Equations and Relations:

Coulomb's law: $F = k \dfrac{|q_1||q_2|}{r^2} = \dfrac{1}{4\pi\varepsilon_0} \dfrac{|q_1||q_2|}{r^2}$

$k = 8.99 * 10^9 \, Nm^2/C^2$

$\varepsilon_0 = \dfrac{1}{4\pi k} = 8.85 * 10^{-12} \, C^2/Nm^2$

magnitude of an electron's charge:
$e = 1.6 * 10^{-19} \, C$

mass of an electron:
$m_e = 9.11 * 10^{-31}$ Kg

Electric Field: $E = \dfrac{F}{q_0}$

Electric field of a point charge: $E = k \dfrac{|q|}{r^2}$

Electric flux: $\Phi = EA\cos\theta$

Gauss's law: $\Phi = \dfrac{Q}{\varepsilon_0}$

Electric Potential: $E = -\dfrac{\Delta V}{\Delta s}$

Electric Potential of a point charge: $V = \dfrac{kq}{r}$

Electric Potential Energy: $U = q * V = k\dfrac{q_1 q_2}{r}$

In your work in Tutorial, please remember to

   1) Draw pictures and/or diagrams of the situation before beginning a solution
   2) Write down the known quantities and the desired unknown(s)
   3) Start your solution by writing down a fundamental relation or equation that you think is relevant.

1. The force of attraction between a - 40.0 μC and + 108 μC charge is 4.00 N. What is the separation between these two charges?

2. Two point charges of magnitudes + 8.00 μC, and + 10.0 μC are placed along the x-axis at x = 0 cm and x = 100 cm, respectively. Where must a third charge be placed along the x-axis so that it does not experience any net force because of the other two charges?

3. Suppose you want to neutralize the gravitational attraction between the earth and moon by placing equal amounts of charge on each.
    (a) Should the charges be both positive, both negative, or opposite? Why?
    (b) Do you need to know the distance between the earth and moon to find the magnitude of the charge? Why or why not?
    (c) The masses of the earth and moon are 5.98×10^{24} and 7.35×10^{22} kg, respectively. Identical amounts of charge are placed on each body such that the net force (gravitational plus electrical) on each is zero. What is the magnitude of the charge?

   ➤ *Compare the gravitational and electrostatic forces acting on the particles in a Hydrogen atom.*

➢ *Compare the universal law of gravity with Coulomb's law. What are the similarities and what are the differences?*

4. Two identical metal spheres have charges q_1 and q_2. They are brought together so they touch, and then they are separated.
   (a) How is the net charge on the two spheres before they touch related to the net charge after they touch?
   (b) After they touch and are separated, is the charge on each sphere the same? Why?

➢ *Describe the location on the metal sphere where the charges would be located.*
➢ *What is the electric field within the spheres?*
➢ *How can you shield electronic circuits?*

5. Look at the figure. In each situation the charges are directly on the *x*- and *y*-axes, the same distance from the origin. Without doing any calculations, does the electric field at the origin in (a) have a magnitude that is greater than, less than, or equal to the electric field at the origin in part (b)?
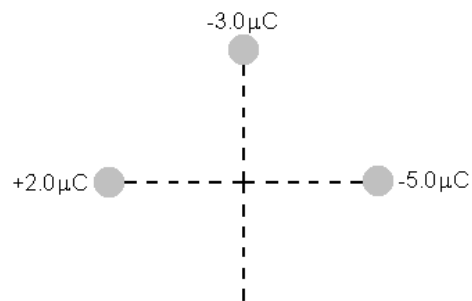
   If the distance between each of the charges and the origin is 9 cm, determine the magnitude of the electric field at the origin for both (a) and (b).

-3.0μC

+2.0μC   -5.0μC

(a)

-1.0μC
(b)

+5.0μC   +1.0μC

+6.0μC
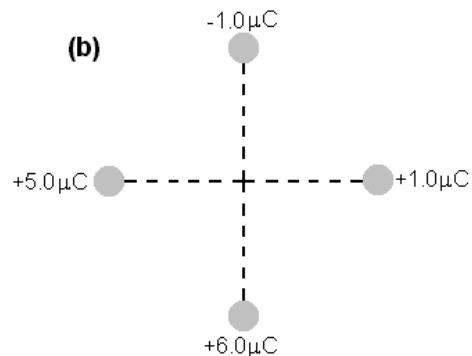
6. For the electric field lines shown in the Figures to the right (I and II) decide if the following statements are true:
   a.) The electric field is generated by positive charges on the right and negative charges on the left.

