Physics 3940/3941: Electromagnetism (Advanced)
Lecturer: Prof. Tim Bedding (Room 558)

Textbook and reference books

The textbook is *Introduction to Electrodynamics (Third Edition)* by David J. Griffiths. All students will be expected to have access to a copy. It can be bought from the Co-Op book shop, and there are also copies on closed reserve in the Scitech Library. Note that Griffiths will also be used as a reference book for the Physics Honours course on “Advanced Electromagnetic Theory.”

There are many other suitable books on electromagnetism. One of the best is *The Feynman Lectures on Physics*, Volume 2, by Feynman, Leighton & Sands. A few copies are held on closed reserve in the Madsen Library, while other university libraries also have copies – check the catalogue.

We will always follow the notation in Griffiths, but be aware of differences in other books. For example, Griffiths uses $V$ for electric potential, whereas Feynman uses $\phi$.

Lectures

There will be 19 lectures in Lecture Theatre 2: Wednesdays at 1pm and Fridays at 12pm. The detailed week-by-week timetable can be found on the Senior Physics Web site.

Assignments

There will be two assignments, counting for 25% of your total mark. They should be done individually and handed in to the Student Support Office. Be sure to include a signed cover sheet.

COURSE OUTLINE

This course develops the classical theory of electromagnetism, one of the cornerstones of physics. It builds on courses in Junior and Intermediate Physics, which introduced Maxwell’s equations in their integral form. In this course we will develop the equations in differential form, using the power of vector calculus. The main application will be to electromagnetic waves, including the interaction of waves with matter through reflection and absorption. These have application in fields such as optics, plasma physics and astrophysics. We will also consider a simple model for origin of electromagnetic radiation from oscillating charges. This course lays the foundation for more advanced treatments, such as a full description of the origin of radiation. The course content is defined in terms of the textbook.

Chapter 1: Vector Analysis
- this chapter should be read for mathematical background, and will be referred to as needed
- Omit: Section 1.5 (The Dirac delta function)

Chapter 2: Electrostatics
- Section 2.1: Coulomb’s law, principle of superposition, definition of electric field, continuous charge distributions
- Section 2.2: field lines, flux, Gauss’s Law in integral and differential form (omit Section 2.2.2)
- Section 2.3: electric potential, boundary conditions
- Section 2.4: work and energy in electrostatics
- Section 2.5: conductors, capacitors

1Books on closed reserve can be borrowed for two hours, or overnight provided they are returned by 10am the next day.
Chapter 3: Special techniques

- Section 3.1: Laplace’s equation, uniqueness theorems
- omit Section 3.2 (Method of images), Section 3.3 (Separation of variables) and Section 3.4 (Multipole expansion)

Chapter 4: Electric fields in matter

- Not explicitly examinable (mostly revision, but with differential forms)

Chapter 5: Magnetostatics

- Section 5.1: magnetic forces, currents
- Section 5.2: Biot-Savart Law
- Section 5.3: divergence and curl, Ampere’s law
- Section 5.4: Magnetic vector potential (\(A\))

Chapter 6: Magnetic fields in matter

- Not explicitly examinable (mostly revision, but with differential forms)

Chapter 7: Electrodynamics

- Sections 7.1 and 7.2 not examinable (mostly revision, but with differential forms)
- Section 7.3 (Maxwell’s equations)

Chapter 8: Conservation Laws

- main results (omit full derivations): conservation of charge (Eq. 8.4), Poynting vector (Eq. 8.10), energy (Eq. 8.13), momentum (Eq. 8.30)
- omit Section 8.2.2 (Maxwell’s Stress Tensor) and Section 8.2.4 (Angular momentum)

Chapter 9: Electromagnetic Waves

- Section 9.1: waves in one dimension, exponential notation
- Section 9.2: electromagnetic waves in vacuum, exponential notation, energy and momentum
- Section 9.3: electromagnetic waves in matter, reflection and transmission
- Section 9.4.1: electromagnetic waves in conductors

Chapter 10: Potentials and Fields

- Section 10.1 (potentials and gauges)
- Section 10.2.1 (retarded potentials from a charge distribution)

Chapter 11: Radiation

- Sections 11.1.1 & 11.1.2 (Electric dipole radiation)