PHY140Y

Spring Term – Tutorial 15 Discussions

January 24, 2000

1. We are going to investigate Gauss's Law.

   (a) Suppose we have a uniform field $F(\vec{r})$, meaning that this field is constant everywhere. Calculate the *flux* of this field through a square surface of area A oriented at right angles to the field $\vec{F}$. Repeat this for the surface oriented with the normal to the surface perpendicular to the field vector. Note that we define the flux ϕ as the scalar quantity

   $$\phi = \int_S (F(\vec{x}) \cdot \hat{n}) dS, \tag{1}$$

   where $\hat{n}$ is the unit vector normal to the surface at each point $\vec{x}$ on the surface.

   (b) For the same field $\vec{F}$, calculate the flux of this field through a closed cubic surface. Orient the surface any way you want. Repeat this calculation for a sphere.

   (c) Now calculate the flux of the electric field generated by a point charge q through a sphere centred on the point charge at radius R. Show that this is independent of the radius of the sphere.

2. Suppose we have a parallel plate capacitor formed from two plates of area A and separated by a distance d. You can assume that the width and length of the plates are much larger than the separation d.

   (a) We start by putting a charge $+Q$ on the top plate and a charge $-Q$ on the bottom plate. What is the electric field between the plates? What is the electric field outside the plates?

   (b) The electric potential difference, $\Delta V \equiv V_{top} - V_{bottom}$, between the two plates is defined as the negative of work per unit charge done **by the field** when charge is moved from the bottom to the top plate. What is this potential difference?

   (c) What is the force acting on each plate.

   (d) Calculate the capacitance, $C \equiv Q/\Delta V$, of this system.

3. Suppose we have a charge $+q$ located on the $\hat{z}$ axis at $d/2$ and a charge $-q$ located on the same axis at $-d/2$. This is called a dipole.

   (a) Sketch the field lines for this charge distribution.

   (b) At a point z along the $\hat{z}$ axis, calculate the electric field. Assume that $|z| \gg d$. How fast is it falling off? Does this make sense?

4. Three charges, two with magnitude $+4q$ and one with magnitude $-q$, are placed on a line. Is there a configuration in which the forces on all three are zero?