Intermediate Electricity and Magnetism Study Guide

Chapter 2:

Chapter 5:

Coulumb’s Law

Find the Electric Field at a point in space from a known charge configuration or distribution. The electric field is a function of the charge and the distance away from the charge.

Biot Savart

Find the Magnetic Field at a point in space from a known current or current distribution. The Magnetic field is a function the current and the distance away from the current (a cross product).

Gauss’ Law

Find the Electric Field using symmetry in the field due to a known charge configuration or distribution. To solve these problems we must choose a Gaussian surface where along the surface the Electric Field is constant due to symmetry. The Electric Field should be parallel or perpendicular to our Gaussian Surface, or the field could be zero.

Ampere’s Law

Find the Magnetic Field using symmetry (mirror rule) in the field due to a known current or current distribution. To solve these problems we must choose and Amperian Loop where along the loop the magnetic field is constant due to symmetry. The amperian loop should be perpendicular to the magnetic field; it is beneficial if the magnetic field is zero along a side of the loop.

Electric Potential

Find electric potential from a charge configuration or a distribution using Poisson’s and Laplace’s equations to break a scenario down to a scalar quantity. This makes it so that you do not have to deal with components making the problem simpler. From a known electric potential it is not too difficult to calculate the Electric field, or the charge distribution.

Vector Potential

Find the vector potential from a current distribution. The vector potential is handy because it is not too difficult to calculate the magnetic field or the current distribution from a known vector potential.

Energy in a Field

The energy in a field due to a charge distribution can be calculated using the Electric field, from the electric potential, or a charge configuration based on Coulumb’s Law.

Capacitance

The capacitance is a constant of proportionality, based purely on the geometry of the problem. Capacitance is useful for determining the Electric Potential, work or energy associated with the field.

Chapter 3:

Multipole Expansion

When more detail in calculating the electric potential instead of an approximation it can be beneficial to use a multipole expansion.

Multipole expansion of the vector potential

When more detail in calculating the electric potential instead of an approximation it can be beneficial to use a multipole expansion.

Chapter 4

Electric Dipoles in an Electric Field

Electric dipole in an electric field becomes polarized. And because of the polarization it experiences a torque because electric dipoles will seek to align themselves with the electric field.

Induced Dipole

An induced dipole is caused by the separation of the electron and nucleus due to an electric field. An induced dipole will seek to anti align itself with the electric field.

Magnetic Dipole

The magnetic dipole moment of a loop is a function of the current and the area of the loop.

Polarization

Polarization is the dipole moment per unit volume. A polarized object emits an electric field.

Magnetization

If an object is placed in a magnetic field the object should become magnetized. When an object becomes magnetized it experiences a torque because it will seek to align parallel, or anitparallel with the magnetic field. When an object becomes magnetized it seeks to align itself somehow due to the magnetic field because of the magnetic dipole moment per unit volume (magnetization) that occurs. Magnetic dipole moment per unit volume emits a magnetic field.

Bound Charges

It can be easy to calculate the electric potential from a known polarization. The polarization determines the bound charges; the polarized bound charges emit their own electric field.

Bound Current

The volume and surface bound current can be found by knowing the magnetization. There is a large amount of bound current within an object. The bound currents emit their own magnetic field.

Free Charges

Free charges are the charges that are not a result of polarization. The combination of free and bound charges is the total charge and the enclosed charges will be the sum of both free and bound charges. Free charges might consist of electrons on a conductor or ions embedded in the dielectric material or whatever.

Free Current

Free current is the current that is not caused by the magnetic field. The free current is due to an electric potential difference. The free current distinction is a convenience because then we do not have to deal with the bound current.

Electric Displacement

D can be calculated from a modification of Gauss’ Law, but is extremely useful because then we do not need to worry about the bound charges, just the free charges. Knowing the electric displacement, and the electric field, will tell us the polarization per unit volume.

Auxiliary Field

H permits us to express Ampere’s law in terms of free current. H is extremely useful because it makes determine the magnetic field die to current much simpler.

Calculating the Electric Field from the Electric Displacement

Calculating the Electric field form the electric displacement is easy because it is a matter of dividing the electric displacement by the the permittivity of the material. The permittivity of the material is a function of the electric susceptibility.

Calculating the Magnetic Field from the Auxillary Field

Calculating the magnetic field from the auxillary field is easy because it is a matter of multiplying the auxillary field by the permeability of the material. The permeability of the material is a function of the magnetic susceptibility.

**EQUATIONS**

CHAPTER 2

coulombs law

Gauss’s Law

Stokes’ theorem

Potential

Energy

and

Capacitance

Force

CHAPTER 3

Multipoles

CHAPTER 4

Torque

bound charges

Electric Displacement

Linear Dielectrics

CHAPTER 5

Forces

bound currents

surface

Biot-Savart

{for surface and volume currents sub I for K(r’) and dl’ for J(r’) in above eq}

Ampere’s Law

Vector Potential

Magnetic Dipole Moment

CHAPTER 6

Torque

Bound Currents

Ampere’s Law in magnetized materials

Permeability and Auxiliary Field