MSE 1058: Electromagnetic Properties of Materials
Spring 2026

Instructor

Dr. Liwei Geng
RM N402
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Meeting Time & Location

Thursdays 13:50-16:25 at RM S503

Office Hour

Wednesday & Friday: 13:00-17:00

TA Information

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Course Materials

Required Textbook

Jerrold Franklin, "Classical Electromagnetism", Dover, 2nd edition, 2017.
Rolf E. Hummel, "Electronic Properties of Materials", 4th edition, 2011.

Class notes

Handouts

Reference Textbooks

Safa O. Kasap. "Principles of electronic materials and devices", 2006.
John David Jackson, "Classical Electrodynamics", Wiley; 3rd edition, 1998.
Charles Kittel, "Introduction to Solid State Physics", Wiley, 8th edition, 2005.

Course Description

This course provides an introduction to electromagnetic properties of materials at the undergraduate student level. The course mainly focuses on the electrical, magnetic and electromagnetic properties of materials. This course begins with fundamental physical theories of electrostatics and magnetostatics, such as Coulomb's & Gauss's laws, Ampere's & Faraday's laws, and then culminates with Maxwell's equations and electromagnetic waves in materials. Specific materials associated with electrical, magnetic and electromagnetic properties are introduced, which include dielectrics, ferroelectrics, ferromagnetic or ferromagnetic materials, etc. As a major feature, comprehensive mathematical derivations and analytical solutions in Cartesian, cylindrical and spherical coordinate systems are provided as needed for the underlying physics of electromagnetism.

Course Objectives

Upon successful completion of this course, students will be able to:

1. learn the fundamental theories and mathematical formulations of classical electromagnetism.
2. understand the physical origins of electronic, magnetic, and optical properties of materials.
3. learn how to analytically solve Laplace's equations or similar differential equations in Cartesian, cylindrical and spherical coordinate systems.
4. analyze electromagnetic properties of solid dielectric or magnetic materials.

Learning Outcomes:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
4. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Prerequisite

Physics for Science and Engineering
Differential Equations

Grading

Homework	20%
Participation	10%
Project	10%
Midterm Exam	30%
Final Exam	30%

Grade Policy

A: 90 – 100	A−: 85 – 89	B+: 80 – 84	B: 76 – 79	B−: 73 – 75
C+: 70 – 72	C: 66 – 69	C−: 63 – 65	D: 60 – 62	F: < 60

Course Topics

1. Foundations of Electrostatics
2. Further Development of Electrostatics
3. Methods of Solution in Electrostatics
4. Spherical and Cylindrical Coordinates
5. Green's Functions
6. Dielectric materials
7. Magnetostatics
8. Magnetization and Ferromagnetism
9. Maxwell's Equations
10. Electromagnetic Plane Waves
11. Electromagnetic Waves in Matter
12. Quantum Mechanics Basics
13. Electrons in Crystals
14. Semiconductors
15. Optical Properties

Course Policies

1. Show up on time.
2. It is OK to discuss homework assignments with your classmates, but all submissions must be your own work.

3. It is expected that you will work on assignments consistently from the day they are made available.

Late Assignment Policy

10% deduction/day

Evaluation Policy

Partial credit will be awarded to recognize that some portion of the work is correct. However, partial credit grading is only practical if the work is clearly developed, with clear and well-marked diagrams when fitting, with the appropriate equations prominently displayed, where the substitutions into the equations are quite clear, and the assumptions used are obvious to the grader. That is, it is the student's responsibility to present her/his work so clearly that the grader can quickly ascertain the location and nature of the error(s) and can follow the subsequent work through. If this is not clear on the work submitted, credit cannot be given (then or later). ***Partial credit is assigned at the discretion of the grader.*** It is therefore always in your best interest to practice clarity and completeness in your solutions when working homework problems. This is applicable to exam problems as well.

Copyrights

Academic Integrity

All students are expected to adhere to the standards of academic honesty. Any student engaged in cheating, plagiarism, or other acts of academic dishonesty would be subject to disciplinary action. Any student suspected of violating this obligation for any reason during the semester will be required to participate in the procedural process, initiated at the instructor level, as outlined in the University Guidelines on Academic Integrity. This may include but is not limited to the confiscation of the examination of any individual suspected of violating the University Policy.

Tentative Lecture/Lab Schedule

Week	Date	Lecture Content
1	3/12	Mathematical Preliminaries, Vector Calculus
2	3/19	Foundations of Electrostatics
3	3/26	Further Development of Electrostatics
4	4/02	Methods of Solution in Electrostatics
5	4/09	Solution in Spherical Coordinates
6	4/16	Solution in Cylindrical Coordinates
7	4/23	Dielectric Materials, Polarization
8	4/30	Micro/Macro Electric Field, Capacitance, Ohm's Law
9	5/07	Foundations of Magnetostatics
10	5/14	Midterm Exam
11	5/21	Magnetization and Ferromagnetism

12	5/28	Maxwell's Equations
13	6/04	Electromagnetic Plane Waves
14	6/11	Electromagnetic Waves in Matter
15	6/18	Quantum Mechanics Basics, Electrons in Crystals
16	6/25	Semiconductors, Optical Properties
17	7/02	Final Exam

Final Project

Requirement: Written Report + Oral Presentation

Goal: To gain a deeper understanding of electromagnetism, apply the knowledge you have acquired to explain, predict, or even design something related to electromagnetism

Topic: Anything related to electricity and/or magnetism, whether through experiments, simulations, calculations, or theoretical analysis. This could include your own research topic, a common electromagnetic phenomenon in daily life, your perspective on an existing electromagnetic problem, or anything that sparks your curiosity and interest.

Examples:

- ✧ thunder and lightning
- ✧ charge accumulation at sharp points
- ✧ electric shock at door knobs
- ✧ Tesla coil
- ✧ Earth's magnetic field
- ✧ electric guitar, radio, antenna, microwave oven
- ✧ stealth aircraft
- ✧ right-handed materials
- ✧ magnetic monopole, spin ice
- ✧ particle accelerators
- ✧ aurora, polar lights, rainbow, sundog, halo
- ✧ bioelectromagnetism, nerve cells
- ✧ UFO
- ✧ ……

Written Report Format:

1. Introduction
2. Methodology
3. Results and Discussion
4. Conclusion
5. References

Oral Presentation:

5 minutes' seminar-style presentation in class, followed by a question-and-answer part in class.