EE243 Advanced Electromagnetic Theory

Lec #1: Overview and Background

- Goals
- Cherry Picking Jackson
- Syllabus Flow, Homework and Reading
- Roots and Horizon of EM Theory
- Review of Vector Calculus

Reading: Jackson

Inside front and back covers

Preface, Introduction and Survey

EE243 Advanced IC Processing and Layout

http://inst.eecs.berkeley.edu/~ee210/

Lectures: TuTh 12:30pm –2:00pm , Cory 400
Prof Neureuther's Office Hours See instructor web site

Prerequisite: Undergraduate EM Course (advised)

Required Textbooks:
J.D. Jackson, "Classical Electrodynamics," 3rd edition, Wiley, 1998.
Readings:
Buckman, Collin, HP AN 154, Kogelnik, Lynn, Tamir
Supplemental Material Provided:
Dielectric Waveguides, Coupled Mode Theory, Signal Flow Graphs, Brillouin Diagrams, Distributed Couplers

Goal of EE 210

Establish key capabilities beyond simple undergraduate EM courses

- Integral interactions, representations and equations
- Boundary Value Solution Methods based on separation of variables in N-1 dimensions and eigenfunctions in N dimensions
- Analysis of guided wave systems
- Radiation and simplification/limits for small and large sources

Advantages of Jackson Texst

- Shows the EM roots and horizon
- Notation is an efficient working language
- Developments are very efficient
- Coverage is quite comprehensive
- Includes concepts and methods relevant to Engineering
  - Poles and zeros of the permittivity
  - Reaction integral evaluation of source generation

Supplementation of Jackson

Via readings and handouts:

- Dielectric Guides (Kogelnik)
- Coupled modes on transmission lines (Lynn)
- Theory of Small Reflections (Collin)
- Signal flow graph theory (HP AN 154)
- Floquet Theorem and Brillouin Diagrams (Collin)
- Coupled Optical Guides (Buckman)
- Distributed Couplers (Tamir)

What Give Up From Jackson Text

- Relativity (and Cherenkov Radiation)
- Analysis of Materials
- Numerical Methods
- Special Functions
  - Do most examples in cartesian coordinates
  - Some Spherical when look at limits of scattering

Addition of Emerging Application

Identify application examples during lectures and follow up in short individual student presentations the last week of class.

- Broadband reflection from a 1D photonic grating
- Photonic systems
- Plasmon uses
- Radiation resistance of small wireless antennas

Roots and Horizons of EM

- Math came first: 1824 Green's Theorem
- Electrostatics 1771 Cavendish, Coulomb 1875
- Magnetostatics etc. 1831 Faraday
- Electrodynamics 1864 Maxwell
- Relativity 1905 Einstein
- Quantum Mechanics 1960 Standard Model

Limits to Maxwell's Equations

- Discrete Photons when photon momentum is similar to material momentum
  - Compton Effect; Spontaneous Emission
- Superposition failure
  - Scattering of light by light, vacuum polarization
  - Nonlinear materials (high fields)
- Idealizations
  - Surface charges and discontinuities are actuall smoth over plus and minus 2A at surfaces

Maxwell's Equation pp. 2 & 3

- Four Standard Euations
- Constitutive relationships
- Force on a moving charge

Boundary Conditions at Surfaces

- Derive from ME
  - Surface pill box for divergence
  - Surface loop in two orientations for curl
- At any surface
  - B normal is continuous
  - D normal is discontinuous by the surface charge density
  - E tangential is continuous (no Mag. currents)
  - H tangential is discontinuous by surface current normal to the loop

Review of Vector Calculus: Plan

- Vectors, Identities, Differential Operators
  - Application to radial functions and plane waves
- Differential Operators in 3 coordinate systems
- Vector Taylor Series
  - Application to radial functions and plane waves
- Integral Theorems from Vector Calculus

Material from inside front and back covers of Jackson as well as scattered through

Vectors, Identities, Differential Operators

- Vectors & Vector Identities

- Differential Operators (Grad, Div, Curl)
- Mutiple Operators

- Multiple Operands

Vectors, Identities, Differential Operators (Cont.)

- Application to radial functions

- Application to plane wave functions

Vector Taylor Series

- General Form
- Inverse distance case
- Planewave case

Integral Theorems from Vector Calculus

Volume to Surface

- Divergence Theorem
- (Gradient Theorem)
- (Curl Theorem)
- Green's First Identity
- Green's Theorem

Surface to line

- (Curl)
- (Gradient)
- {Divergence}

Self-adjoint Differential Expression