Chapter 16

Terms

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

1. uniform charge distribution
2. point particle (or point charge)
3. dq
4. $d\vec{E}$
5. superposition

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.

- $\vec{E}$ along the perpendicular bisector of a dipole

$$|\vec{E}|_{\text{dipole}} \approx \frac{1}{4\pi\epsilon_0}\frac{|q|s}{r^3} \quad \text{along perpendicular bisector if } r >> s$$

- $\vec{E}$ along the axis of a dipole

$$|\vec{E}|_{\text{dipole}} \approx \frac{1}{4\pi\epsilon_0}\frac{2|q|s}{r^3} \quad \text{along axis of dipole if } r >> s$$

- $\vec{E}$ along the perpendicular bisector of a uniformly charged rod

$$|\vec{E}| = \frac{1}{4\pi\epsilon_0}\left(\frac{|Q|}{r(r^2+(L/2)^2)^{1/2}}\right) \quad \text{along } \perp \text{ bisector of the rod}$$

- $\vec{E}$ along the perpendicular bisector of a uniformly charged rod for $L >> s$

$$|\vec{E}| \approx \frac{1}{4\pi\epsilon_0}\left(\frac{2|Q|/L}{r}\right) \quad \text{along } \perp \text{ bisector of the rod if } L >> r$$

- $\vec{E}$ along the axis of a uniformly charged ring (in this case z is aligned with the axis of the ring with $z = 0$ at the center of the ring)

$$|\vec{E}| = \frac{1}{4\pi\epsilon_0}\frac{|Q|z}{(R^2+z^2)^{3/2}} \quad \text{along the axis of a ring}$$

- $\vec{E}$ along the axis of a uniformly charged disk (in this case z is aligned with the axis of the disk with $z = 0$ at the center of the disk)

$$|\vec{E}| = \frac{|Q|/A}{2\epsilon_0}\left(1 - \frac{z}{(R^2+z^2)^{1/2}}\right) \quad \text{along the axis of a disk, } A = \pi R^2$$

- $\vec{E}$ along the axis of a uniformly charged disk for distances much less than the radius of the disk

$$|\vec{E}| \approx \frac{|Q|/A}{2\epsilon_0}\left(1 - \frac{z}{R}\right) \quad \text{along the axis of a disk, } z << R$$

- $\vec{E}$ along the axis of a uniformly charged disk for points extremely close to the disk

$$|\vec{E}| \approx \frac{|Q|/A}{2\epsilon_0} \quad \text{along the axis of a disk, extremely close to the disk}$$

- $\vec{E}$ inside a capacitor, near the axis of the plates

$$|\vec{E}| \approx \frac{|Q|/A}{\epsilon_0} \quad \text{inside a capacitor, near the axis of the plates}$$

- $\vec{E}$ outside a capacitor, near the axis of the plates. It is very small, but not always negligible.

$$|\vec{E}|_{fringe} \approx \frac{|Q|/A}{2\epsilon_0}\left(\frac{s}{R}\right) \quad \text{outside a capacitor, near the axis of the plates}$$

- $\vec{E}$ inside a uniformly charged sphere

$$|\vec{E}| = 0$$

- $\vec{E}$ outside a uniformly charged sphere

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

Skills

1. Given the size (e.g. length or area) of a discrete piece of an object, find the charge on the given piece using the fact that the charge is uniformly distributed.
2. Numerically calculate the electric field due to a uniform charge distribution by breaking the object into discrete pieces, finding the electric field due to each piece (treating it as a point particle), and summing to calculate the net electric field.
3. Analytically calculate the electric field due to a uniform charge distribution by breaking the object into infinitesimally small pieces of charge dq, finding an expression for the electric field $d\vec{E}$ due to each piece (treating it as a point particle), expressing dq in terms of a spatial variable, and integrating $d\vec{E}$ over the entire object.

Lab Skills

1. Develop a spreadsheet to numerically calculate the electric field at any given location due to a charged rod.
2. Develop a VPython program to numerically calculate the electric field at any given location due to a charged rod.
3. Develop a VPython program to numerically calculate the electric field at any given location due to a charged ring.
4. Develop a VPython program to numerically calculate the electric field at any given location due to a charged disk.