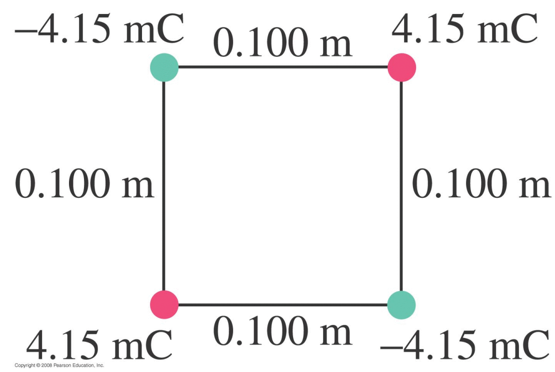
**Test 1 Practice : Additional Good Homework Problems**
(updated to include chapter 23)

## Chapter 21 : Electric Charge and Electric Field

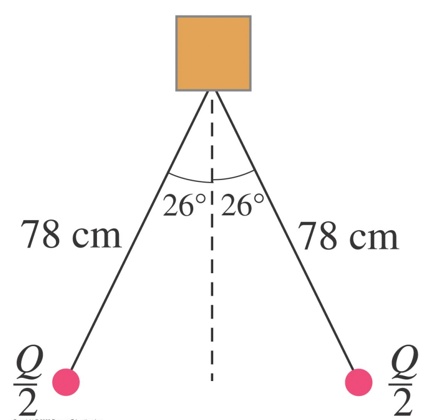
- HW 21-75 : Dry air will break down and generate a spark if the electric field exceeds about $3 \times 10^6\ N/C$. How much charge could be packed onto the surface of a small green pea (treat as a sphere of diameter 0.75 $cm$, with the charge uniformly distributed) before the pea spontaneously discharges?

- HW 21-16 : Two negative and two positive point charges (of magnitude $|Q| = 4.15\ mC$) are placed on opposite corners of a square as shown in the figure. Determine the magnitude and direction of the force on each charge.

  (Think about this a bit. All the charges have the same magnitude, so there aren't that many actual calculations required here. Pick one and look at the forces the others are exerting on it. We have some symmetries we can exploit here.)



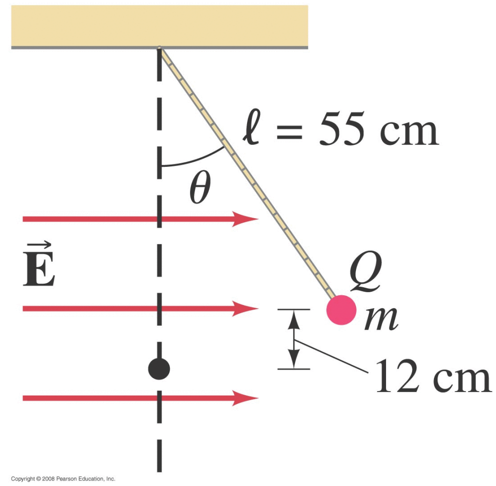

- HW 21-18 : A large electroscope is made with 'leaves' that are 78 $cm$ long wires with tiny 24 $g$ spheres at the ends. When a charge Q is added to the point on the top, the charge redistributes itself leaving $Q/2$ on each sphere. At equilibrium, the wires each make an angle of $26^o$ relative to the vertical. How much total charge $Q$ was applied to the electroscope?




- HW 21-33 : Calculate the (vector) electric field at the center of a square 42.5 $cm$ along each side if one corner is occupied by a $-33.8\ \mu C$ charge and the other three corners are occupied by $-22.0\ \mu C$ charges? (Hint: be sure to sketch this out and think about it before bringing in any equations. The actual calculation part for this problem will be almost negligible.)

- HW 21-82 : A point charge ($m = 1.5$ $gram$) at the end of an insulating cord of length 55 $cm$ is observed to be in equilibrium in a uniform horizontal electric field of 9500 $N/C$ when the pendulum's position is as shown in the figure, with the charge 12 $cm$ above its lowest (vertical) position. If the field points to the right, determine the magnitude and sign of the point charge.

  (Remember the pith-ball example we worked in class. What are the three forces acting on the charged ball? How do we determine the angle $\theta$ using the distances they provided?)



**Chapter 22 : Gauss's Law**

(The first few are just conceptual problems and not really test problems, but they're good practice for understanding what Gauss's Law **means**.)

- HW 22-10 : A point charge Q is placed at the exact center of a cube with sides of length $l$. What is the flux through one face of the cube?

  (Don't actually do any integrals here - what symmetry can we exploit here? Remember the total flux through all the sides combined is equal to $Q/\epsilon_o$ via Gauss's Law...)

