

Physics 2555
Advanced Classical Electricity and Magnetism
Winter/Spring 2016 (2164)

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I am available for discussions either by appointment or informally.

Text: *Classical Electrodynamics* (Third Edition) by J.D. Jackson.

The Course: Physics 2555 is the **four**-credit graduate core course in classical electricity and magnetism. The intent is to cover selected material in Jackson, Chapters 1-12, 14, and possibly other topics from the later chapters, if time permits. Topics will include: electrostatics, magneto-statics, time varying fields, electromagnetic waves, waveguides, antennas, special relativity and radiation from moving charges. Required mathematical background is covered in Physics 2373.

Lectures: Mondays and Fridays 10:00 – 10:50 am, Wednesdays 9:00 – 10:50 am, 106 Allen Hall.

Homework: Homework problems will be assigned weekly. Much of the learning in this course takes place by doing the problems. It is important to do the homework problems on time and not fall behind. You are allowed to work with others on the homework if you find this helpful, but your solutions should be your own. Cite any assistance, whether from books or people. You must not consult solutions available on the internet. Late homework will not be graded, particularly if it is so late that the solution has been made available and the set has already been graded.

Exams and Grading: There will be two “in-term” exams, scheduled for Friday, February 12, and Friday, April 1, and a comprehensive final exam, scheduled for Friday, April 29. The “in-term” exams will each count 100 points. The final exam will be worth approximately 150 points. The homework will contribute 150 points. The course total will be about 500 points. Your numerical score will be converted to a letter grade.

Help Session: I plan to hold a weekly help/question/discussion session if there is interest and if we can determine a mutually agreeable time slot.

Reserve Books: A list of books on classical electrodynamics and related topics appears on the back of this sheet. These books will be on reserve in the Engineering Library in Benedum Hall.

Courseweb Site: I will use a Courseweb site to post announcements, lecture notes, problem assignments, solution sets, etc.

Disability Resources: If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services (DRS), 140 William Pitt Union, phone (412) 648-7890, e-mail drsrecep@pitt.edu, (412) 228-5374 for P3 ASL users, as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course. DRS website: www.drs.pitt.edu

Academic Integrity: Students in this course will be expected to comply with the [University of Pittsburgh's Policy on Academic Integrity](#). Any student suspected of violating this obligation for any reason during the semester will be required to participate in the procedural process, initiated at the instructor level, as outlined in the University Guidelines on Academic Integrity. This may include, but is not limited to, the confiscation of the examination of any individual suspected of violating University Policy. Furthermore, no student may bring any unauthorized materials to an exam, including dictionaries and programmable calculators.

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Books

Winter/Spring 2015 (2164)

R.P. Devaty

1. *Classical Electrodynamics* (3rd Edition) by John David Jackson
2. *Electrodynamics* by Fulvio Melia
3. *Modern Electrodynamics* by Andrew Zangwill
4. *Introduction to Electrodynamics* (4th Edition) by David J. Griffiths
5. *The Classical Electromagnetic Field* by Leonard Eyges
6. *The Feynman Lectures on Physics* (Vol. II) by R.P. Feynman
7. *The Classical Theory of Fields* by L.D. Landau and E.M. Lifshitz
8. *Electrodynamics of Continuous Media* by L.D. Landau and E.M. Lifshitz
9. *Principles of Optics* by M. Born and E. Wolf
10. *Classical Electricity and Magnetism* by Wolfgang K.H. Panofsky and Melba Phillips
11. *Electromagnetic Theory* by J.A. Stratton (available on-line through PittCat)
12. *Static and Dynamic Electricity* by W.R. Smythe
13. *Foundations of Electromagnetic Theory* by J.R. Reitz, F.J. Milford and R.W. Christy
14. *Classical Electrodynamics* by Julian Schwinger, L.L. DeRaad, Jr., K.A. Milton and W. Tsai
15. *Optical Properties of Solids*, by Frederick Wooten

Mathematics and Tables

1. *Methods of Theoretical Physics* by P.M. Morse and H. Feshbach
2. *Table of Integrals, Series and Products* by I.S. Gradshteyn and I.M. Ryzhik
3. *Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables* by M. Abramowitz and I.A. Stegun (available on-line through PittCat)

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List of Topics

Electrostatics (Topics 2, 4 and 5 were covered in Physics 2573)

1. Review Coulomb's Law, concept of electric field and Gauss' Law
2. Poisson's and Laplace's equations, Green's theorem, uniqueness theorem, solutions with Dirichlet and Neumann boundary conditions
3. Electrostatic potential energy, energy density, capacitance
4. Green's functions in one, two and three dimensions for parallel plates, cylinders and spheres; method of images
5. Solutions of Laplace's equation in two and three dimensions utilizing Fourier series, spherical harmonics and Bessel functions, i.e., solving Laplace's equation in rectangular, spherical and cylindrical coordinates
6. Multipole expansion, macroscopic media, dielectrics. Electrostatics problems with dielectrics. Polarization and energy with dielectrics present. Molecular origin of polarization.

Magnetostatics

1. Review basic equations of magnetism including Biot-Savart and Ampere's Law.
2. Vector potential, magnetic induction for a circular loop, localized current distributions, magnetic moment, force and torque, energy of localized current distributions.
3. Macroscopic equations and magnetic materials, boundary conditions on **B** and **H**, methods of solving boundary value problems in magnetostatics.

Time Varying Fields and Plane Waves

1. Faraday's Law, energy in a magnetic field and inductance, Maxwell's displacement current and Maxwell's equations
2. Quasi-static fields and skin depth
3. Vector and scalar potentials, gauge transformations and gauges, wave equation, development of Green's function for wave equation and solution of wave equation
4. Poynting's theorem, conservation of energy and momentum for a system of charged particles and electromagnetic fields, Maxwell's stress tensor
5. Plane waves, linear, circular and elliptical polarization, reflection and refraction of electromagnetic waves at a plane interface between dielectrics
6. Frequency dispersion characteristics of dielectrics, conductors and plasmas. Waves in conducting or dissipative medium.
7. Superposition of waves, group velocity, spreading of a pulse.
8. Causality in the connection between **D** and **E**, Kramers-Kronig relations.

Wave Guides and Resonant Cavities

1. Fields at the surface and within conductors
2. Cylindrical cavities and wave guides
3. Modes in wave guides, energy flow and attenuation in wave guides
4. Resonance and power loss in conducting cavities

Radiation

1. Nonrelativistic treatment of simple radiating systems including electric dipole and magnetic dipole radiation from a localized oscillating source.
2. Center fed linear antenna, half wave and full wave antennas.
3. Scattering at long wavelengths, Rayleigh scattering (blue sky), optical theorem

Relativity

1. Lorentz transformations and basic kinematic results of special relativity, addition of velocities, four vectors, relativistic energy and momentum of a particle
2. Invariance of electric charge, covariance of electrodynamics, transformation of electromagnetic field, covariant notation
3. Lagrangian and Hamiltonian for a relativistic charged particle in an external electromagnetic field, Lagrangian for the electromagnetic field
4. Motion of a charged particle in uniform static electric and/or magnetic field

Radiation from Moving Charges

1. Development of the Lienard-Wiechert potentials and fields using the Green' function solutions of the wave equation. Include discussion of the Heavyside and Feynman fields if this wasn't done earlier.
2. Power radiated by an accelerated charge, the Larmor formula, and the more general relativistic results for linearly accelerated and circularly accelerated charges
3. Frequency spectrum and angular distribution of radiation from accelerated charged particles, synchrotron radiation
4. Thomson scattering