Program for the Course Electrodynamics
1st Semester 2018

Marek Nowakowski, edificio IP402
email: manowakos@uniandes.edu.co
Universidad de los Andes

Grade

100%= 3 partial exams, 3 × 20%=60%
final exam 25%
homework and exercises 15%

Dates

1st partial exam: 14.02.2018

2nd partial exam: 09.03.2018

3rd partial exam: 18.04.2018

Literature

1. J. D. Jackson
"Classical Electrodynamics", 3rd edition
Wiley, 1998
2. M. A. Heald and J. B. Marion
"Classical Electromagnetic Radiation"
Thomson Learning 1995
3. J. Vanderlinde
"Classical Electromagnetic Theory"
Springer 2004
4. J. W. Muüller-Kirsten
"Electrodynamics"
World Scientific 2011
5. F. Scheck
Classical Field Theory
Springer 2012

Objectives

Electrodynamics, is one of the two classical field theories [1], the other one being General Relativity as a theory for gravitation. In the 19th century, when the theory was being developed, unexpected features started to emerge from it: wave equation for the propagation of the electromagnetic fields, radiation as electromagnetic fields of accelerated charges, Lorentz and gauge symmetries. In the first half of the 20th century, this theory has served as a main pillar for technological applications e.g. in communication and electron motion. From the scientific point of view the important step forward was the successful combination of Electromagnetism with Quantum Mechanics leading to the theory of QuantumElectroDynamics (QED). QED has been not only the prototype theory for all fundamental interaction (especially, the strong and weak interactions), but had a large lasting impact also on other branches of physics, e.g. Quantum Optics.

The aim and scope of the course is to lay the foundation to understand the development described above. The first step is to derive the Maxwell's equations which together with the Lorentz force comprise all the Electrodynamics. Along this line, we will of course discuss also the individual laws (Faraday, Ampere etc.) separately. In the next step, we will study the dynamical consequences of Maxwell's equations (wave equation) and their formulation in terms of potentials which allows better insight into the symmetries and the derivation of electromagnetism from the action principle. A connection to Special Theory of Relativity will be established and the latter will be presented in a modern form. Electrodynamics as a classical field theory will be discussed within the framework of a Lagrangian. Time dependent problems including the solution of the inhomogeneous wave equation will lead to the physical phenomenon of radiation. Additional topics will cover static problems like the general solutions of the Poisson equation.

Table of Contents

[1] In short, a field theory is the study of physical objects which not only depend on time, but in addition also on space coordinates. The equations of motions are therefore partial differential equations in contrast e.g. to Newton's law of motion.

Physics versus engineering or why the emphasis of the course is not on circuit theory
II. Mathematical compendium
Vectors and vector identities using Kronecker delta and Levi-Cevita symbols/ Nabla operator and applications/Identities with nabla/Integrals (multiple, surface and path) and identities
III. The road to Maxwell's equations
Gauss law /Faraday law/Ampere law/ The whys for Ampere-Maxwell law/Putting things together: Maxwell's equations in integral and differential form
IV. Dynamics:The homogeneous wave equation and the propagation of the fields in vacuum
The wave nature and dynamical electromagnetic fields: wave equation
V. Dynamics: Maxwell's equations in terms of potentials and the inhomogeneous wave equation; symmetries of Maxwell equations
VI. A quick tour through the Special Theory of Relativity
Lorentz transformations, four-vectors and tensors
VII. Time dependent problems
Solution of the inhomogeneous wave equation, radiation and its consequences
VIII. Static problems
From dynamics to statics: solutions of the Poisson equation

Pre-requisites: some knowledge of electromagnetism (Coulomb force, Gauss, Faraday, Ampere law etc.)

Time Table: The semester consists roughly of 15 weeks. Roughly we have two weeks per chapter, but, some sections, are shorter than the rest.

Attendance: Mondays and Fridays from 3 to 5pm