Physics 222 Lecture 2 Notes

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1 Electric Field

1.1 Conceptual definition

According to Coulomb's Law, the reach of electric force is infinite.

In the early 1800's, **Michael Faraday** proposed the existence of an **Electric Field** which allows charges to exert force on one another, even at great distance, by **"distorting"** space. An intuitive example of how this works is how throwing a rock into a pond causes ripples.

1.2 Mathematical Definition

We quantify Electrical fields by the force they exert on the particles around them.

1.2.1 High-level equation

Our definition of electrical field "E", at location (x,y,z) would be defined as:

$$E(x, y, z) = \frac{F_{onq}}{q}$$

To calculate the force exerted on a point by an electrical field, you would use the variant:

$$F = qE$$

The SI unit used to measure electrical fields is that of the force it exerts, which is to say **Newtons**

Example Problem 1: At location x,y,z a -2 nC chg experiences a force of 5N. What is the strength of the electric field at the location?

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

$$E = \frac{5N}{-2nC}$$

$$E = -2.5N$$

1.2.2 Inverse Square Law (practical application equation)

$$F_p = k * \frac{q_1 q_{test}}{r^2}$$

1.3 Electric Field Lines

Rather than representing an electric field as a series of vectors, we can represent it as a series of **Electric Field Lines**.

Density of electric lines (i.e. num of field lines per unit area) is proportional to the magnitude of the Electric field it represents. In other terms:

$$E \propto \frac{NumberofFieldLines}{A}$$

IMPORTANT: No two electric field lines will ever cross. Where they interact, the will *bend*, but because charged particles either attract or repel, their fields will not ever cross one another.

We can represent the cumulative electric field of several point charges as the series:

$$E_p = \sum E_{iP}$$

where E_{iP} is the electrical field generated by a given particle.

1.4 Electric Dipole

An **Electric Dipole** occurs anytime there are two opposite charges with a slight seperation between them. Dipoles are either:

- induced by an external electric field
- permanent and naturally existing (as with a water molecule)

1.4.1 Dipole moment

Given: two equal charges, Q+ and Q-, separated by distance L, we can define the **dipole moment**:

$$p = QL$$

where:

- L is a distance measured in meters
- Q is a charge, measured in Coulombs

A dipole in an electric field will have a net force of zero (because the force of the fields are equal and opposite), but it will have a **torque**, which is to say it will rotate.

The **torque** can be defined as:

$$\tau_{net} = pEsin(\theta)$$

If the electric field causes the dipole to rotate. It has done **work** on it. The work done by the electric field can be represented as:

$$dW = -\tau E\theta$$