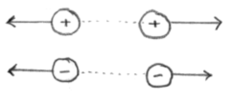
Physical Sciences 3
Lectures 1 and 2 – February 6, 2008 – Coulomb's Law and Electric Fields
Reading for Understanding: Chapter 21

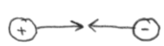
ELECTRIC CHARGE

- There are two types of electric charge: positive and negative → called elementary charge $e = 1.6 \times 10^{-19}$ C → where C = Coulomb .... leads us to [Coulomb's Law]
  both positive and negative charges have this same magnitude, different sign.
- when two positive & two negative charges come near each other, they REPEL



like charges REPEL

- when a positive & a negative charge come near each other, they ATTRACT



opposite charges attract

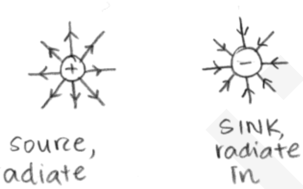
ELECTRIC FIELDS

acts over a distance

$\vec{E} = \frac{\vec{F}}{q}$ where q is a small positive test charge
BUT want to know the $\vec{E}$ without the charge .. so $q \to 0$

∴ $\vec{E}$ cannot depend on q

now write $\vec{E} = \frac{k_c Q}{r^2}$, $\vec{E}$ is also a VECTOR quantity

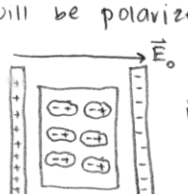


* the field lines between (connecting) a ⊕ and ⊖ is called an electric dipole
* Field lines are more crowded where the field is stronger.

$\vec{E}$ always ⊕ to ⊖

DIELECTRIC MATERIALS

usually are insulating materials that do not have free electrons; therefore if exposed to an external $\vec{E}_0$, the molecules in the material will be polarized.



This means there is an induced $\vec{E}$ in the dielectric, $\vec{E}_d$ in the opposite direction

these molecules respond to field orienting ⊖⊕

$$\therefore \vec{E} = \vec{E}_0 + \vec{E}_d = \frac{\vec{E}_0}{\kappa}$$

where κ is the dielectric constant, usually greater than 1.

COULOMB'S LAW

The force of one small charged object on another is given by:

$$\vec{F} = k_c \frac{Q_1 Q_2}{r^2}$$

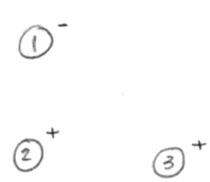
proportionality constant, $k_c = 8.99 \times 10^9$ Nm²/C²
can also write as $k_c = \frac{1}{4\pi\epsilon_0}$ — permittivity of free space
$\epsilon_0 = 8.85 \times 10^{-12}$ C²/Nm²

Notice that $\vec{F}$ is a VECTOR QUANTITY, meaning that it has both magnitude and direction. magnitude is shown by the length of the arrow from the charge.

IF there is more than ONE charge near the charge in question, coulomb's law should be applied to each of these charge-pairs. This is called the

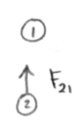
SUPERPOSITION PRINCIPLE

ex.

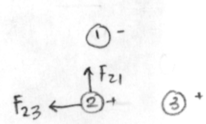


Step 1: draw a diagram
Step 2: determine the charge of each object
Step 3: Say charge 2 is the charge in question. to determine the direction of force on charge 2 due to charge 1, see if these two charges have the same or opposite charge.

They have opposite charge, so charge 2 will be attracted to charge 1



Step 4: repeat for remaining charge-pairs.
Step 5: Sum all the forces using horizontal & vertical components, or triangles.



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