Electromagnetism Qualifying PhD Exam Guidelines

Department of Physics, Southern Methodist University

Established in August 2014

History

- The majority of these guidelines were established in 2014.
- They were updated in 2017 to reflect the change in subject exam duration from 3 to 2 hours for academic year 2017-2018.

Guidelines

0) The exam will cover 4-8 questions, there is likely to be some minor variation in their point value.

1) The exam will be closed book. Very detailed physics formulas and integrals will be provided you.

2) No calculator is required or allowed.

3) You will have up to 2 hrs to complete the exam.

4) Partial credit will be given for sensible but not entirely correct answers.

Topics

The exam will be at the advanced undergraduate level. Sample texts that contain problems similar to the type on the exam include Lorrain and Corson ("Electromagnetic Fields and Waves"), Barger and Olsson ("Classical Electricity and Magnetism"), Griffiths ("Introduction to Electrodynamics"), and Pollack and Stump ("Electromagnetism"). We do not recommend J.D. Jackson's text since its problems are too difficult for an exam of this type. Our advice is to spend a substantial portion of your studying time actually doing problems.

What to study? You should be thoroughly familiar with the following topics:

0) You should know the numerical value of the electronic charge, the electric permittivity of free space, the magnetic permeability of free space and the speed of light in vacuum.

1) Determination of electrostatic potentials and fields in vacuum for simple charge distributions. Application of boundary conditions for the electric field at the surface of a conductor.

2) Solution of Laplace's equation using the method of images and in

spherical coordinates for problems with azimuthal symmetry.

3) Calculation of the potential energy of a charge distribution and the energy density in a static electric field

4) Calculation of electrostatic fields in linear and homogeneous dielectric materials and knowledge of boundary conditions at the boundary of two dielectrics. How to calculate the torque and force on an electric dipole, including the case of a non-homogeneous but static electric field.

5) Calculation of magnetic fields from simple, uniform current distributions. This includes knowledge of the Biot-Savart law, Ampere's law and magnetic vector potential. Knowledge of the magnetic dipole moment, both its definition and the magnetic field it produces. You should be able to calculate magnetic forces on simple current distributions and the torque on a magnetic dipole. Knowledge of magnetic potential energy.

6) Knowledge of the boundary conditions at the surface of a current-carrying sheet in vacuum. Knowledge of magnetic fields in matter and magnetostatic boundary conditions for magnetized media.

7) Simple circuit analysis of resistors, capacitors and inductors.

8) Magnetic force on a moving charge, electric and magnetic dipole radiation and the power emitted by an accelerated charge, knowledge of the Poynting vector.

9) Lenz’s law, Faraday’s law and Maxwell’s equations in vacuum. Propagation of waves in one dimension and reflection and refraction at a boundary.

10) Knowledge of radiation from a single accelerated charge, and of electric and magnetic dipole radiation.