

Engineering Electromagnetics

Course Description

Instructor

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Office: N412 SCU Jiang 'an South

Classroom: S508 SCU Jiang 'an South

Lectures: Wednesday 8:15 – 11:00

Sections: 1

Office Hours: Monday, 14:45 – 15:30 PM, Wednesday 13:50 – 14:35 PM

Description

An electromagnetics curriculum offers a comprehensive study of electromagnetic theory. It starts with foundational concepts such as vector analysis and static fields, then progresses to dynamic fields governed by Maxwell's equations. The course emphasizes applying these principles to real-world physical scenarios, including wave behavior, transmission line theory, antenna design, and the influence of fields on materials. Students use these ideas to solve problems involving waves, how signals travel through cables, how antennas work, and how materials are affected by these fields.

Prerequisites

Students are assumed to have a good understanding of the principles and practices of Physics 2 (PHYS xxxx), Calculus 3 (MATH xxxx), Differential Equations (MATH xxxx), and Methods of Applied Mathematics (MATHxxxx).

Course Learning Objectives

On satisfying the requirements of this course, students will have the knowledge and skills as follows:

- Demonstrate proficiency with vector analysis, including coordinate systems (Cartesian, cylindrical, and spherical), and apply vector operators like gradient, divergence, and curl to electromagnetic problems.
- Explain the foundational laws and concepts of electromagnetism, including Coulomb's Law, Gauss's Law, Ampere's Law, and the Lorentz force equation.
- Characterize and explain the behavior of materials in electric fields, including conductors and dielectrics.
- Apply the boundary conditions that electric fields must satisfy at the interface between different materials.
- Understand and apply the Biot-Savart and Ampere's laws to calculate magnetic fields generated by steady currents.
- Magnetic materials: Differentiate between various magnetic materials (diamagnetic, paramagnetic, and ferromagnetic) and describe their properties and applications.

- Understand time-varying phenomena, including Faraday's Law of Induction and the concept of displacement current. Interpret and apply the differential and integral forms of Maxwell's equations to solve for electric and magnetic fields in different media.
- Electromagnetic waves: Explain the unified theory of electromagnetism and derive the electromagnetic wave equation from Maxwell's equations. Wave characteristics:
- Understand the properties of electromagnetic waves, Analyze the reflection and refraction of electromagnetic waves at boundaries between different media.
- Engineering applications: Apply electromagnetic principles to practical technologies, such as transmission lines, waveguides, and antennas.

Resources

Prescribed Textbook:

Engineering Electromagnetics, 9th Edition, William H. Hayt and John A. Buck, McGraw-Hill Companies, Inc., 2018

Technological Resources (Virtual Lab)

Students may find virtual simulations an effective tool for the operations of real-world processes or systems. The computer simulations are widely used and are available for free at

<https://eem-iitd.vlabs.ac.in/home.html>

<http://www.walter-fendt.de/ph14e/>

[Mathworks.com](https://www.mathworks.com)

Blackboard

Lecture notes, assignments, projects, announcements, and your grades will be uploaded on the Blackboard (<https://pibb.scu.edu.cn/>) for the Engineering Electromagnetics course.

Tutorials

Tutorials, run by TA, will start in Week 02.

Assessments and Grades

The assessments include homework/assignments, quizzes, midterm, and final exams. The final grade will be computed according to the following scheme (100% total), but the percentages of each portion can be flexible accordingly:

Assignment/Homework:	10-15%
Attendance & Attitude:	05-10%
Quizzes:	15-20%
Midterm:	25-30%
Final Exam:	25-30%

Letter grades will be determined from accumulated point total according to the scale below:

A [90, 100], A- [85, 90), B+ [80, 85), B [76, 80), B- [73, 76), C+ [70, 73), C [66, 70), C- [63, 66), D+ [61, 63), D [60, 61), F (60, 0).

Assignments/Homework

Homework will be assigned every week and due by the following weekend submitted online by the specified date. Late homework may be accepted but will be significantly deducted and plagiarism is not tolerated. The homework will be graded, and solutions will be posted after the submission due date. Discussions on homework problems are encouraged.

Quizzes

In-class quizzes will be conducted before, or after the Midterm exam, or both to check the progress of the students' understanding of the course.

During Class

Computers may be allowed in class for the electronic recording of notes. But please refrain from using computers for any activities unrelated to the course. Phones are not suggested for use.

Attendance Policy

Attendance is expected in all lectures. Valid excuses for absence will be accepted before class, and valid excuses with proof will be accepted after class.

Policies on Exams

Late submission for previous assignments during the final exam period will NOT be accepted in any form for any excuses. All tests and the final exam are mandatory. If you miss the midterm or final exam, a makeup exam may be given if the student has approval from the instructor or emergencies and health issues with valid proof.

Academic Assistance

You are encouraged to attend office hours and tutorials if you have questions regarding class materials, homework problems, grading issues, etc. Otherwise, you may email the TA or the instructor.

Academic Integrity

At Sichuan University, we are guided by the values of academic integrity: honesty, trust, fairness, responsibility, and respect (The Centre for Academic Integrity, Duke University, 1999). As a student, you must demonstrate these values in all your work. Everyone at SCAI is expected to treat others with dignity and respect. The Code of Student Conduct allows Sichuan University to take disciplinary action if students do not follow this community expectation.

Special Needs

The Office of Special Needs Services at Sichuan University ensures that students with special needs have equal access to the campus and course materials. We will work with the Office of Special Needs to provide adequate services to students with special needs.

