Phys. 3202: Electricity and Magnetism II

(Electrodynamics)

Lecture Outlines

Lecture 1

I. Introduction to the Classical Electrodynamics (ED)

- topics and methods
- connections with the Electrostatic and Magnetostatics (course EM I)
- Maxwell equations and electromagnetic waves
- relativistic mechanics and ED

2. Time-Dependent Electric and Magnetic Fields (Griffiths, Chapter7)

Electromotive Force (emf)

- Ohm's Law and Joule heating, conductivity

Lecture 2

- electromotive force (definition)
- example: motional emf

Faraday's Law of Induction

- circulation of the E-vector in a variable magnetic field
- Maxwell equation derived from the Faraday's Law
- *Curl* of electric field and Stokes' theorem

Lecture 3

Problem solutions:

- Ohm's Law and resistance
- vector-potential **A**(**r**,t) of the uniform time-dependent magnetic field and induced electric field **E** and *emf*

Coefficients of Self- and Mutual Inductances

- magnetic fluxes
- mutual inductance

Lecture 4

<u>Coefficients of Self- and Mutual Inductances</u>
- self-inductance
- examples and solutions of EM problems

<u>Energy of Magnetic Field</u>
-energy of electric current in magnetic field

Lecture 5

- density of magnetic energy
- self-energy of electric current

<u>Solutions of the HW1 problems</u>

Lecture 6

<u>Solutions of the HW1 problems</u>

Lecture 7

<u>Displacement Current in the Maxwell Equation</u>
- generalization of Ampere's law
- Maxwell equation for induced ***B*** -field (integral and differential forms)

<u>Analysis of the system of the Maxwell Equations for ***E*** and ***B*** fields</u>

- equations for the static sources of the electromagnetic field
- equations for the interaction of ***E*** and ***B*** fields

<u>Wave Equations for ***E*** and ***B*** Fields in Vacuum</u>

Lecture 8

Electromagnetic (EM) Energy Conservation and Poynting's vector

- differential form of the EM energy conservation
- Poynting's vector and Poynting's theorem

Lecture 9

Wave Equations for the Scalar and Vector Potentials

- interaction between the vector ***A*** and scalar φ fields
- separation of ***A*** and φ equations
- gauge invariance for the time-dependent fields
- Lorentz gauge and Coulomb (radiation) gauge

Lecture 10

Solution of the Wave Equation

- general solutions of the wave equation
- separation of variables, harmonic waves
- propagation of the wave signal; phase velocity

Lecture 11

- harmonic EM waves in vacuum
- ***E*** and ***B*** plane waves; wave vector ***k*** (Griffiths, 9.2.2)
- Poynting vector for the plane EM waves

Lecture 12

- energy and momentum in electromagnetic waves (Griffiths , section 9.2.3)
- polarization of plane EM waves (Griffiths, sections 9.1.4 and 9.2.2)

Lecture 13

Electromagnetic Waves in Linear Media (Reading: Griffiths, section 9.3.1 and 9.3.2)

- index of refraction
- reflection and transmission of EM waves

Lecture 14

Retarded Potentials and Propagation of EM Waves

- retarded and advanced solutions of the wave equation
- general solutions for the vector $\boldsymbol{A}(\boldsymbol{r},t)$ and scalar $\varphi(\boldsymbol{r},t)$ potentials
- general solutions for the $\boldsymbol{E}$ and $\boldsymbol{B}$ vectors