

ECE 331:Engineering Electromagnetics I

Catalog Description

Concept of a traveling wave with application to transmission lines; review of vector algebra and calculus in various coordinate systems; Maxwell's equations for magnetostatics and electrostatics; weekly lab.

Credit hours: 4

Goals

Students will have the ability to use mathematics and physics to formulate, and solve engineering electromagnetics problems. With the accompanying laboratory assignments, students will use modern engineering equipment and tools to solve practical electromagnetic problems.

Prerequisites

Mth 254, Mth 256, Ph 223 or Ph 213.

Corequisite: ECE 331L

Course Coordinator and Committee

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Textbooks

Fundamentals of Applied Electromagnetics, (7th edition) by Fawwaz T. Ulaby and Umberto Ravaioli, Pearson Prentice Hall, ISBN-13: 978-0133356816.

The course instructor may choose to use a different textbook. Please check with your instructor before purchasing.

Learning Outcomes

At the end of this course, students will be able to:

1. Apply math and physics to solve engineering electromagnetic problems.
2. Analyze transmission line parameters, characteristic impedance, reflections and power transfer from generator to load. Perform transmission line analysis using Smith chart.

3. Perform electromagnetic lab experiments including using bench-top.
4. Write technical lab reports, analyze and summarize results.
5. Use Matlab/Python as a tool to solve for electric and magnetic fields from charges and currents.

Topical Outline

- Equations governing electric and magnetic forces. Mathematical formulation for traveling waves.
- Complex algebra in rectangular and polar forms.
- Phasor domain techniques to analyze circuits with sinusoidal sources.
- Transmission line parameters, characteristic impedance and propagation constants for coaxial, two-wire, parallel plate and microstrip transmission lines.
- Reflection coefficients, standing wave patterns and voltage and current maxima and minima.
- Power transferred from generator to load through transmission lines.
- Smith Chart to perform transmission line calculations.
- Time-domain approaches to analyze transient response on transmission lines.
- Vector calculus for solving electromagnetic problems. Apply vector algebra in Cartesian, cylindrical and spherical coordinates and perform transformations between.
- Gradient, divergence and curl operations, Divergence Theorem and Stokes Theorem.
- Maxwell's equations (including Coulomb's Law) for electrostatic problems. Electric field from distribution of electric charges.
- Resistance of arbitrarily shaped objects.
- Capacitance of two-conductor configurations.
- Magnetic force of a current carrying wire in a magnetic field.
- Biot-Savart and Ampere's laws for magnetostatic problems.
- Magnetic hysteresis in ferromagnetic materials.
- Inductance of a solenoid or coaxial transmission line.
- **Laboratory experiments:**
- **Lab 1:** Acoustics Lab. Experimental exploration of characteristic properties of acoustic waves. Concepts covered: propagation of acoustics waves in air, Interference of traveling waves, spreading loss, and the matched filter detection technique.
- **Lab 2:** TDR Lab. Learn to locate and identify transmission line discontinuities using Time Domain reflectometry. Concepts Covered: transmission line transient analysis, identifying and locating transmission line discontinuities from their TDR waveforms, and TDR resolution, accuracy, range factors.
- **Lab 3:** VNA Lab. The vector network analyzer is introduced as a measurement tool, and used to study the characteristic parameters of transmission line networks and for characterizing a student designed bandpass filter. Concepts Covered: vector network analyzer calibration, scattering matrices, voltage standing wave ratio, Smith charts, and characteristic parameters of transmission lines.
- **Lab 4:** Computational Electromagnetics. Develop static electromagnetic equations in numerical form. Compute divergence and curl, and magnetic field on a wire.

Course Structure

The class meets for two 90-minute lectures each week plus four 180-minute labs during the term. The grade is based on class participation, reports, homework assignments and exams. Grading criteria may vary with the instructor. Please refer to the individual instructor's syllabus for information on the grading breakdown (i.e., percentage weight for each category) and grading scheme.

Relevant Program Outcomes

The following program outcomes are supported by this course:

(1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. Course learning outcomes 1,2,5.

(6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions. Course learning outcomes 2,3,4,5

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