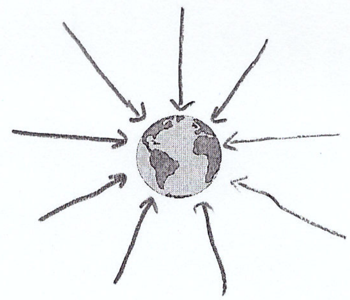
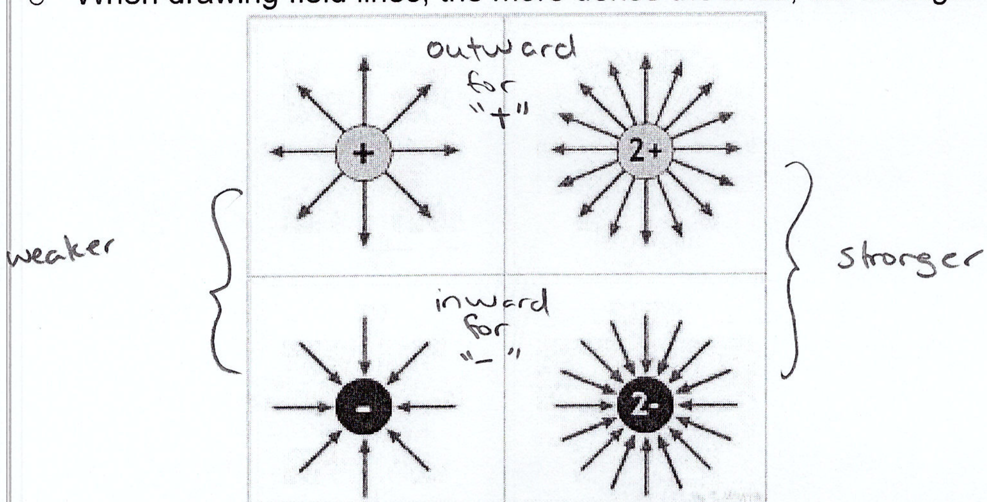
Electric Fields

- The concept of *fields* was introduced to explain why two objects that weren't in contact with each other could still exert a force on each other (ie. be able to explain why two similar charges objects will repel each other even if the charges are not physically in contact with each other)
- **Fields** are spheres of influence and can cause an "action at a distance"
  - Fields with specific directions are defined as *vector fields*
  - An example of a vector field would be *gravitational fields*, where the gravitational field lines are always directed toward the mass creating the field

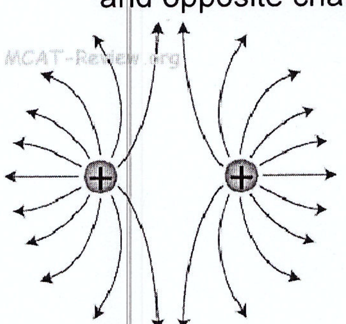


* • Just as every mass creates its own gravitational field, every charge will create its own *electric field*

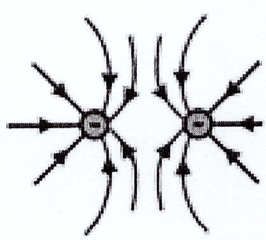
* • Electric fields are also vector fields and have very specific directions
  - Electric field always radiate outward/away from positive charges and always radiate toward/into negative charges
  - When drawing field lines, the more dense the lines, the stronger the field



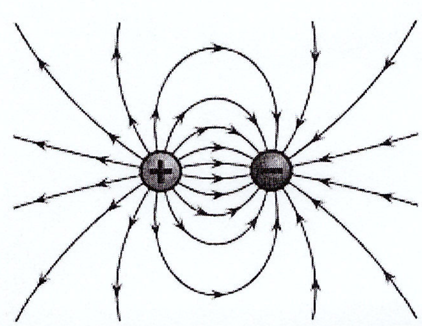
- The interaction of electric field lines can help explain why similar charges repel and opposite charges attract.



repel



repel



attract

* area in middle has no electric field

- The strength of the electric field depends on the distance from the charge producing the electric field and can be described by the following equation:

$$\vec{E} = \frac{kq}{r^2}$$

* use absolute values !

where $\vec{E}$ is electric field or electric field strength (N/C)

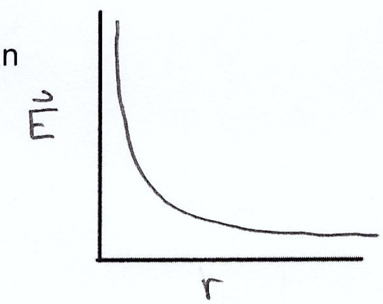
k is Coulomb's constant ($8.99 \times 10^9 \frac{N \cdot m^2}{C^2}$)

q is the charge on the object *producing* the electric field (C)

r is the distance from the charge *producing* the electric field (m)

