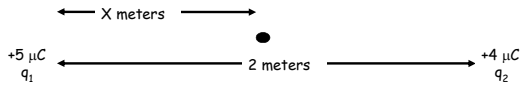
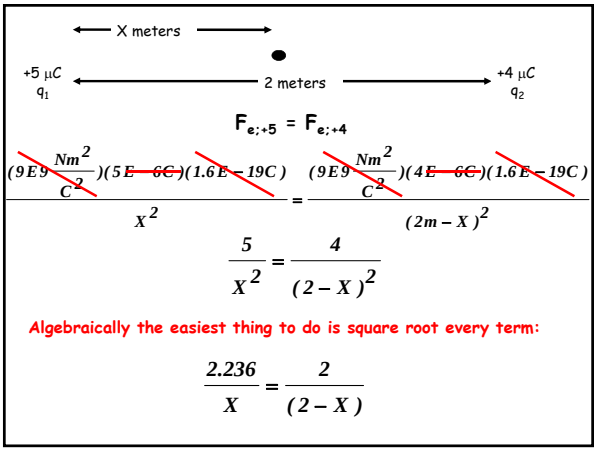
Electric Fields

Superposition

- Two charges q_1 (+5 μC) and q_2 (+4 μC), lie 2 meters apart along the x-axis. How far from q_1 should an electron be placed so that the resultant electric force on the electron is zero?





$$F_{e;+5} = F_{e;+4}$$

$$\frac{(9E9\ \frac{Nm^2}{C^2})(5E-6C)(1.6E-19C)}{X^2} = \frac{(9E9\ \frac{Nm^2}{C^2})(4E-6C)(1.6E-19C)}{(2m-X)^2}$$

$$\frac{5}{X^2} = \frac{4}{(2-X)^2}$$

Algebraically the easiest thing to do is square root every term:

$$\frac{2.236}{X} = \frac{2}{(2-X)}$$

$$\frac{2.236}{X} = \frac{2}{(2-X)}$$

Cross multiply:

$$2.236(2-X) = 2X$$

Distribute:

$$4.472 - 2.236X = 2X$$

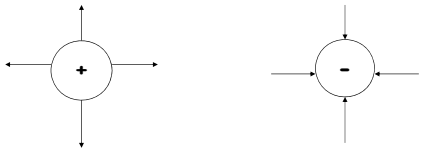
Solve for X

$$X = 1.056\,m$$

Electric Fields

- Field forces are forces that are capable of acting through space and do not require direct contact.
- An electric field is a region in space around a charged object in which a stationary object experiences an electric force because of its charge.
- It is a vector force.

Electric Fields



Arrows AWAY from positive charges.

Arrows TOWARD negative charges.

The arrows point the direction a small positive test charge would move.

The number of arrows is proportional to the charge.

Electric Fields

$$\vec{E} = \frac{K|Q|}{r^2}$$

$\vec{E}$ = electric field (N/C)

Q = charge that creates the field (C)

K = electric constant $= 9x10^9\ \mathrm{Nm^2/C^2}$

r = distance (m)

Example

- **The E-field at a distance of 50 cm from a certain charge has a magnitude of 300 N/C. What is the magnitude of the charge that created the E-field.**

$$\vec{E} = \frac{K|Q|}{r^2} \qquad 300\frac{N}{C} = \frac{(9x10^9\ \frac{Nm^2}{C^2})Q}{(.5m)^2}$$

$$\frac{300(.5)^2}{(9x10^9)} = Q$$

$$8.33E-9C = Q$$

Electric Force

$$\vec{F}_e = q\vec{E}$$

$\vec{F}_e$ = electric force (N)

q = charge in field (C)

$\vec{E}$ = electric field (N/C)

Example

- The magnitude (size) of an E-field (electric field) at a certain location is 5.7 E 5 N/C. What is the electric force on a point charge of 8 E -7 C at that location?

$$\vec{F}_e = q\vec{E}$$

$$\vec{F}_e = (8x10^{-7}\,C)(5.7x10^5\ \frac{N}{C})$$

$$\vec{F}_e = 0.456N$$

Practice

What is the magnitude of the E-field located 5nm from a proton?

$$\vec{E} = \frac{K|Q|}{r^2}$$

$$E = \frac{(9E9\frac{Nm^2}{C^2})(1.6E-19C)}{(5E-9m)^2}$$

$$E = 5.76E7N/C$$

Practice

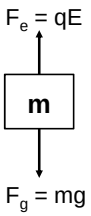
What is the force on an electron located 5 nm to the left of the above proton.

$$\vec{F}_e = q\vec{E}$$

$$\vec{F}_e = (-1.6E-19)(-5.76E7\frac{N}{C})$$

$$\vec{F}_e = 9.22E-12N$$

Practice



What E-field would be needed to balance the weight of a carbon nucleus? What is the direction of the E-Field?

$$q\vec{E} = mg$$

$$6(1.6E-19C)\vec{E} = 12(1.67E-27kg)(9.8m/s^2)$$

$$\vec{E} = 2.05E-7N/C \quad up$$