PHYS30441 Physics with Theoretical Physics Core Unit
Prof. T. Wyatt. Physics Option Unit
Credit Rating: 10

PHYS30441 Electrodynamics (M) (C/O) SEM1

Prerequisites PHYS20141

Useful but not essential PHYS20401

Follow-up units PHYS40481, PHYS40682, PHYS40771, PHYS40772

Classes 22 lectures in S6

Assessment 1 hour 30 minutes examination in January

Recommended texts

Griffiths, D.J., *Introduction to Electrodynamics* (Benjamin Cummings; 4th edition (2013)

Heald, M.A. & Marion, J.B. *Classical Electromagnetic Radiation*, (Academic Press, 1995)

Supplementary reading

Feynman, R.P., *The Feynman Lectures on Physics, Vol II* (Addison Wesley, 1964)

Jackson, J.D., *Classical Electrodynamics* (John Wiley & Sons, 3rd edition 1999)

Schwartz, M., *Principles of Electrodynamics* (Dover Publications, 1972)

Zangwill, A., Modern Electrodynamics (Cambridge University Press, 2013)

Feedback

Feedback will be offered by examples class tutors based on examples sheets, and model answers will be issued. Some optional sessions will provide extra problem-solving opportunities and cover a few interesting “extra-curricular” topics.

Aims

To cover theoretical aspects of electromagnetic fields and radiation, and their connection to special relativity.

Learning outcomes

On completion successful students will be able to:

1. use scalar and vector potentials, and explain the concept of gauge invariance;
2. demonstrate the compatibility of electrodynamics and special relativity;
3. use Lorentz covariant formalism (scalars, 4-vectors and tensors) in the context of electrodynamics and special relativity;.
4. solve Poisson's equation and the inhomogeneous wave equation;

5. distinguish between radiation fields and other electromagnetic fields;
6. calculate the radiated power produced by accelerating charges.

Syllabus

1. **Electromagnetic Field Equations** (7 lectures)

   Maxwell's equations and wave solutions. Definition of scalar and vector potentials. Electro- and magnetostatics and Poisson's equation; multipole expansions. Electrodynamics in Lorentz Gauge; the inhomogeneous wave equation and the retarded time.

2. **Electromagnetism and Relativity** (7 lectures)

   Covariant and contravariant formalism of Lorentz transformations; Scalars, four vectors and tensors; relativistic dynamics. Consistency of Maxwell's equations and relativity. Electromagnetic field tensor and electrodynamics in covariant form.

3. **Accelerating Charges** (6 lectures)

   Lienard-Wiechert potentials; Power radiated from an arbitrarily moving charge. Larmor’s power formula; synchrotron radiation; bremsstrahlung.

4. **Harmonically Varying Sources** (2 lectures)

   Multipole radiation: electric (Hertzian) and magnetic dipole radiation; slow-down of pulsars. Rayleigh and Thomson scattering.