Exam I Study Guide

Chapter 13

- Definition of electric field:

$$\vec{E} = \frac{\vec{F}}{q}$$

  - Know how to calculate electric field given force and charge
  - Know how to calculate electric force given field and charge
  - Be familiar with the direction of the force for both positive and negative particles. Positive charges experience a force in the same direction as $\vec{E}$. Negative charges experience a force in the opposite direction as $\vec{E}$.
  - Example problems: P17, P20, P22

- Electric field of a point charge

$$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{|\vec{r}|^2}\hat{r}$$

  - $\vec{r}$: the vector pointing from the charge to the point where the field is being measured ($\vec{r}_{\text{obs}} - \vec{r}_{\text{src}}$)
  - Be able to sketch the field lines of a point charge (radially outward for a positive charge, radially inward for a negative charge)
  - Example problems: P28, P33, P35, P36

- The principle of superposition

$$\vec{E}_{\text{total}} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + ...$$

  - The total electric field of several point charges is the vector sum of the individual fields of each charge
  - Find the field vector of each charge, then add them together
  - Make sure you know how to add vectors!
  - Example problems: P47, P48, P49

- Dipoles
  - You will be given the expression for the electric field on-axis and perpendicular

$$|\vec{E}_{\text{dipole,on-axis}}| \approx \frac{1}{4\pi\epsilon_0}\frac{2p}{r^3}$$
$$|\vec{E}_{\text{dipole,perp}}| \approx \frac{1}{4\pi\epsilon_0}\frac{p}{r^3}$$

  - Remember how we derived these expressions. There is nothing magic about them, a dipole is just two point charges and we used superposition to find the field
  - Know how to calculate the dipole moment $p = qs$
  - Example problems: P52, P53, P57, P59

Chapter 14

- Be familiar with the behavior of charges on both insulators and conductors
- Be able to calculate the mutual force between a point charge and a neutral insulator
- Be familiar with the conditions for static equilibrium within a conductor
  - $\bar{v} = 0 \Leftrightarrow |\vec{E}_{\text{net}}| = 0$

  - Only the total field $\vec{E}_{\text{net}}$ needs to be 0 in equilibrium. There can still be a field due to an external charge, it is just exactly canceled by the induced field due to polarization inside the metal
- What are the mechanisms for charging/discharging for both insulators and conductors?
  - Insulators
    - Charge by contact (excess charge stays put)
  - Conductors
  - Charge/discharge by contact
  - Charge by induction
  - Grounding
- Example problems: P29, P37, P45, P49, P50, P56, P61

	Insulators	**Conductors**
Mobile Charges?	No	Yes
Location of excess charge	Anywhere	Surface only
Does excess charge spread?	No	Yes, uniformly around the surface
$\vec{E}_{\text{net}}$ **inside**	Can be non-zero	0 in equilibrium
Polarization	Induced dipoles ($p = \alpha\lvert\vec{E}\rvert$)	Moving charges ($\bar{v} = u\lvert\vec{E}\rvert$)

Chapter 15

- Be able to set up integral expressions for the electric field of uniform, one-dimensional charge distributions
  - Find charge density (total charge ÷ length).
  - Divide the distribution into very small pieces.
  - Find the charge dq of a single piece (in terms of the charge density and a differential variable).
  - Find $\vec{r} = \vec{r}_{\text{obs}} - \vec{r}_{\text{src}}$ for this piece, and use dq and $\vec{r}$ to find the electric field $d\vec{E}$ of the piece of charge, assuming it is a point charge.
  - The total field of the distribution is simply the integral of the field of every little piece $d\vec{E}$ over every possible charge location $\vec{r}_{\text{src}}$. Find the bounds of integration, and write this expression in integral form.
  - Be able to derive the field of a charged rod or ring
  - Example problems: P27, P29, P30 (a)
- Be able to use superposition to find the electric field of multiple charge distributions
  - You do not need to memorize any of the field equations in the book. If I want you to use an equation for the field of a charge distribution, I will either give it to you or ask you to derive it as a part of the problem.
  - Example problems: P31, P53, P58

Chapter 16

- Know the connection between potential difference ΔV, change in potential energy ΔU, and change in kinetic energy ΔK.
  * $\Delta K = W = -\Delta U$
  * $\Delta U = q\Delta V$
  * $\Delta V = -\int \vec{E} \cdot d\vec{r}$
    - if $\vec{E}$ is uniform: $\Delta V = -\vec{E} \cdot \vec{\Delta r}$
  * Example problems: P28, P37, P42
- Know the meaning of the sign of potential difference (for a positive particle, $-\Delta V \implies -\Delta U \implies +\Delta K$, particle gains kinetic energy and therefore speed.)
  - Particles will move in the direction of *decreasing* potential energy.
  - Positive particles: move in the direction where ΔV is negative (move from high potential to low potential).
  - Negative particles: opposite
  - Example problems: P29, P30, P32
- Given a function for electric potential: be able to calculate the electric field:

$$\vec{E} = -\left\langle \frac{dV}{dx}, \frac{dV}{dy}, \frac{dV}{dz} \right\rangle$$

  - Example problems: P33, P48
- Be familiar with the so-called "potential at a single point" V, which is simply useful shorthand the potential difference between that point and infinity
  - Know the potential of a point charge at a point in space, $V = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$
  - Be able to use superposition to find the total potential of several point charges
  - Be prepared to use this result to determine the electric field and potential energy of the charge distribution (note: since $\Delta U = q\Delta V, U = qV$)
  - Example problems: P71, P74