Chapter 19

Terms

Be able to define or discuss the following terms and ideas, with their SI units if appropriate.

1. Coulomb's law
2. superposition (of forces)
3. electric field
4. electric potential
5. electric potential energy
6. The magnitude of the charge of an electron or proton, 1.6×10^{-19} C

Equations

Understand the meaning and know the SI units of all symbols in these equations; know how to perform each mathematical operation, such as trig functions; know how to solve for any unknown quantity; understand how changing one quantity affects another quantity (if all other quantities remain constant); be able to apply one or more equations to solve a problem.

- Coulomb's Law.

$$|\vec{F}| = (9 \times 10^9 \text{ Nm}^2/\text{C}^2)\frac{|q_1||q_2|}{r^2}$$

- The electric field due to a point particle of magnitude charge $|q|$ at a distance r from the particle.

$$|\vec{E}| = (9 \times 10^9 \text{ Nm}^2/\text{C}^2)\frac{|q|}{r^2}$$

- The force by an electric field on a charged particle in that field.

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

- The electric field due to a point particle of charge q at a distance r from the particle.

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

- Potential difference between two points Δx apart along the x-axis for a uniform electric field in the x-direction.

$$\Delta V = -E_x \Delta x$$

- Magnitude of the potential difference between two capacitor plates a distance d apart.

$$|\Delta V| = Ed$$

- Magnitude of the potential difference between the two ends of a wire with a constant current flowing in the wire.

$$|\Delta V| = EL$$

- Electric potential energy of an electric field and charged particle, if the particle is at a location where the electric potential is V.

$$PE = qV$$

  The change in electric potential energy of a system as a charged particle moves through a potential difference ΔV.

$$\Delta PE = q\Delta V$$

- Magnitude of the drag force for an object moving at a slow speed through a fluid, such as a protein moving through a gel.

$$F_{drag} = Cv$$

  where C is a constant that depends on various factors such as the cross-sectional area of the object, the density of the fluid, the drag coefficient, etc.

Skills

1. Solve for the net force on a charged particle due to other charged particles, using Coulomb's Law and Superposition, in both one dimension and two dimensions.
2. Know that the force of an electric field on a *positively* charged particle is *parallel* to the electric field.
3. Know that the force of an electric field on a *negatively* charged particle is *opposite* to the electric field.
4. Sketch the electric field vector due to a point particle at a given point in space. It points away from a positively charged particle and toward a negatively charged particle.
5. Sketch the electric field along the axis of a ring of uniform charge density.
6. Sketch the direction of the electric field in a wire that is connected to a battery in a circuit.
7. Sketch the direction of the electric field between two oppositely charged plates (such as a capacitor or the plates used in a CRT)
8. Sketch the path of a particle moving through a region of uniform electric field between two oppositely charged plates.
9. Apply conservation of energy to a charged particle moving between two charged plates.

10. Calculate electric field due to a charged particle at a point not on the x or y axis, and write the x and y components for the electric field vector.

11. Calculate the net electric field due to two or more charged particles by calculating the electric field vector due to each particle and using Superposition to add the electric field vectors; be able to do this for both one dimensional and two dimensional vectors.

12. Apply Newton's second law to a charged molecule that moves between two oppositely charged plates, such as in gel electrophoresis.

13. Know that the electric field outside the plates of a capacitor is very small compared to the electric field within the plates, but is nonzero. It points toward the negatively charged plate and away from the positively charged plate.

Lab Skills

1. Calculate the electric force of one charged sphere on another charged sphere that is attached to a thread and is in equilibrium at some angle θ from the vertical.

2. Fit a curve to a graph of F_{elec} vs. r for two charged spheres and use the proportionality constant to calculate the charge on each sphere.

3. Determine the electric field between oppositely charged plates by analyzing a graph of V vs. x across the plates.