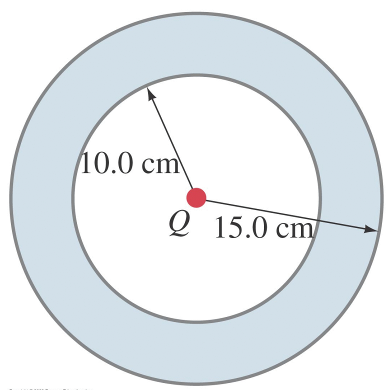
- HW 22-11 : A 25 $cm$ long uniformly charged plastic rod is sealed inside a plastic bag. The total electric flux passing through the bag is $7.3 \times 10^5\ N\ m^2/C$. What is the linear charge density on the rod?

  (Another one to think about first. Way easier than it looks.)

- HW 22-28 : A spherical rubber balloon carries a total charge of Q uniformly distributed on its surface. At $t = 0$ the conducting balloon has a radius of $r_o$ and the balloon is then slowly blown up so that $r$ increases to $2r_o$ in a time $T$. Determine the electric field as a function of time (a) just outside the expanding balloon's surface and (b) at the fixed point at $r = 3.2r_o$.

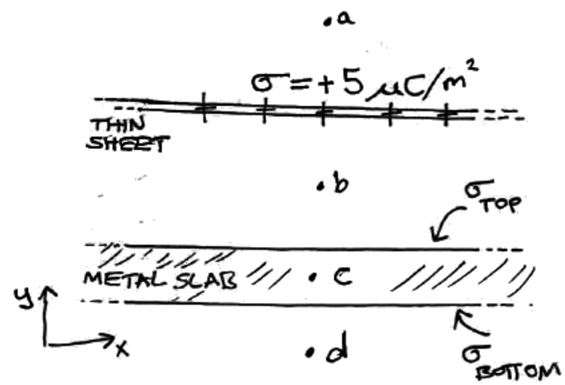
  (Again, this is a thinking problem - no calculations will be needed. The answer should be 'obvious'...)

- HW 22-65 : A **conducting** spherical shell has an inner radius of 10 $cm$, an outer radius of 15 $cm$, and has a $+3\ \mu C$ point charge Q located at its center. An additional charge of $-3\ \mu C$ is now **added** to the spherical shell. (a) Where on the conductor does that $-3\ \mu C$ charge end up? (b) After we've added the additional charge to the shell, what is the electric field both inside and outside the shell (i.e. what does $E$ look like as a function of $r$)?



- Inspired by HW 22-63, but slightly simpler. This is mostly a thought problem too, but is expecting numerical results. **We walked through this in class Friday. Since you won't need to derive any electric fields using Gauss's Law on the test, you can skip this problem and the next one as far as test practice, but it's an interesting problem that will definitely exercise your understanding of conductors and how Gauss's Law works!**

  Suppose we have a very large **metal** slab that's 2 $cm$ thick and initially electrically neutral. 5 $cm$ ABOVE this metal slab (and parallel to it) we place a very large, but very thin **non-conducting sheet** that has a (uniform) charge density of $\sigma = +5.00\ \mu C/m^2$.
  Use Gauss's Law to determine the charge density that must be on the top surface of the metal slab. That same charge density (but of opposite sign) will be on the bottom surface of the metal slab.

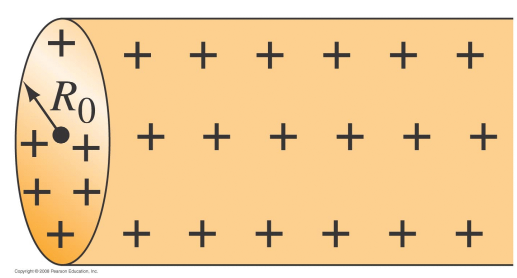
  
  

  What will the resulting electric fields be (magnitude and direction) at the points labelled in the figure?

  - Point ⓐ is just above the non-conducting sheet
  - Point ⓑ is anywhere between the sheet and the slab
  - Point ⓒ is inside the metal slab
  - Point ⓓ is below the metal slab

  (They take pains to describe these as 'very large', so assume they're in effect infinitely large. Symmetry arguments restrict what E can be. For example, it can't have any 'lateral' component anywhere: $\vec{E}$ has to be perpendicular to the surfaces. It also can't change as we move to the left or right in the figure, and so on. How did we use Gauss's Law in these infinite-sheet type geometries before? The slab is a conductor, so what **must** be the electric field at point (c) in the figure? Where could we put a little Gaussian cylinder (hint) that would let us use the given $\sigma$ on the sheet to find the $\sigma$ on the top surface of the slab?)

