basic problems in vector algebra, including dot product, cross product, gradient, curl, divergence, etc.
2. Understand and analyze Electrostatic fields and currents
3. Understand and analyze Static magnetic fields and currents
4. Understand and analyze time varying fields using Maxwell’s equations
5. Understand and explain basic principles of plane wave propagation and radiation.

ABET Outcome Coverage
ABET is responsible for accrediting engineering degree programs throughout the USA. This course has coverage in the following ABET objectives. For more information on ABET objectives, visit www.abet.org.

(a) An ability to apply knowledge of mathematics, science, and engineering.  
This course is heavy on vector mathematics and calculus, and principles in mathematics will be used to derive some of the important relationships. Accordingly, a portion of the course time will be devoted to reviewing these concepts, and if you understand these principles well, you will find that they will apply directly to electromagnetic phenomena.

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.  
In electromagnetics it is important to understand vector math and 3D visualization. Accordingly, we will utilize the popular software Matlab to perform vector and matrix calculations, and to plot 2D and 3D vector fields.
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

Electromagnetics is a fundamental topic necessary to understand electrical and electronic devices/phenomena. During class we will find some common

(e) an ability to identify, formulate, and solve engineering problems

Electromagnetics is a challenging course in problem solving. In this course you will learn groups of techniques used to solve canonical problems in electrostatics and magnetostatics. In exams and homework, there may be more than one way to solve the problem, and you will need to choose which approach is most appropriate for problems.

Textbook and Other resources:


If you are confused about a topic in our textbook or my lecture notes, try to look up additional references in the list below. **Whether you end up in industry or grad school, it is very important to learn how to independently become an expert in a new subject.**

- Popular textbooks in semiconductor physics
  - D. Cheng, Electromagnetic Fields and Waves
  - Ulaby Fundamentals of Applied Electromagnetics
- Hyperphysics (http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html). Click the circle which says “Electricity and Magnetism”.
- Other online sources such as Wikipedia (http://www.wikipedia.org). Be careful with online sources because their accuracy cannot be verified.

Course Modules (Tentative)

1. Introduction/Motivation – why study semiconductor device physics
2. Vector Calculus
   a. Review of matrix math
   b. Vector addition/subtraction
   c. Vector Multiplication – Dot product and Cross product
   d. Review of 3D coordinate systems – Cartesian, cylindrical, spherical
   e. Gradients
   f. Divergence
   g. Curl
   h. Stokes Theorem
3. Static Electric Fields (Electrostatics)
   a. Fundamental rules of analysis
   b. Coulomb’s Law
   c. Gauss’s Law
   d. Electric potential
   e. Material media in static electric fields – conductors and dielectrics
   f. Electric flux density, definition of dielectric constant
   g. Boundary conditions for electrostatic fields
   h. Capacitance/capacitors
   i. Electrostatic energy and forces
4. Steady Electric Currents (also part of electrostatics)
   a. Current Density and Ohm’s Law
   b. Equation of Continuity and Kirchoff’s Law
   c. Power Dissipation and Joule’s Law
   d. Calculating Resistance
5. Static Magnetic Fields (Magnetostatics)
   a. Fundamentals of magnetostatic analysis
   b. Vector magnetic potential
   c. Biot-Savart Law
   d. Magnetic Dipoles
   e. Magnetization and Equivalent Current Densities
   f. Magnetic Field Intensity and Magnetic Permeability
   g. Magnetic materials
   h. Boundary conditions
   i. Inductances/Inductors
   j. Magnetic Energy
   k. Magnetic Forces and Torques – DC motors Static
6. Time Varying Fields and Maxwell’s Equations
   a. Faradays Law
   b. Maxwell’s equations – integral form and electromagnetic boundary conditions
   c. Potential Functions
   d. Time-Harmonic Fields – phasors, field analysis, electromagnetic spectrum
7. Plane Electromagnetic Waves
   a. Plane waves in Lossless Media – doppler effect, transverse/longitudinal, polarization
   b. Plane waves in Lossy Media – Low-loss dielectrics, good conductors
   c. Group velocity
   d. Flow of electromagnetic power, Pointing Vector
   e. Normal incidence of plane waves at planar boundaries
   f. Oblique incidence of plane waves at planar boundaries – total reflection, polarization, Brewster angle, Snell’s law
8. Transmission lines (if time permits)
   a. Transmission line equations
   b. Transmission line parameters
   c. Infinite transmission lines
   d. Finite transmission lines
   e. Smith Chart
   f. Transmission line impedance matching

Attendance Policy:
Students are required to attend class, and attendance will be taken if necessary. 3 absences are allowed for documented personal/medical reasons. Please email me in advance if you know you will miss a class.

However, on the following dates, attendance is absolutely mandatory. No makeup exams will be given, so please email me within the first week of classes if you have a conflict on these dates.

Midterm 1: Monday, October 3rd during class
Midterm 2: Monday, November 14th during class
Final exam: Wednesday, December 14th during regular class time
Grading Policy:
- 15% Homework. There will be 3-5 homework assignments. 
  
  *Homework is due at the beginning of the lecture. 3 late days allowed, maximum 2 late days per assignment. After that, HW will not be accepted for credit.*
- 45% Two midterms (each 22.5%)
- 35% Final exam
- 5% reserved for attendance, and pop quizzes if necessary

Grading scale (subject to change)

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Cheating Policy and Penalty for Cheating:
Cheating is defined by the University as “intentionally using or attempting to use, or intentionally providing or attempting to provide, unauthorized materials, information, or assistance in any academic exercise.” This includes any group efforts on assignments or exams unless specifically approved by the professor for that assignment/exam. Evidence of fabrication or plagiarism, as defined by the University in its brochure Academic Integrity, will also result in downgrading for the course. Students who cheat on any assignment or during any examination will be assigned a failing grade for the course.

Blackboard:
We will use the WSU blackboard website extensively in this course. Please log on to http://blackboard.wayne.edu and make sure you have access to ECE 4570 course website. Our blackboard site will be used for the following:

- **Lecture slides, homeworks, and course information** will be posted. I will plan to upload lecture slides at least 2 hours before lecture begins. Please print them out and bring them to class with you.
- **Lecture and homework related questions** Discussion boards in blackboard will be used to post answers to questions related to the lectures and homework. Please post your questions to the appropriate blackboard discussion group. I will be checking them periodically and will post answers as soon as possible.
- **Anonymous feedback:** There is a blackboard discussion group specifically for anonymous course feedback. Please be sure to check the ‘anonymous’ box and feel free to give your honest feedback and constructive criticism about how the course can be improved.
- **Grades:** You will be able to access your current grades at any time.
- **Urgent notices:** Those who have registered with the WSU emergency alert system can receive text messages on your cell phone. I will use the broadcast system in case of last minute class cancellations or other urgent notices.

Feedback:
I as well as the ECE department value your feedback in how we can make this course better and better serve your needs.

- The standard WSU course evaluations will also be given at the end of the term.
- We may have midterm teaching evaluations of the course sometime in the middle of the semester.
- Anonymous feedback can be posted anytime through blackboard.
- If you have any personal issues with the course, please come to office hours or setup an appointment to speak with me individually.