Spring 2018 **Classical Electrodynamics II** **Phys 712**

Instructor: Charles R. Evans

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MW 11:15-12:30

This course treats the dynamical, classical electromagnetic field, with attention to dynamical formulations, gauge, causality, plane wave solutions, polarization, partial polarization, dispersive media or plasmas, multipole radiation, special relativity, interaction between radiation and matter, and radiation from relativistic charges. The reference text is *Classical Electrodynamics,* third edition, by J. D. Jackson. However, while some material and the order of some topics are drawn from Jackson, I also draw upon other texts (listed below) and upon my own notes in devising lectures.

In the third edition Jackson decided to switch partly to SI units. The first ten chapters use SI units while the remaining chapters retain use of Gaussian units. For this class, I continue to use Gaussian units, which is the more natural choice for radiation calculations. (The more natural choice for electronics would be SI units.) The text contains a very readable appendix giving the relationships between these and other units.

Learning physics involves working problems. I will assign roughly three to five problems every week to ten days. Homework problems will contribute roughly 50% toward your course grade. Assignments should be turned in on time, even if only partially completed. You may discuss the problems with others in the class but the actual calculations and the written solutions should be the product of your own individual effort. Problem write-ups should contain both step-by-step calculations and generous annotation (we need to be able to follow your steps). There will be a midterm (∼25% of grade) with the date TBD but near spring break. There will be a three-hour in-class exam at the end of the semester, scheduled on May 8 at 12 PM. In keeping with departmental policy this exam will serve two purposes. From the standpoint of the course it will count as a final exam worth 25% of the grade. It will separately be scored by a graduate exam committee as the electrodynamics part of the qualifying exam. The UNC Honor Code applies in this course.

Other references on electrodynamics, radiation, plasma physics, etc.:

Landau and Lifshitz, *The Classical Theory of Fields,* fourth edition

Rybicki and Lightman, *Radiative Processes in Astrophysics*

Landau and Lifshitz, *Electrodynamics of Continuous Media*

Landau and Lifshitz, *Physical Kinetics*

Bekefi, *Radiation Processes in Plasmas*

Some recommended sources on mathematical physics:

Mathews and Walker, *Mathematical Methods of Physics*

Arfken, *Mathematical Methods for Physicists*

Outline of Course Topics

Chapter 6
Time-varying fields, Maxwell equations and conservation laws

- Gauge conditions; Green functions and integral solutions
- Review of complex variables, residue theorem
- Poynting's theorem, Poynting flux
- Conservation laws for macroscopic media
- Harmonic time dependence; field admittance and impedance

Chapters 7
Plane EM waves, polarization, propagation, dispersive media

- Plane waves in dispersive media or plasmas
- Fourier transform concepts: time and frequency structures
- Random fields; energy flux and energy spectrum relationship
- Partial polarization, Stokes parameters, incoherent waves
- Reflection and refraction; polarization from reflection
- Dispersion in dielectrics, conductors and plasmas
- Group velocity; pulse dispersion
- Causality, Kramers-Kronig relations; absorption and anomalous dispersion

Chapter 8
Wave guides and resonant cavities

- Boundary conditions, modes, energy flow, and Q (usually homework only)

Chapter 9, 10
Simple radiating systems, slow-motion sources, scattering and diffraction

- Dipole approximation and Larmor's formula
- Higher multipoles
- Thomson scattering
- Diffraction
- Optical theorem

Chapters 11, 12
Special relativity, covariance, particle dynamics

- Lorentz transformations: boosts, aberration, beaming, Doppler shift
- Transformation of E and B
- Four-dimensional form of Maxwell's equations, field strength tensor, stress tensor
- Lorentz force on charged particles

Outline of Course Topics–continued

Chapter 14
Radiation from relativistic charges

- Lienard-Weichart potentials, retarded E and B
- Boosted generalization of Larmor's formula
- Angular distribution
- Power from perpendicular and parallel accelerations
- Synchrotron and cyclotron emission: total synchrotron power, frequency spectrum, beaming, time dilation concepts
- Transition (appearance/disappearance) radiation

Chapter 15
Bremsstrahlung emission

- Nonrelativistic bremsstrahlung
- Relativistic bremsstrahlung
- Gaunt factors

Time Permitting:

Chapter 13
Charged particle collisions and radiation

- Coulomb collisions
- Cherenkov radiation
- Razin effect

Chapter 16
Radiation damping, self-force

- Radiative reaction force from energy conservation
- Abraham-Lorentz self-force