- HW 22-34 : A very long solid nonconducting cylinder of radius $R_o$ and length $l$ (where $l$ is very much larger than $R_o$, so assume it's infinitely long) has a uniform volume charge density of $\rho$ throughout the material making up the cylinder. Use Gauss's Law to derive an equation for the electric field outside ($r > R_o$) and inside ( $r < R_o$ ) the cylinder.

  **(Safe to skip since you won't be deriving $\vec{E}$ fields using Gauss's Law on the test...)**

**Chapter 23 : Electric Potential**

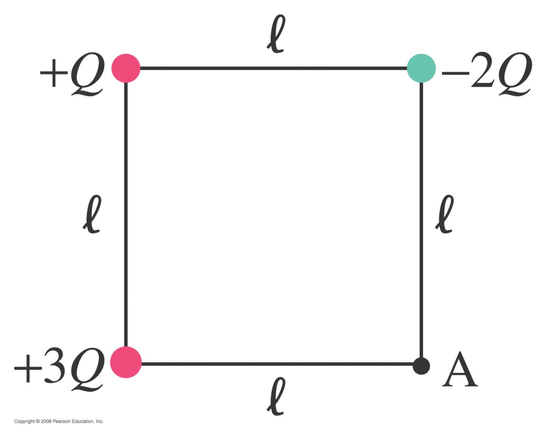
As usual, a couple of easy warm-up questions:

- HW 23-03 : What potential difference is needed to stop an electron that has an initial velocity of $v = 5.2 \times 10^5\ m/s$? (Sketch out the scenario : if the electron is travelling from the left to the right, which 'side' of the figure has the higher voltage and which has the lower voltage?)

- HW 23-05 : An electron accelerates from rest in a uniform electric field of $E = 6000\ N/C$ to a speed of $20,000\ m/s$. (a) How far did it travel? (b) Through what potential difference was the electron accelerated?

- HW 23-12 : What minimum radius must a large conducting sphere have if it is to be at $45,000\ V$ without discharging into the air? How much charge will it be carrying?

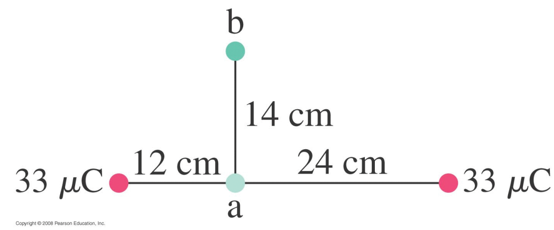
- HW 23-28 : Three point charges are arranged at the corners of a square of side $l$ as shown in the figure. What is the potential at the fourth corner (point A in the figure), taking $V = 0$ when we're infinitely far away from these charges?
(Obviously this will be a symbolic answer involving $Q$ and $l$.)




- HW 23-37 : A 12.0 $cm$ radius thin ring carries a uniformly distributed $+15.0\ \mu\ C$ charge. A small 7.5 $gram$ sphere with a charge of $+3.6\ \mu C$ is placed exactly at the center of the ring and given a very small push so it moves along the ring axis. How fast will the sphere be moving when it is 2 $m$ from the center of the ring (ignore gravity)?

  (Think of this in terms of conservation of energy. The electrical potential energy of the sphere at each location will be it's charge times the voltage being created by the ring at that point. The 'very small push' wording means assume the initial velocity of the sphere is so small we can assume it's essentially zero.)

- HW 23-80 : Three point charges are arranged as shown in the figure. A $-1.8\ \mu C$ charge is located at point A, with a $+38\ \mu C$ charge located 12 $cm$ to its left, and another $+38\ \mu C$ charge located 24 $cm$ to its right. The $+38\ \mu C$ charges are fixed in place and cannot move.
  How much **work** is required to move the $-1.8\ \mu C$ charge from point A to point B?

  (Hint: look at the change in electrical potential energy between the two locations. The positive charges aren't moving, so focus on just the $U$ of the negative charge at points A and B.)

- HW 23-52 : A dust particle with mass of 0.050 $grams$ and a charge of $+2.0 \times 10^{-6}\ C$ is in a region of space where the potential is given by $V(x) = (2.0\ V/m^2)x^2 - (3.0\ V/m^3)x^3$ (where $x$ is measured in meters). If the particle starts at $x = 2.5\ m$, what is the initial acceleration of the charge?

  (The force on the dust particle will be $F = qE$ and how can we find the electric field from the potential? Note: we won't get to this relationship until the last lecture on this chapter...)