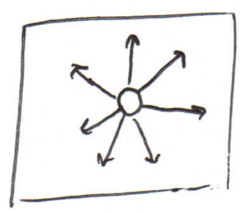
Name Key

Homework Questions

Electric Forces + Fields #3 (Gauss' Law)

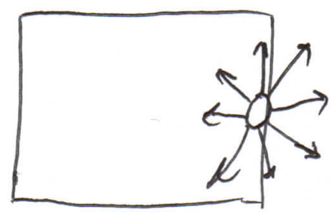
Multiple Choice Practice:

1. A particle with charge q is located inside a cubical Gaussian surface. No other charges are nearby.
   a. If the particle is at the center of the cube, what is the flux through each one of the faces of the cube?
      i. 0
      ii. q/ε_0
      iii. $q/2\varepsilon_0$
      iv. $q/4\varepsilon_0$
      v. $q/6\varepsilon_0$
      vi. $q/8\varepsilon_0$



6 faces on cube, so 1/6 of field lines will go through each face

   b. If the particle can be moved to any point within the cube, what maximum value can the flux through one face approach?
      i. 0
      ii. q/ε_0
      iii. $q/2\varepsilon_0$
      iv. $q/4\varepsilon_0$
      v. $q/6\varepsilon_0$
      vi. $q/8\varepsilon_0$



1/2 of the field lines will go through a face if it's pushed up against one side.

   c. If the particle can be moved anywhere within the cube or on its surface, what is the minimum possible flux through one face?
      i. 0
      ii. q/ε_0
      iii. $q/2\varepsilon_0$
      iv. $q/4\varepsilon_0$
      v. $q/6\varepsilon_0$
      vi. $q/8\varepsilon_0$

It will be 0 if charge is on a surface.

2. The net electric flux through a closed surface is
   A) infinite only if there are no charges enclosed by the surface
   B) infinite only if the net charge enclosed by the surface is zero
   C) zero if only negative charges are enclosed by the surface
   D) zero if only positive charges are enclosed by the surface
   E) zero if the net charge enclosed by the surface is zero

Free Response Practice

3. The electric field everywhere on the surface of a thin, spherical shell of radius 0.780 m is measured to be 880 N/C and points radially toward the center of the sphere.

   a. What is the net charge within the sphere's surface?

   -59.6 nC   E = 880 r = .78 $E = \frac{kQ}{r^2}$ Q = -59.6 nC

   b. What can you conclude about the nature and distribution of the charge inside the spherical shell? (Circle One)

   i. the negative charge has an asymmetric charge distribution
   ii. the positive charge has a spherically symmetric charge distribution
   iii. the positive charge has an asymmetric charge distribution
   (iv.) the negative charge has a spherically symmetric charge distribution

   (negative → point inward; symmetric → Uniform field)

4. The charge per unit length on a long, straight filament is -94.0 μC/m. $E = \frac{2kQ}{yL}$ – we derived this earlie

   a. Find the electric field 10.0 cm from the filament. Distances are measured perpendicular to the length of the filament. (Take radially inward toward the filament as the positive direction.)

   16.9 MN/C   r = 0.1m Q/L = -94 μC   E = 16.9 MN/C

   b. Find the electric field 27.0 cm from the filament.

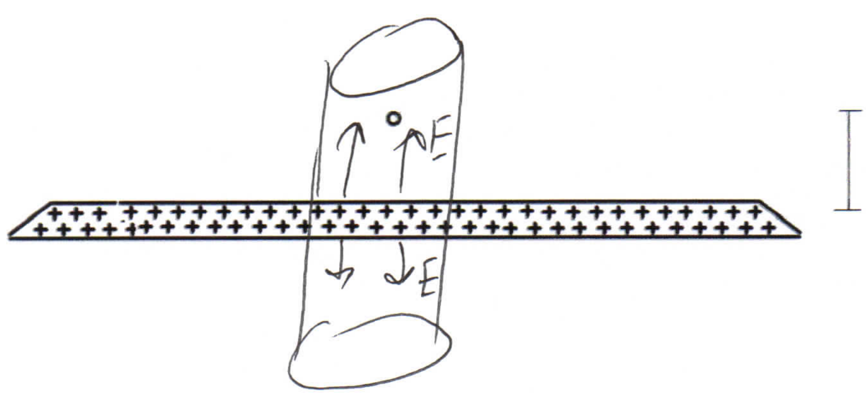
   6.26 MN/C   r = .27m   E = 6.26 MN/C

   c. Find the electric field 130 cm from the filament.

   1.3 MN/C   r = 1.3m   E = 1.3 MN/C

5. Instead of an infinitely long line of charge (class example), let's instead look at an infinitely long, infinitely wide sheet of charge. Can you draw a Gaussian surface that would work with this charge formation?

   *No mathematical solution necessary. All you need to do is draw a Gaussian surface that follows our laws for drawing Gaussian surfaces.



6. Use Gauss' Law to prove that the electric field a distance *r* away from the center of a spherical charge *Q* with radius *a* is equal to kQ/r^2. Note that $r > a$ for this problem.

$$E\int dA = \frac{Q_{in}}{\varepsilon_0}$$

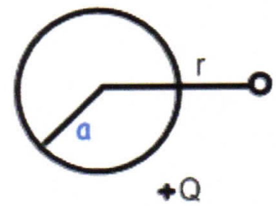
$$A = 4\pi r^2$$

↓ surface area

$$EA = 4\pi kQ$$

$$E(4\pi r^2) = 4\pi kQ$$

$$E = \frac{kQ}{r^2}$$



7. Use Gauss' Law to prove that the electric field a distance *r* away from the center of a spherical charge *Q* with radius *a* is equal to kQr/a^3. Note that $a > r$ for this problem.
   a. Hint: Think about how much of the charge *Q* is actually "enclosed" for this situation

$$EA = 4\pi k\left(\frac{\frac{4}{3}\pi r^3}{\frac{4}{3}\pi a^3}\right)Q$$

$$E(4\pi r^2) = 4\pi k\frac{r^3}{a^3}Q$$

$$E = \frac{kQr}{a^3}$$