PHYS 5322 - Electromagnetism II

Fall Semester 2005

Schedule: 2:00 pm - 3:15 pm Monday and Wednesday
Location: SETB 1.350 and video

Instructor: Andreas Hanke
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Office Hours: 4:00 pm - 6:00 pm Monday and Wednesday

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Text: "Classical Electrodynamics" by J. D. Jackson, Third Edition

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Course Objectives

The course will be dealing with advanced topics of Electrodynamics, building on Maxwell's theory of electromagnetism. The first part of the course will cover various macroscopic phenomena relevant to practical applications: Plane waves in different media, wave guides, radiation generated by localized sources, scattering and diffraction. The second part will emphasize the role of classical electrodynamics as a fundamental example of the covariance of physical laws under Lorentz transformations. The formulation of the theory in terms of relativistic Lagrangian and Hamiltonian functions will be developed, leading to a coherent description of the dynamics of relativistic charged particles in electromagnetic fields. Applications of the theory to scattering of charged particles and radiation generated by accelerated charges will be discussed. The overall emphasis of the course will be on physical concepts rather than mathematical methods - the latter should be available by previous courses. The role of electrodynamics as a foundation for many areas of modern physics will be illustrated; some prior knowledge of condensed matter physics and quantum theory at the graduate level would thus be helpful.

Syllabus

The material covered will be that which is traditional for Physics 5322, the material in Chapters 7 through 15 in the Text. We will not cover every Section, and we will not give equal emphasis to the Sections covered. **Topics covered in the class following today's date are highlighted.** It will be expected that you read the corresponding Section(s) in the Text prior to the class.

A) Repetition
Maxwell Equations in Vacuum and Macroscopic Media
Scalar Potential and Vector Potential
Gauge Transformations
Conserva tion of Energy and Momentum

B) Plane Electromagnetic Waves
Wave Propagation in Non-Conducting Media
Reflection and Refraction
Waves in Conducting Media
Phase Velocity and Group Velocity

C) Wave Guides and Resonant Cavities
Boundary Conditions for Fields at Interfaces
Propagation Modes in Waveguides
Energy Flow and Attenuation
Dielectric Waveguides
Resonant Cavities

D) Radiating Systems
Multipole Expansion for Localized Sources
Electric Dipole Radiation
Magnetic Dipole and Electric Quadrupole Radiation
Angular Distribution of Radiation

E) Scattering and Diffraction
Scattering at Long Wavelengths
Perturbation Theory for Scattering
Rayleigh Scattering
Scalar Diffraction and the Kirchhoff Integral
Vector Diffraction Theory

F) Special Theory of Relativity
Relativistic Forms for Maxwell's Equations and Force Laws
Covariance of Electrodynamics
Dynamics of Relativistic Particles and Electromagnetic Fields
Covariant Dynamical Equations: Lagrangian and Hamiltonian

G) Collisions between Charg ed Particles
Coulomb Collisions
Density Effect due to Bound Particles
Cherenkov Radiation

H) Radiation by Accelerated Charges
Lienard-Wiechert Potentials
Angular and Frequency Distribution of Radiation
Synchrotron and Bremsstrahlung
Method of Virtual Quanta

Communications

One of the most important ways in which I can help you is by answering questions. You should struggle with your question on your own for a while, but there is no point in wasting a large amount of time with the struggle. Electronic mail makes it possible for you to get rapid answers to your questions. I will assume that you do not object to sharing your question and the answer with everyone, via email. If you prefer to remain anonymous I will honor that.

A second way of communicating is through the course website. The website will contain class notes, homework assignments and solutions. **You will be responsible for checking your email frequently and the course website for assignments and announcements.**

Homework

Homework is probably the most important element in the course. The amount of effort you spend on the problem sets determines largely the progress you make through the course. **The maximum credit per problem set is 20 points.** However, there will be a number of "star problems" which go beyond the scope of the lecture. The credit you earn for star problems come *in addition* to the credit for regular problems, which gives you an opportunity to make up for points not earned by regular problems and the exams.

You are not prohibited from working with other students on homework. Quite to the contrary, students are encouraged to work together. But the work you hand in must be your own work, not a solution copied from another student. In other words, it is acceptable for you to get the ideas for the solution from another student, but not the words and symbols. **Unless stated otherwise, homework will be due at class on Wednesdays.**

Basis for Grade

The special logistical nature of this course means that certain details must be tentative. The *tentative* basis for your grade reflects the emphasis on the Homework: **Problem Sets 60%, Midterm Exam 20%, Final Exam 20%.**