2B29 Electromagnetic Theory

i) Aims, Objectives, Prerequisites etc.

Prerequisites
Students taking this course should have taken 1B26: Electricity and Magnetism. The mathematical prerequisites are 1B21: Mathematics for Physics and Astronomy in the first year and 2B21: Mathematical Methods in Physics and Astronomy in the first term of the second year, or equivalent mathematics courses (e.g.1B71 and 2B72).

Aims of the Course
- to discuss the magnetic properties of materials;
- to build on the contents of the first-year course 1B26; Electricity and Magnetism, to establish Maxwell's equations of electromagnetism, and use them to derive electromagnetic wave equations;
- to understand the propagation of electromagnetic waves in vacuo, in dielectrics and in conductors;
- to explain energy flow (Poynting's theorem), momentum and radiation pressure, the optical phenomena of reflection, refraction and polarization, discussing applications in fibre optics, radio communication and wave guides;
- to give a simplified account of the radiation from an oscillating dipole.

Objectives
After completing the course the student should be able to
- understand the relationship between the **E, D** and **P** fields and between the **B, H** and **M** fields;
- be able to derive the continuity conditions for **B** and **H** at boundaries between media; distinguish between diamagnetic, paramagnetic and ferromagnetic behaviour;
- calculate approximate values for the **B** and **H** fields in simple electromagnets and magnetic forces on movable parts of such magnets**;**
- understand the need for displacement currents;
- explain the physical meaning of Maxwell's equations, in both integral and differential form, and use them to; (i) derive the wave equation in vacuum and the transverse nature of electromagnetic waves; (ii) account for the propagation of energy and momentum, and for radiation pressure; (iii) determine the reflection, refraction and polarization amplitudes at boundaries between dielectric media, and derive Snell's law and Brewster's angle; (iv) establish the relationship between relative permittivity and refractive index; (v) explain total internal reflection, its use in fibre optics, its frustration as an example of tunnelling; (vi) derive conditions for the propagation of electromagnetic waves in, and reflection from, metals; (vii) derive the dispersion relation for the propagation of waves in a plasma, and discuss its relevance to radio communication; (viii) determine the conditions for wave propagation in rectangular wave guides;
- understand that oscillating charges radiate and be able to calculate energy fluxes in the far-field.

Lectures and Assessment
27 lectures plus 6 discussion periods. Assessment is based on the results obtained in the final examination (90%) and in the best 12 questions from 5 sets of 3 homework problems (10%).

Textbooks

"Electromagnetism", 2nd edition by I.S. Grant and W.R. Phillips (Wiley)

"Electricity and Magnetism", 4th edition, by W.J. Duffin (McGraw-Hill)