General Physics III. Electromagnetism

1 Lecture times

- Mon: 14:00-16:00
  Tues: 13:00-15:00
- Exercises
  Wed: 8:00-10:00am

2 Course content:

The course covers the phenomena, concepts, principles and formalism of electricity and magnetism. The unity of the electric, magnetic and optical phenomena are emphasized. A conceptual understanding (physical intuation) of the subject and the mathematical concepts underlying the formalism of electromagnetism will be covered.

3 Instructor information

- Instructor: Prof. Guillermina Ramirez-San Juan.
- Teaching assistants: Each exercise section has a team of two graduate student instructors and four student assistants. These are the graduate student instructors that will be the lead teachers for each exercise section. The teaching assistants can help you with questions regarding the exercise sheet and the topics it covers.

CM1106	CE1106	CM1105	CE1104
Hao Chen Yeh	Santiago Nicolás Rodriguez Alvarez	Mauricio Cruz Reyes	Xinyu Liu
Hanning Zhan	Daphne Laan	Aikaterini Maria Kourkoulou	Chinmaya Kavalakodu Venkatesh

4 Course exercise sheets

-There will be an exercise sheet for every week of the course.
-Exercise sheets will be posted at least a week in advance of the exercise session in which they will be discussed. For example the exercise sheet to be discussed on Wednesday, September 18 will be provided by Wednesday, September 11. The only exception is during the first week of class.
-The exercise sheet for the first week of class will be provided the first day of class.
-Solutions to the current exercise sheet will be posted when a new exercise sheet is uploaded. For example solutions to the exercise sheet discussed on Wednesday, September 11 will be posted by Wednesday, September 18.
-Exercise sheets and their solutions will be posted on moodle.

5 Course Materials

Course materials such as lecture notes, links to class recordings, and any additional reading material are provided to you as a courtesy and will be provided at the instructor's discretion. If provided they will be posted on moodle

6 Grading

- 100% of your grade will be the written final exam, which will be held on Thursday January, 16, 2025.
- Exam will be 3 hours long and consist of several problems to solve.

7 Course content

These are the topics that will be covered during the course. It is possible that we won't have time to cover chapter X.

I. Electrostatics: Charges and Fields

Electric charge and its properties

Coulomb's law

Principle of superposition

Energy of a system of charges

The electric field

Gauss's law

II. The electric potential

Potential difference and the potential function

Potential of a charge distribution

Equipotential surfaces and electric field lines

Poisson's and Laplace's equations

Conductors in the electrostatic field

Capacitance and capacitors

Energy stored in a capacitor

III. Electric fields in matter

Induced and permanent dipole moments

The field of a polarized object

Susceptibility, permittivity and the dielectric constant

The field of a charge in a dielectric medium, and Gauss's law.

The electric displacement

Energy in dielectric systems

Another look at the capacitor

IV. The fields of moving charges

- Field of a point charge moving with constant velocity
- Interaction between a moving charge and other moving charges
- Electric current and current density
- Steady currents and charge conservation
- The physics of electrical conduction
- Electrical conductivity and Ohm's law
- Circuits and circuit elements. Kirchhoff's laws
- Joule effect

V. Magnetostatics

- Magnetic fields and forces
- The Biot-Savart Law
- Ampere's law
- Comparison of electrostatics and magnetostatics
- Magnetic Vector potential
- Electromagnets

VI. Magnetic fields in matter

- Magnetization
- Diamagnets, Paramagnets and Ferromagnets
- The field of a magnetized object
- Ampere's law in magnetized materials
- Magnetic susceptibility and permeability

VII. Electromagnetic induction

- Faraday's law
- The induced electric field
- Mutual inductance and self-inductance
- Circuit containing self-inductance
- Energy stored in magnetic fields
- Alternating current circuits

VIII. Maxwell's equations

- Electrodynamics before Maxwell
- How Maxwell fixed Ampere's law
- Maxwell's equations
- Maxwell's equations in matter

IX. Electromagnetic waves and radiation

Electromagnetic waves in vacuum

Electromagnetic waves in matter

Absorption and dispersion

Radiation systems

X. Special relativity

Michelson-Morley experiment

Einstein's Postulates

Lorentz Transformations

8 Bibliography

All the course content is taken from the Purcell and Griffiths textbooks referenced below. I am following the exact editions in the refrence. If you are interested in the course material I encourage you to read Feynman. The course does not follow that book but it's a great book to read if you are looking to solidify your understanding.

- Purcell, Edward M.; Morin, David J. (2013). Electricity and Magnetism (3rd ed.). Cambridge University Press.
- Griffiths, David J. (2023). Introduction to Electrodynamics (5th ed.). Cambridge University.
- The Feynman Lectures on Physics Vol. II. Richard Feyman. The New Millennium Edition of the Lectures is available free at `www.feynmanlectures.caltech.edu`.