ECE3025 - Electromagnetics (3-0-3)

Prerequisites: See topical outline
Corequisites: None

Catalog Description: To present the laws and applications of electromagnetics.

Textbook(s):
Hayt & Buck, *Engineering Electromagnetics* (8th edition), McGraw Hill, 2012. (required) (comment: A free note packet is available through on PDF through the GT Library.)

Peterson and Durgin, *Transient Signals on Transmission Lines: An Introduction to Non-Ideal Effects and Signal Integrity Issues in Electrical Systems*, Morgan Claypool, 2009. (required) (comment: This book is free to GT students & faculty through the GT Library. ISBN listed is for e-book. ISBN for paperback version is 9781598298253.)

Course Objectives - As part of this course, students:
1. develop an understanding of the fundamental concepts of electromagnetic fields, with an emphasis on wave propagation. [6]
2. relate basic electromagnetic concepts to the performance of devices, circuits, and systems. [6,8]

Course Outcomes - Upon successful completion of this course, students should be able to:
1. determine parameters associated with waves on lossless and lossy transmission lines, including frequency, phase velocity, attenuation and phase consts
2. solve transient problems involving initially uncharged or charged transmission lines with resistive and reactive loads
3. design transmission line terminations to minimize reflections and maximize received power
4. explain the fundamental processes by which crosstalk between transmission lines occurs
5. determine frequency-domain parameters associated with a transmission line system, including input impedance, reflection coefficient, and SWR
6. analyze transmission line problems in the frequency domain with complex load impedances, to determine input and load voltage/current, power delivered
7. calculate the electric field, scalar potential, stored energy, and capacitance associated with simple distributions of charge
8. calculate the magnetic field, stored energy, and inductance for simple distributions of current density
9. calculate the resistance of simple structures of given conductivity
10. apply boundary conditions to determine current and charge densities produced on conducting boundaries by applied fields
11. identify Maxwell's equations and apply them in both their integral and differential forms to time-varying field problems
12. identify an electromagnetic wave and determine parameters (frequency, phase constant and velocity, associated intrinsic impedance) and power density
13. determine the attenuation constant, phase constant, and skin depth for waves in a lossy medium, where the conductivity may range from low to high
14. distinguish between linear polarization, circular polarization, and elliptical polarization with right-hand/left-hand orientation
15. calculate reflection and transmission coefficients and fields for uniform plane waves normally-incident and obliquely-incident on planar interfaces

Topical Outline:

Prerequisites: (ECE 2040 [min C] or ECE 3710) and (ECE 2025/2026 [min C] or NRE 2110) and MATH 2401/2411/24X1 [min C] and MATH 2403/2413/24X3 [min C]

Electrostatics
- Scalar Potential, Energy Density, Force
- Electrostatic Field of Charge Distributions
- Permittivity (Dielectric Constant)
- Boundary Conditions
- Concept of Capacitance

Electric Current
- Equation of Continuity
- Electrical Conductivity and Resistance

Magnetostatics
- Vector Potential, Energy Density, Force
- Magnetostatic Field of Current Distributions
- Permeability
- Boundary Conditions
- Concept of Inductance

Time-Varying Fields
- Maxwell's Equations
- Transformers
- Motors and Generators
- Energy, Power and Poynting's Theorem
- Time-Harmonic Fields

Transmission Lines
- Lumped Circuit Model
- Transmission Line Equations
- Pulse Excitation
- Time-Harmonic Excitation
- Matching

Plane Waves and Geometric Optics
- Concept of a Plane Wave, Polarization
- Fresnel's Equations
- Lossy Media, Skin Depth
- Lenses and Mirrors
- Overview of Optical Fibers

Radiation
- Hertzian Dipole
- Antenna Parameters (Directivity, Beamwidth, etc.)
- Aperture Antennas
- Friis Transmission Formula