Physics 471 - Study guide for exam 1
Dr Colton, Winter 2025

- Chapter 0 – Important Math Review
  - Vector calculus
    - Conceptually what gradient, divergence, and curl are all about. How to calculate them
  - Complex numbers
    - How to convert between polar and rectangular and vice versa
    - How to represent sinusoidal waves as complex numbers, understand what the magnitude and phase represent, how to add them together
- Chapter 1 – Basics of E&M
  - Maxwell's equations
    - What they mean, how to use
    - Gauss's law to find electric field for high symmetry; Ampere's law to find magnetic field for high symmetry
    - Types of charge density, types of current density
    - Linear isotropic materials, esp. susceptibility and dielectric function (aka relative permittivity). You can assume non magnetic for all our materials so relative permeability is just 1.
  - Wave equation in free space, and inside materials

  Chapter 2 – E&M Basics, cont.
  - Plane waves – how and why to represent plane waves as complex exponentials; what all of the symbols mean (i.e. how to specific direction of travel, polarization, wavelength, frequency, strength of field)
  - Relationships between E, B, and k in plane waves; what they are and how/why Maxwell's equations say they are that
  - Complex index of refraction, wave number, and relative permittivity – how they all relate, how they relate to wavelength and skin depth
  - Lorentz oscillator model – applied to insulators, applied to conductors. What real and imaginary parts of index of refraction look like plotted vs frequency (or wavelength).
  - Poynting vector and Poynting theorem – how it relates to energy transfer, especially for a plane wave.
- Chapter 3 – Two Materials, One Interface
  - Polarizations, s vs p (i.e. what they are for a given situation)
  - Snell's law
  - Fresnel equations, i.e. how to calculate reflection and transmission across a single interface. Little r, t. Capital R, T. How to derive both little r, t and capital R, T.
  - Details/special cases:
    - Brewster's angle
    - total internal reflection (and how to deal with complex theta)
    - materials with complex index of refraction (i.e. conductors, and insulators near a resonance).
- Chapter 4 – Three Materials, Two Interfaces
  - How to calculate reflection and transmission across two interfaces. Little t, capital T.
  - What Tmax, F, and Phi are in the Ttot equation, and how Ttot varies with changes to them
  - Fabry-Perot application specifically; full width half max and free spectral range, and little f finesse.
  - How to use the matrix method to determine transmission and reflection for a multilayer stack