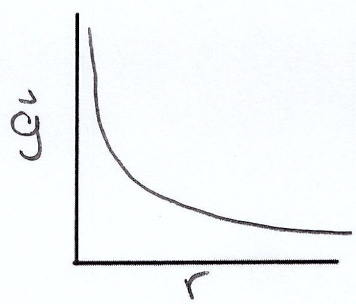
  - From the equation, we can see that the electric field strength and distance have an inverse squared relationship

$$\vec{E} \propto \frac{1}{r^2}$$



  - The electric field equation is very similar to the gravitational field equation which also has an inverse squared relation between field strength and distance

$$\vec{g} = \frac{Gm}{r^2} \quad \therefore \quad \vec{g} \propto \frac{1}{r^2}$$



- The electric field strength can also be calculate based on the force another charged object will experience when placed in the existing field at a fixed distance from the charge producing the field

$$\vec{E} = \frac{\vec{F_e}}{q}$$

* use absolute values!

where $\vec{E}$ is electric field or electric field strength (N/C)

$\vec{F}_e$ is the electrical force (N)

q is the charge on the object in the electric field (C)

↳ not creating field

EXAMPLES:

1. If the distance from a point charge is tripled and the charge on the point charge is also tripled, by what factor does the electric field strength change?

<u>Original</u>

$\vec{E}$

r

q

$\vec{E} = \frac{kq}{r}$

<u>Modified</u>

$\vec{E}' = ?$

$r' = 3r$

$q' = 3q$

$$\vec{E}' = \frac{k(3q)}{(3r)^2} = \underbrace{\frac{kq}{r^2}}_{\vec{E}}\left(\frac{3}{9}\right) = \vec{E}\left(\frac{1}{3}\right)$$

$\boxed{\therefore \vec{E}' \text{ changes by } \frac{1}{3}\vec{E}}$

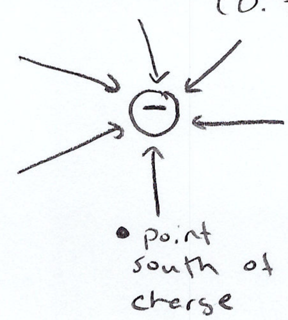
2. Determine the electric field strength 0.700m south of a -8.50μC charge object.

$\vec{E} = ?$

$r = 0.700\,m$

$q = 8.50\times10^{-6}\,C$

$$\vec{E} = \frac{kq}{r^2} = \frac{(8.99\times10^{9})(8.50\times10^{-6}\,C)}{(0.700\,m)^2} = 155948.9\ldots\ N/C$$



$\boxed{\vec{E} = 1.56\times10^{5}\,N/C,\ \text{north}}$

3. A +5.00μC charged object is placed in an electric field of 2.20×10^4N/C to the east. Determine the electric force acting on the charge.

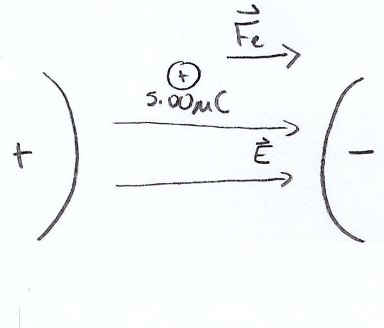
$q = 5.00\times10^{-6}\,C$

$\vec{E} = 2.20\times10^{4}\,N/C$

$\vec{F}_e = ?$

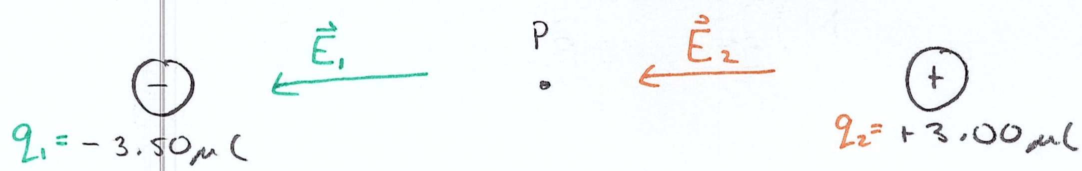
$$\vec{E} = \frac{\vec{F}_e}{q} \Rightarrow \vec{F}_e = \vec{E}q = (2.20\times10^{4}\,N/C)(5.00\times10^{-6}\,C)$$

$\vec{F}_e = 0.11\,N$



$\boxed{\vec{F}_e = 0.11\,N,\ \text{east}}$

4. What is the electric field strength midway between charged objects of -3.50 μC and 3.00 μC that are placed 0.440m apart?



$$\vec{E}_1 = \frac{kq}{r^2} = \frac{(8.99\times10^9)(3.50\times10^{-6}c)}{(0.220m)^2} = -6.50103\ldots\times10^5 N/c$$

$$\vec{E}_2 = \frac{kq}{r^2} = \frac{(8.99\times10^9)(3.00\times10^{-6}C)}{(0.220m)^2} = -5.5723\ldots\times10^5 N/c$$

$$\vec{E}_{net} = \vec{E}_1 + \vec{E}_2 = (-6.50103\ldots\times10^5 N/c) + (-5.5723\ldots\times10^5 N/c)$$

$$\vec{E}_{net} = -1.20733\ldots\times10^6 N/c$$

$$\boxed{\vec{E}_{net} = 1.21\times10^6 N/c,\ \text{left}}$$

*****Now try pg. 98 #, 1, 3-5, 8-11, 13-16*****