Topical Outline of the Course Contents

The schedule is tentative and subject to change. The listed objects below should be viewed as the key concepts you should grasp each week and as a study guide before each exam and at the end of the semester.

Teaching Plan

Week	Topics	Learning outcomes
1 - 2	<i>Vector Analysis</i>  Basic Laws of Vector Algebra  Orthogonal Coordinate Systems and transformations between Coordinate Systems  Divergence and Curl of a Vector Field, Laplacian Operator  <i>Applied Examples</i> - Global Positioning System (GPS) - X-Ray Computed Tomography	✓ Correctly describe and apply, both qualitatively and quantitatively, gradient, divergence, and curl to electromagnetic problems
3	<i>Basic Laws of Electrostatics</i>  Maxwell's Equations  Charge and Current Distributions  Gauss's Law  Electric Scalar Potential  Conductors and Dielectrics	✓ Understand how to apply Gauss's law ✓ Characterize and explain the behavior of materials in electric fields, including conductors and dielectrics.

4	Basic Laws of Electrostatics (Contd.)  Electric Boundary Conditions Capacitance  Electrostatic Potential Energy  Image Method - Electric Field Due to a Dipole	✓ Apply the boundary conditions that electric fields must satisfy at the interface between different materials.
5	Basic Laws of Electrostatics (Contd.)  A Charged Particle in an External Electric Field  A Dipole in an Electric Field  Applied Examples - Capacitive Sensors	✓ Determine how humidity, pressure and noncontact sensors work.
6	Magnetostatics  Magnetic Forces and Torques  The Biot-Savart Law  Maxwell's Magnetostatic Equations  Vector Magnetic Potential  Applied Examples - - Electromagnets	✓ Understand and apply the Biot-Savart and Ampere's laws to calculate magnetic fields generated by steady currents.
7	Magnetostatics (Contd.)  Magnetic Properties of Materials  Magnetic Boundary Conditions  Inductance  Magnetic Energy  Applied Examples - Inductive Sensors	✓ Differentiate between various magnetic materials and describe their properties and applications.
8	Midterm Exam	✓ Materials taught from weeks 1-7
9	Time-varying Electromagnetic Field  Faraday's Law  Stationary Loop in a Time-Varying Magnetic Field  Moving Conductor in a Static Magnetic Field  The Electromagnetic Generator  Moving Conductor in a Time-Varying Magnetic Field	✓ Understand and apply the general form of sources in the electromagnetic field and Electromagnetic potentials

10	<i>Time-varying Electromagnetic Field (Contd.)</i>  Displacement Current  Boundary Conditions for Electromagnetics  Charge–Current Continuity Relation  Free-Charge Dissipation in a Conductor  Electromagnetic Potentials  Applied Examples - EMF Sensors	✓ Interpret and apply the differential and integral forms of Maxwell's equations to solve for electric and magnetic fields in different media.
11	<i>Maxwell's Equations</i>  Maxwell's Equation in general form  Maxwell's Equation for Linear Isotropic Homogeneous Media  Electromagnetic Momentum  Applied Examples - Electromagnetic Pumping	✓ How Faraday's law of electromagnetic induction relates to the curl of the electric field ✓ How Maxwell's equations lead to electromagnetic waves and how the speed of light is related to static properties of the vacuum.
12	<i>Electromagnetic Waves</i>  Light as an Electromagnetic Wave and the Electromagnetic Spectrum  Energy in EM Waves; the Poynting Vector  Reflection of EM Waves	✓ Why there are both electric and magnetic fields in a light wave. ✓ What determines the amount of power carried by an electromagnetic wave.
13	<i>Plane Wave Propagation</i>  Plane Waves in Conducting, Nonconducting, and Charged Media  Plane Waves in an Arbitrary Direction  Complex Solutions and Time-Average Energy Relation	✓ Derivation of the wave equation and the diffusion equation. ✓ Instantaneous value and complex representation (phasors) of magnitudes of the electromagnetic field with a harmonic time change.
14	<i>Plane Wave Propagation (Contd.)</i>  Wave Polarization  Electromagnetic Parameters  Applied Examples - RFID System - Liquid Crystal Display (LCD)	✓ How to describe linear, circular, and elliptical polarization in various media.
15	<i>Wave Reflection and Transmission</i>  Wave Reflection and Transmission at Normal Incidence  Snell's Laws	✓ Formulation of basic laws and coefficient calculations through Fresnel equations. ✓ Flat non-uniform wave

	 Fiber Optics  Wave Reflection and Transmission at Oblique Incidence  Applied Examples - Lasers - Bar-Code Readers	properties and total reflection
16	Wave Reflection and Transmission (Contd.)  Waveguides  General Relations for E and H  TM Modes in Rectangular Waveguide  TE Modes in Rectangular Waveguide  Propagation Velocities  Cavity Resonators	✓ Engage with the diverse interactions of waves, such as reflection, refraction, diffraction, and interference.
17	Electromagnetic Radiation and Antennas  The Hertzian Dipole  Antenna Radiation Characteristics  Half-Wave Dipole Antenna  Dipole of Arbitrary Length  Effective Area of a Receiving Antenna  Friis Transmission Formula  Radiation by Large-Aperture Antennas  Applied Examples - Health Risks of EM Fields	✓ Interpret the important elements of antenna and propagation theory ✓ Calculate and apply fundamental antenna parameters ✓ Compare important classes of antennas and their properties ✓ Apply theoretical principles to design an antenna, using Electromagnetic simulation.
18	Final Examination	