

EEE 341 Electromagnetic Fields and Waves (4) [F,S]

Course (Catalog) Description:

Fundamental principles of time-varying electromagnetic fields as well as some of the technologies that have been developed to exploit these phenomena.

Lecture, Laboratory. Pathway course, required for all majors and minors.

Prerequisite: EEE 241, **EEE203**.

Textbook: D. K. Cheng, *Field and Wave Electromagnetics*, Second Edition, Addison Wesley, 1989.

Supplemental text: S. Ramo, J. R. Whinnery, T. V. Duzer, *Fields and Waves in Communication Electronics*, John Wiley and Sons, 1994.

Coordinator: J. Aberle.

Prerequisites by Topic:

1. Electrostatic and magnetostatic, 2. Phasors and complex numbers 3. Differential equations. 4. Vector analysis

Course Objectives:

1. This is an undergraduate level course in engineering electrodynamics that encompasses topics from all major areas of applied electromagnetics.
2. It constitutes a foundation for more advanced courses for students with emphasis in electromagnetics.
3. It serves as an introduction to wave phenomena and high-frequency concepts for students with areas of emphasis other than electromagnetics.

Course Outcomes:

1. Students can write and interpret phasor Maxwell's equations in differential and integral forms, both in time and frequency domains.
2. Students understand the meaning of complex ϵ , μ , and σ , and perfect electric and perfect magnetic conductors.
3. Students can comfortably work with plane waves, derive Snell's laws from phase matching, and calculate the reflection and transmission coefficients at the interface of simple media.
4. Students understand the meaning of and can differentiate between phase velocity and group velocity.
5. Students understand and can apply complex Poynting theorem to calculate average power.
6. Students understand the meanings of characteristic impedance and complex propagation constant and can relate them to the basic transmission line parameters (L' , C' , R' and G').
7. Students can calculate input impedance and reflection coefficient of an arbitrarily terminated transmission-line and can use Smith chart to convert these quantities.
8. Students can use attenuation constant to calculate the losses of a transmission line section or the quality factor of a transmission-line resonator.
9. Students understand the concept of propagating modes, TE and TM decomposition, evanescent modes and cutoff frequency in waveguides.
10. Students can calculate the cutoff frequency and propagation constant for parallel plate, rectangular, and dielectric slab waveguides.
11. Students can calculate the resonant frequency of simple cavity resonators.

12. Students understand the meaning of elemental electric and magnetic dipoles.
13. Students understand the basic parameters of antennas and can relate antenna radiation pattern to its directivity.
14. Students are exposed to the examples of array theory.

Course Topics:

- 1- Recap of electrostatic and magnetostatic axioms (1 week)
- 2- Time-varying fields and Maxwell's equations (1 week)
- 3- Time-harmonic electromagnetic fields (1 week)
- 4- A general introduction to the theory of transmission lines (1 week)
- 5- Wave characteristics in finite transmission lines (1 week)
- 6- Transients on transmission lines (0.5 week), Smith chart (0.5 week)
- 7- Calculating transmission line parameters (0.5 weeks), Plane waves in lossless media (0.5 week)
- 8- Plane waves in lossy media (0.5 week), Poynting vector and energy transport (0.5 week)
- 9- Reflection of plane waves by conducting boundaries (1 week)
- 10- Reflection and refraction of plane waves by the interface of simple media (1 week)
- 11- Electromagnetic waves in uniform guiding structures (0.5 week), Parallel plate and rectangular waveguides and cavity resonators (1.5 weeks), Dielectric slab waveguide (0.5 week)
- 12- Radiation fields and elemental dipoles (0.5 week), Radiation pattern and other antenna parameters (0.5 week), Half-wave dipole antenna (0.5 week), Receiving antennas (0.5 week), Introduction to antenna arrays (0.5 week)
- 13- Tests, quizzes, and examinations (1 week)

Computer Usage:

Students use MATLAB to develop and visualize solutions to moderately complicated field problems. Students are exposed to industry standard electromagnetic field solvers such as Ansys HFSS.

Laboratory Experiments:

Students meet weekly for a three-hour laboratory under the guidance of a TA.

- Lab 1 - Time domain reflectometry
- Lab 2 - SWR measurements using slotted waveguide
- Lab 3 – Software Lab 1: Method of moments (MoM) applied to electrostatics
- Lab 4 – Software Lab 2: Finite difference time domain (FDTD) method in 2D
- Lab 5 - Microwave power measurement
- Lab 6 - Reflection of plane waves
- Lab 7 - Software Lab 3: Modes of a rectangular waveguide using Ansoft HFSS
- Lab 8 - Antenna measurements

Course Contribution to Engineering Science and Design:

EEE 341 contributes to engineering science through creating a basic understanding of electromagnetics theory and its most important applications in electrical engineering, and allows the student to develop and apply the mathematical skills that are vastly used in different areas of engineering and applied physics.

Course Relationship to EE Program Outcomes:

a: EM is the foundation of all contemporary electrical technology and is applicable to almost all EE industry work. Differential equations, Vector differential Operators and physics backgrounds are utilized.

b: Students receive some experiment design/data interpretation instruction in the lab and are taught problem solving methodologies and acquire some modeling experience.

k: MATLAB and industry standard electromagnetic field solver software are used for solving field theory problems.

Person preparing this description and date of preparation: J. Aberle, June 2015.