ECE 341: Electromagnetic Fields and Devices I

IN

Mathematics

- Solve integrals, take derivatives, and solve differential equations by classical analytical techniques
- Use vector algebra in three-dimensional problems in space
- Use standard orthogonal coordinate systems
- Knowledge of geometry and trigonometry
- Understands basics of vector calculus
- Command of complex algebra

Circuit Theory

- Analyze linear circuits with time-invariant currents
- Analyze RLC circuits in time-harmonic regime
- Command of power and energy relations for circuit elements, in both instantaneous and time-average forms
- Analyze electric circuits with time-harmonic currents using phasors and complex variables

Physics and Engineering

- Understands basics of electricity and magnetism
- Use Coulomb's law and Biot-Savart law to compute electric and magnetic fields due to simple charge and current distributions
- Use Gauss' law and Ampère's law in integral form to solve simple electric and magnetic static field problems
- Command of basic mechanical principles and relations in motion, force, energy, work, rotation, torque, and equilibrium
- Use engineering problem-solving skills
- Understands algorithmic and modular approach to problems in engineering

Pre-requisites

- ECE202 with a minimum grade of C; MATH340 with a minimum grade of C; PHYS142 with a minimum grade of C; ECE311, may be taken concurrently; ECE331, may be taken concurrently

Concepts:

- Electrostatic field in free space
- Electrostatic field in material media
- Steady electric currents
- Magnetostatic field
- Low-frequency electromagnetic field

Applications:

- Electronics
- Power systems
- Electromagnetic compatibility
- Modeling of transmission lines
- Communications
- Computer engineering
- Computational electromagnetics

Tools:

- Vector algebra
- Vector calculus
- Complex algebra
- MATLAB – optional

OUT

Maxwell's Equations

- Use Maxwell's equations in integral and differential forms, and boundary conditions to solve complex static and low-frequency electromagnetic-field problems
- Mathematically model electric and magnetic properties of material media in relation with field equations
- Understand how electromagnetic material properties can be exploited in engineering applications
- Understand and appreciate EM field theory as a foundation of circuit theory and electrical engineering as a whole

EM Field Computation

- Can solve realistic static and low-frequency electromagnetic-field problems utilizing physical conceptual reasoning and mathematical synthesis of solutions, and not pure formulaic solving
- Visualize electric and magnetic fields and understand associated abstract field phenomena
- Geometrically represent and spatially visualize three-dimensional structures

EM Energy and Loss Power

- Understand concepts and is able to evaluate electric and magnetic energy densities and total electric and magnetic energies of different structures
- Understand concepts and is able to evaluate Joule loss power density and total dissipated power of different structures

EM Devices and Systems

- Compute and analyze potentials and fields in time-invariant and low-frequency EM devices and systems of various shapes and material compositions
- Evaluate capacitance, inductance, resistance, and conductance of EM structures
- Understand limitations of circuit theory as an approximation of field theory, and can relate them to problems and issues in designs of devices and systems
- Understand the influence of fields in the acquisition and processing of the signals and in the electronic design of devices and systems

Reviewed 2/2024