Electricity and Magnetism, third term
Description

Instructor: Jens Nöckel. Location: Willamette 318. Times: MWF 11:00 - 11:50 am.

You see, wire telegraph is a kind of a very, very long cat. You pull his tail in New York and his head is meowing in Los Angeles. Do you understand this? And radio operates exactly the same way: you send signals here, they receive them there. The only difference is that there is no cat.

*Albert Einstein*

Prerequisites

- MATH 282, several-variable calculus (including Gauss'/Stokes' theorems)
- PHYS 412, 413

Topics

1: Transmission lines, impedance
2: Characteristic impedance
3: Electromagnetic energy and momentum
4: Poynting vector and momentum
5: Momentum conservation, Maxwell stress tensor
6: The Hertzian dipole
7: Electric dipole radiation
8: Thompson, Rayleigh scattering
9: Dielectric constant of a plasma
10: Birefringence
11: Faraday rotation
12: Propagation in a conductor
13: Dielectric constant of a collisional plasma
14: Reflection at a dielectric boundary
15: Wave-guides
16: Relativity and electromagnetism
17: The Lorentz transformation
18: Transformation of velocities
19: Tensors
20: Space-time, proper time
21: 4-velocity, 4-acceleration, potentials
22: Gauge invariance, retarded potentials
23: Tensors and pseudo-tensors
24: The electromagnetic field tensor
25: The dual electromagnetic field tensor
26: Potential and field due to a moving charge
27: Relativistic particle dynamics
28: The electromagnetic energy tensor

Description

The course is primarily intended for students majoring in physics and is a continuation of PHYS 412. This intermediate-level course makes use of differential and integral calculus in three dimensions. Several other mathematical techniques will also be used: in particular, functions of complex variables and differential equations.
PHYS 412 mainly dealt with electricity and magnetism in free space and in the presence of conductors, focusing on Maxwell's equations and their solutions with the help of integral theorems and (vector) potentials.

PHYS 413 built on this knowledge to describe electric and magnetic fields in materials, which leads to practical applications in electronic circuits. In this context, fundamentals of the interaction between matter and fields are introduced, and conservation laws are formulated. Many devices and circuits can be understood under quasi-static conditions where the relativistic aspects of Maxwell's equations do not play a large role, and the central quantities are capacitance, inductance and resistance.

PHYS 413 is divided into two parts: In the first part, we go from transmission lines (an application of circuit concepts such as "impedance") back to the general Maxwell equations and its radiating solutions in different media. In the second part, a main goal is to understand radiation and conservation laws for moving charges in free space. This will require a detailed study of the theory of relativity, beginning with Lorentz invariance and ending with the tensor formulation of physical quantities.

Text

The course will use the online textbook by

Richard Fitzpatrick,  
"Classical Electromagnetism: An intermediate level course"

You may also buy the bound version of the book, but that is not required.

Grading

Homework must be turned in on the due date at the beginning of the lecture. Grades will be determined by the following weighting.

Homework (weekly): 60%  
Midterm (May 4): 15%  
Final (10:15 Tuesday, June 7): 25%