   b.) The electric field increases as you move from the left to the right.
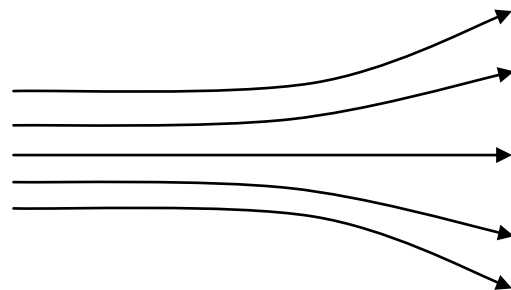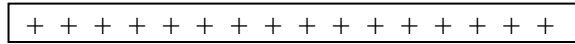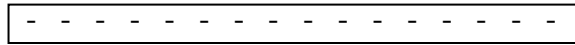

I.)

c.) The electric field is the same everywhere.

d.) Figure II shows the field inside a parallel plate capacitor with the plates parallel to the field lines.

II.)

7. An electron enters the region between the plates of a parallel plate capacitor.

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e⁻ ⟶

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   a.) Draw the field lines between the two plates.
   b.) Draw the trajectory of the electron
   c.) Which vector is parallel to the field lines? The particles
       i. momentum
       ii. velocity
       iii. acceleration.
   d.) The distance between the two plates is 0.2 cm. The electron enters the capacitor in the middle of the two plates with an initial velocity of 10×10^6 m/s.
       i. What is the magnitude of the electric field if the electron hits the upper plate 3 cm after entering the capacitor?
       ii. What is the charge per unit area on either plate?
       iii. What is the total charge on the plates if the plates are 4 cm x 4 cm?

➢ *Discuss the use of a parallel plate capacitor as deflection plates in printhead of an inkjet printer.*
➢ *Why could you ignore gravity in this problem?*

8. A 4.0–μC charge is situated at the origin of an $\xi\psi$-coordinate system. What is the potential difference between a point $x_1 = 2.0$ m and another point $x_2 = 4.0$ m because of this charge?

9. The figure at right shows a square with different fixed positive charges on two corners. A third charge that is negative is brought to one of the empty corners.

(a) At which of the empty corners, A or B, is the potential greater?

(b) Is the electric potential energy of the third charge positive or negative? At which of the two locations will the third charge have a greater magnitude of electric potential energy? Explain.

(c) If the length of a side of the square is $L = 20$ cm, find the electric potential energy of a charge $q_3 = -4.0 \times 10^{-9}$ C placed at corner A. Find the same for corner B

A   B

$q_1 = +1.3 \times 10^{-9} C$ $q_2 = +5.2 \times 10^{-9} C$
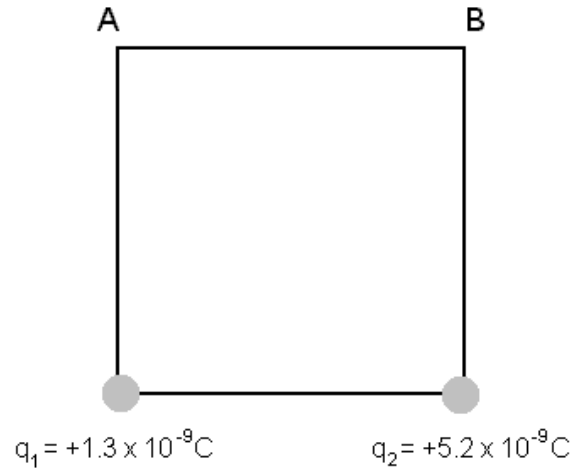
Additional questions

1. Two charges, +Q and –Q, are in a Gaussian surfarce. Gauss' law states that the electric flux through the surface must be zero, hence $\Phi = 0$. Does that mean that the electric field is zero at any point on the Gaussian surface?

2. Describe the relationship between Gauss's law and Coulomb's law

3. When you rub a balloon against your shirt a net charge is given to the balloon. When you touch the balloon to the ceiling it will remain stuck even after being released. What forces act on the balloon? Why does it remain stuck?

4. Discuss how the electrostatic force is used in an office photocopier.

5. If the electric field at a certain location is zero does that mean that the electric potential is zero at this point as well?