Spring 2016 **Syllabus**

Physics 610: Electricity & Magnetism I

TTh 9:30-10:50 in Small Hall room 233

Prerequisite: undergraduate E&M (e.g. *Introduction to Electrodynamics* by D.J. Griffiths)

Instructors

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Course Objectives

The primary purposes of this course are to introduce relativistic electrodynamics as a classical field theory and to cover electrostatic and magnetostatic calculation methods.

The course will cover the following topics:

- Maxwell's equations
- 4-vectors, 4-tensors, and Lorentz transformations
- Classical field theory and Noether's theorem
- Lagrangian formulation of electrodynamics
- Conservation of electromagnetic energy, momentum, etc ...
- Thomas precession of spin in an electromagnetic field
- Boundary value problems in electrostatics
- Method of images, Green's functions
- Multipole expansion and spherical harmonics
- Conductors and dielectric media
- Magnetostatic boundary value problems
- Magnetic media
- Quasi-static electrodynamics

Course Materials

Text: Most of the course materials and problem sets will be taken from the following required text for the course:

Classical Electrodynamics, by J. D. Jackson (3rd ed., 1999).

Some course materials will also be taken from the following texts:

Introduction to Electrodynamics, by J. D. Griffiths (4th ed., 2013).

Modern Electrodynamics, by A. Zangwill (2013).

The Classical Theory of Fields, by L. D. Landau and E. M. Lifshitz (4th ed, 1975).

Evaluations

Your final grade for the course will be determined from the following grading weight distribution:

Problem sets:	45%
Participation:	10%
Midterm:	15%
Final Exam:	30%

Problem sets: The problem sets are the main evaluation of learning for the course and also serve as a significant means of learning the material. Students are expected to do the problems on their own (not as a team effort with other students), though discussion and limited oral consultation with other students is encouraged. Use of a solution manual (or equivalent) for the homework problems is not an acceptable for solving problem sets before they are due.

Participation: The classroom presentation of course material will involve class discussions. All students are expected to participate in these discussions, since they will help elucidate the course material. Participation also reflects class attendance and performance on in-class quizzes.

Midterm: The midterm will cover course material from the first half of the course.

Final exam: The final exam will cover all the material in the course, but with an emphasis on the second half of the course.

Weekly Schedule (tentative)

Week 0: 1/21 **Maxwell's Equations Review**
Maxwell equations for fields and potentials, gauges.

Week 1: 1/26-28 **Relativistic Electrodynamics**
4-vectors, EM field tensor, Lorentz transformations.

Week 2: 2/2-4 **Classical Field Theory**
Least action principle for fields, Euler-Lagrange equation, Noether's theorem.

Week 3: 2/9-11 **Spin in Classical Electrodynamics**
Thomas-precession, spin-orbit coupling, EBT equation.

Week 4: 2/16-18 **Electrostatics**
Coulomb's law, Gauss's law, electric fields and potentials, capacitance.

Week 5: 2/23-25 **Electrostatics: boundary value problem**
Method of images, separation of variables, Green's functions.

Week 6: 3/1-3 **Electrostatics: Green's Function**
Green's functions for different boundary value problems.

---------- Spring Break ----------

Week 7: 3/15-17 **Midterm & Electrostatics: Multipole expansion**
In class mid-term. Legendre polynomials, spherical harmonics, dipoles, quadrupoles.

Week 8: 3/22-24 **Electrostatics: Dielectric media**
Polarization, linear media, electric displacement, bound charges, boundary conditions.

Week 9: 3/29-31 **Magnetostatics**
Bio-savart law, Ampère's law, magnetic vector potential.

Week 10: 4/5-7 **Magnetostatics: Multipole expansion**
Magnetic dipoles, multipole expansion of vector potential, anapoles.

Week 11: 4/12-14 **Magnetostatics in matter**
Magnetization, bound currents, boundary conditions, auxiliary field.

Week 12: 4/19-21 **Quasi-static Electrodynamics I**
Ohm's law, Kirchoff's laws for circuits, Faraday's law, inductance.

Week 13: 4/26-28 **Quasi-static Electrodynamics II**
Skin effect, displacement current, electromagnetic simulation software.

May 4, 2016, 9:00am-noon **Final Exam**