Electromagnetics (ECE 1259)
Fall 2025

Course Description

Instructor

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Office: N516 New SCUPI Building

Classroom: **S104 New SCUPI Building**
Lectures: **Wednesday 8:15 – 11:00**
Sections: 1

Office Hours: Tuesday, 2 – 3 PM, Friday 2 – 4 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 behaviour, 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 0175), Calculus 3 (MATH 0240) and Differential Equations (MATH 0290).

Course Learning Objectives (CLOs)

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

- CLO1 Demonstrate proficiency with vector analysis, including coordinate systems (Cartesian, cylindrical, and spherical), and apply vector operators like gradient, divergence, and curl to electromagnetic problems.
- CLO2 Explain the foundational laws and concepts of electromagnetism, including Coulomb's Law, Gauss's Law, Ampere's Law, and the Lorentz force equation.
- CLO3 Characterize and explain the behaviour of materials in electric fields, including conductors and dielectrics.
- CLO4 Apply the boundary conditions that electric fields must satisfy at the interface between different materials.
- CLO5 Understand and apply the Biot-Savart and Ampere's laws to calculate magnetic fields generated by steady currents.
- CLO6 Magnetic materials: Differentiate between various magnetic materials (diamagnetic, paramagnetic, and ferromagnetic) and describe their properties and

applications.

CLO7 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.

CLO8 Electromagnetic waves: Explain the unified theory of electromagnetism and derive the electromagnetic wave equation from Maxwell's equations. Wave characteristics:

CLO9 Understand the properties of electromagnetic waves, Analyse the reflection and refraction of electromagnetic waves at boundaries between different media.

CLO10 Engineering applications: Apply electromagnetic principles to practical technologies, such as transmission lines, waveguides, and antennas.

Student Learning Outcomes (SLOs)

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

SLO1 Analytical skills: Solve a range of problems in electromagnetism by combining mathematical skills with an understanding of physical principles.

SLO2 Computational skills: Use software like MATLAB to solve and visualize electromagnetic field problems numerically.

SLO3 Experimental skills: Design and conduct experiments to test electromagnetic theories, analyse results, and communicate findings through technical reports

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 the 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

Blackboard

Lecture notes, online quizzes, assignments, projects, announcements, and your grades will be uploaded on the ECE 1259 page of the Blackboard (https://pibb.scu.edu.cn/).

Tutorials

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

Assessments and Grades

The assessments include homework/assignments, weekly quizzes, midterm, and final exams. The final grade will be computed according to the following scheme:

Assignment/Homework:	15%
Attendance:	05%
Quizzes:	25%
Midterm:	30%
Final Exam:	25%

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. No late homework is accepted, and plagiarism is not tolerated. Homework is also randomised, and students are expected to submit the solutions online. The homework will be graded, and solutions will be posted after the submission due date. Discussions on the homework problems are encouraged. For collaborative assignments, grading rubrics are used for *objective and consistent assessment of various performances, assignments, and activities.* The rubrics for the collaborative projects/assignments will be uploaded to the Blackboard.

Quizzes: In-class/online quizzes will be conducted periodically, starting from week 2 of this semester. Each quiz will access the contents discussed in the prior week. The best of five quizzes towards the final grades. Like homework, quizzes will be randomised, and students are expected to submit the quiz solutions individually. For quizzes and homework, you have one week to appeal if you feel your solutions are under-graded. No evaluation requests will be accepted after the solutions are posted.

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 prohibited as they are rarely helpful for anything in the course. Eating and drinking are allowed in class, but please keep from it affecting the course.

Attendance Policy

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

Policies on Late Assignments and Exams

Students should start their homework assignments immediately after they are given, and DO NOT wait until the last minute to meet the deadlines. Late assignments will be NOT accepted except for emergencies and health issues. Any other late assignments handed in will be marked but will be given a zero mark. All assignments will be counted in your total grade. 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. There will be no makeup exam for any quizzes and homework/assignments. 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. I will not accept the student deceleration for absence form for the final exam.

Academic Assistance

You are encouraged to attend office hours if you have questions regarding class materials, homework problems, grading issues, etc. Otherwise, you may email the TA or the instructor. Please allow 24 to 48 hours for any response to emails. The subject of each email must include "[ECE 1259]". For example, if you have a question regarding a homework problem, the email's subject could be [ECE 1259] Question about Problem X of Assignment X. Please make sure that you sign off with your official name (the one that appears in Blackboard). You are encouraged to use academic language in your posts.

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 SCUPI 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 after 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	***Vector Analysis***
	- Basic Laws of Vector Algebra
	- Orthogonal Coordinate Systems and transformations between Coordinate Systems
	- Divergence and Curl of a Vector Field, Laplacian Operator
	- ***Applied Activities***
	  - Global Positing System (GPS)
	  - X-Ray Computed Tomography
		✓ Correctly describe and apply, both qualitatively and quantitatively, gradient, divergence, and curl to electromagnetic problems

3	***Basic Laws of Electrostatics*** - 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 behaviour 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
	- ***Inquiry-based Activity***
	  - Capacitive Sensors
	  - Resistive Sensors
	  - Supercapacitors as Batteries
		✓ 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 - ***Inquiry-based Activity*** - 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 - ***Inquiry-based Activity*** - 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	***Time-varying Electromagnetic Field (Contd.)*** - Displacement Current - Boundary Conditions for Electromagnetics - Charge–Current Continuity Relation - Free-Charge Dissipation in a Conductor - Electromagnetic Potentials - ***Inquiry-based Activity*** - 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	***Maxwell's Equations*** - Maxwell's Equation in general form - Maxwell's Equation for Linear Isotropic Homogeneous Media - Electromagnetic Momentum - ***Inquiry-based Activity*** - 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	***Electromagnetic Waves*** - 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	***Plane Wave Propagation*** - 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	***Plane Wave Propagation (Contd.)***
	- Wave Polarization
	- Electromagnetic Parameters
	- ***Inquiry-based Activity***
	  - RFID System
	  - Liquid Crystal Display (LCD)
		✓ How to describe linear, circular, and elliptical polarization in various media.

15	***Wave Reflection and Transmission*** - 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 ● ***Inquiry-based Activity*** - 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 ● ***Inquiry-based Activity*** - 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**	