# Fields and Waves (ECE230)

**Offering:** Winter Semester
**Instructor (Winter – 2015):** Mohammad Hashmi

**Credits:** 4
**Pre-requisites**: Complex Variables, Calculus, Vector Calculus
**Post Condition (on student capability after successfully completing the course):**

- Write Maxwell's Equations in differential and integral forms and the constitutive relations between the flux densities and field intensities of the electrostatics, magnetostatics and electrodynamic fields.
- Solve Maxwell's Equations using vector calculus concepts.
- Derive the Helmholtz wave equations in its various forms and the wave nature of their solutions for time-harmonic waves in various mediums.
- Use MATLAB to solve simple EM problems in the domains of RF circuits and Antennas.

**Brief Description:**
This course is intended to be a broad introduction to Engineering Electromagnetics and its applications. The course will develop understanding of the principles underlying time-varying fields and Maxwell's equations, describe plane electromagnetic waves and develop its mathematical model for different media for its interaction with interfering planes. The second half of the course builds on the foundations covered in the first half and introduces the transmission line concepts. The subject will be augmented with MATLAB simulation exercises. A small term paper/project is part of the course.

**Detailed Outline:**

| Week | Topics to be Covered | assignments / labs/tests |
|---|---|---|
| 1 | • Introduction<br>• Review of Coordinate Systems & Transformation<br>• Review of Vector Calculus | None |
| 2 | • Electrostatics: Coulomb's Law and Field Intensity, Electric Fields Due to Continuous Charge Distribution<br>• Electrostatics: Electric Flux Density, Gauss's Law – Maxwell's Equation<br>• Electrostatics: Electric Potential<br>• Electrostatics: Maxwell's Equation (Relating E and V) | ~~HA #1~~ |
| 3 | • Electrostatics: Electric Dipole and Flux Lines<br>• Energy Density in Electrostatic Fields<br>• Electric Fields in Material Space: Properties of materials, convection and conduction currents | ~~Class test – 1~~ |

| | | |
|---|---|---|
| 4 | • Conductors, Dielectrics (including polarization)<br>• Dielectric Constant and Strength<br>• Electric Fields in Material Space: Continuity Equation and Relaxation Time<br>• Electric Fields in Material Space: Boundary Conditions | ~~HA #2~~ |
| 5 | • Electrostatic Boundary Value Problems: Poisson's and Laplace's Equations, Uniqueness Theorem, Solution for Poisson's and Laplace's Equations<br>• Resistance and Capacitance | ~~HA # 3~~ |
| 6 | • Magnetostatic Fields: Biot-Savart Law, Ampere's Circuital Law<br>• Applications of Ampere's Law<br>• Magnetic Flux Density | ~~Class test – 3~~ |
| 7 | • Maxwell's equation for Static Fields<br>• Magnetic Scalar and Vector Potentials<br>• Magnetic Torque and Moment<br>• Magnetic Dipole | ~~HA # 4~~ |
| 8 | • Magnetization in Materials<br>• Magnetic Boundary Value Problems<br>• Inductors and Inductances | ~~Class test – 4~~ |
| 9 | • Magnetic Energy<br>• Magnetic Circuits<br>• Magnetic Levitation<br>• Maxwell's Equations: Faraday's Law, Displacement Current, Maxwell's Equations in Differential and Integral Forms<br>• Power and Poynting Vectors | ~~HA # 5~~ |
| 10 | • Time-Varying Potentials, Time-Varying Fields<br>• Wave Propagation in Lossy Dielectrics<br>• Plane Waves in Free Space, Plane Waves in Good Conductors | ~~Class test – 5~~ |
| 11 | • Reflection of Plane Waves at Normal Incidence<br>• Reflection of Plane Waves at Oblique Incidence | ~~HA # 6~~ |
| 12 | • Introduction to Transmission Lines | |
| 13 | • Introduction to Antenna | |

**Texts/Other Resources**

**Text Book:**

- Principles of Electromagnetics $4^{th}$ *Edition,* Mathew N. O. Sadiku.

**Reference Book:**

- Electromagnetic Field and Waves *2nd Edition,* David K. Cheng.
- Fundamentals of Applied Electromagnetics $6^{th}$ *Edition*, Fawwaz T. Ulaby
- Engineering Electromagnetics with MATLAB $2^{nd}$ *Edition*, Karl E. Lonngrenn et al.

**Methodology:**

- Class lectures will be power point slides based and may be augmented by supplementary resources such as video lectures and/or traditional chalk and board
- MATLAB simulations may also be incorporated to help students in understanding the concepts

**Evaluation:**

Class-Test (all compulsory): 20%
Home Assignments (all compulsory): 20%
Mid-sem: 25%
End-sem: 25%
Project: 10%

**Plagiarism Policy:**

As per the institute guidelines