Chapter 13
Electric Fields and Forces Chapter Review

EQUATIONS:

- $\mathbf{F}_{on\ point\ charge} = \frac{1}{4\pi\varepsilon_o}\frac{qQ}{r^2}(\pm\mathbf{r})$ [This is the formal expression of Coulomb's Law. It gives you the force a point charge q feels due to the presence of a second field-producing point charge Q a distance r units away. Note that when this expression is presented in a formal, theoretical way, the notation is polar spherical. MINOR SIDE POINT: Polar spherical notation is used because like point charges repel. That means that no matter where q is on a polar spherical surface (assuming that Q is at the origin), the force on q will be radially away from (i.e., in the +r direction) the field-producing charge Q. By the same token, unlike point charges attract producing a force that is radially inward (i.e., in the -r direction), relative to the field-producing charge. YOU WILL NEVER DO PROBLEMS USING THIS NOTATION. I've included it here because this is the way the expression is presented in other books, and because you ought to have some clue as to what the formal presentation means.]

- $F_{on\ point\ charge} = \frac{1}{4\pi\varepsilon_o}\frac{qQ}{r^2}$ [The Coulomb's Law expression is usually used only to determine the MAGNITUDE of the force a point charge feels due to the presence of a second point charge. The DIRECTION of that force is normally assigned relative to the coordinate system being used. Remember, like charges repel and unlike charges attract each other. Also, remember that in two-dimensional problems, the Coulomb force is a VECTOR and must be treated as such.]

- E = F/q, or F = qE [The first expression is the definition of an electric field. The second expression is a useful alternative as it allows one to determine the amount of force a charge q feels when in the electric field E. Remember, the direction of an electric field at a given point is defined as the direction a test charge, ALWAYS ASSUMED TO BE POSITIVE, would accelerate if put into the field.]

- $E_{due\ to\ a\ point\ charge} = \frac{1}{4\pi\varepsilon_o}\frac{Q}{r^2}$ [This expression defines the magnitude of the electric field generated by a POINT CHARGE, as evaluated a distance r units from the field-producing charge Q. Remember, the direction of the field is the direction a positive test charge would accelerate if put into the field at the point of interest.]

- $E_{due\ to\ a\ differential\ point\ charge} = \frac{1}{4\pi\varepsilon_o}\frac{dq}{r^2}$ [This expression defines the magnitude of the electric field generated by a differential point charge dq. As usual, its direction is the direction a positive test charge would accelerate if put at the point of interest. One way to determine the net electric field due to an extended charge configuration is to define a tiny bit of charge dq within the configuration, determine the electric field due to dq at the point of interest, break that field equation into x and y components, exploit symmetry by canceling components (if any) whose net field will go to zero in the end, and integrate the component(s) that is (are) left.]

- $cos\,\theta = \dfrac{adjacent\ side}{hypotenuse}$ [To eliminate a cosine function in an expression for an electric field component, use the fact that the cosine is defined as the ratio of the side adjacent to a known angle in a right triangle over the hypotenuse.]

- $sin\,\theta = \dfrac{opposite\ side}{hypotenuse}$ [To eliminate a sine function in an expression for an electric field component, use the fact that the sine is defined as the ratio of the side opposite a known angle in a right triangle over the hypotenuse.]

- p = 2aq [An electric dipole is a charge configuration of one positive (+q) and one negative (-q) charge separated rigidly by a distance 2a. An electric dipole moment is a vector that is useful in determining the amount of torque and/or potential energy such a configuration will have when placed in an external electric field. The magnitude of a dipole moment vector is 2aq. The direction of a dipole moment vector extends along the line from the negative charge to the positive charge.]

- $\Gamma = \boldsymbol{p} x \boldsymbol{E}$ [This expression defines the torque experienced by a dipole in an electric field. The magnitude of that torque is equal to the cross product of the dipole moment vector and the electric field vector, where θ in the cross product expression is the angle between the line of p and the line of E.]

- $U(\theta) = -\boldsymbol{p} \bullet \boldsymbol{E}$ [This expression defines the amount of potential energy a dipole has when in an electric field. The angle θ in the dot product is the angle between the line of p and the line of E.]

COMMENTS, HINTS, and THINGS to be aware of:

- Don't be confused by notation. The Coulomb's Law expression is useful in finding the magnitude of the force on one point charge due to the presence of another point charge. In cases where this expression is applicable, the direction of the force vector should be determined relative to the coordinate system being used. Remember, opposites attract and likes repel.

- Don't be confused by the different electric field expressions. E = F/q (or F = qE) is ALWAYS true. It relates the electric field evaluated at a point to the force a charge q will feel if put at that point. $E = \dfrac{1}{4\pi\varepsilon_o}\dfrac{Q}{r^2}$ is specific to the electric field a point charge will produce. Don't confuse the two.

- Be able to deal with extended charge situations. That is, for situations in which you must define a differential (point) charge dq, put dq in terms of some charge density function (i.e., linear charge density $\lambda = \dfrac{dq}{dy}$ or surface charge density $\sigma = \dfrac{dq}{dA}$), determine the direction of dq's differential electric field dE at the point of interest, determine the components of that field, then integrate appropriately to determine the components of the net electric field at that point.

- Remember that when a conductor is approached by a charged object, the valence electrons in the conductor will move around within the topology of the extended object producing a polarized situation.

- Remember that when an insulator is approached by a charged object, the electrons within the atoms of the insulator will not migrate as in the case with a conductor, but they will spend more time on one side of the insulator's atoms producing polarization within the atoms. This is the basis of Van der Waal's forces.

- Don't forget Newton's Second Law. This entire chapter is based on force fields and modified force fields (electric fields). As N.S.L. is force based, it shouldn't be surprising to find that you are required to use electric forces and fields in an N.S.L. type problem.