Summary of chapter 22

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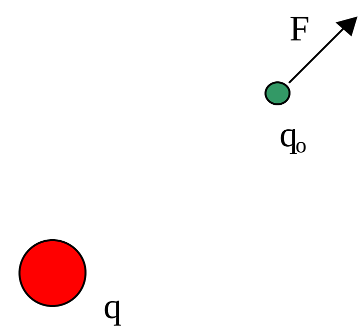
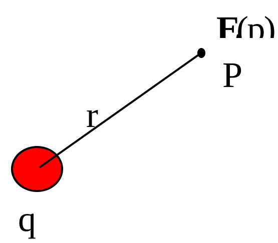
1. The electric field $\vec{E}$ at any point id defined in terms of the electrostatic force on a positive test charge q_o:

$$\vec{E} = \frac{\vec{F}}{q_o}$$



2. The electric field due to a point charge q at a distance r from the charge is given by:



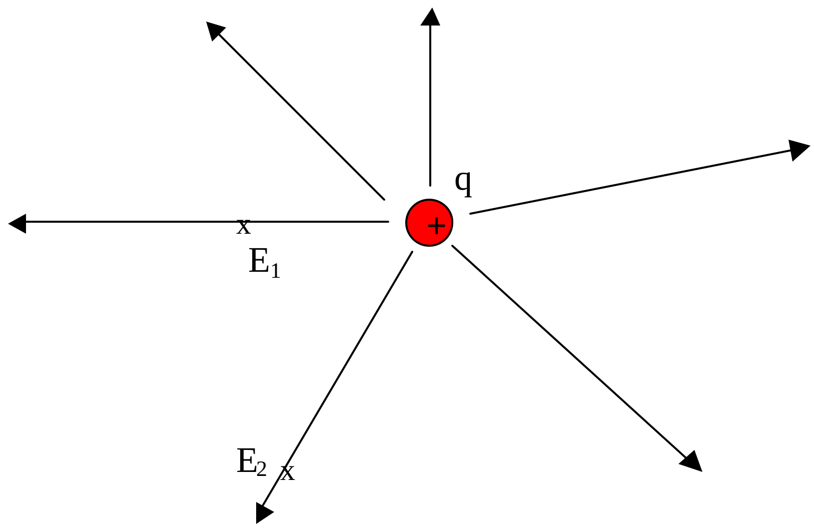
The magnitude of the electric field is given by:

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

where $k = \frac{1}{4\pi\epsilon_o}$ and r is the distance between the charge and the point P where we want to find the magnitude of the electric field.

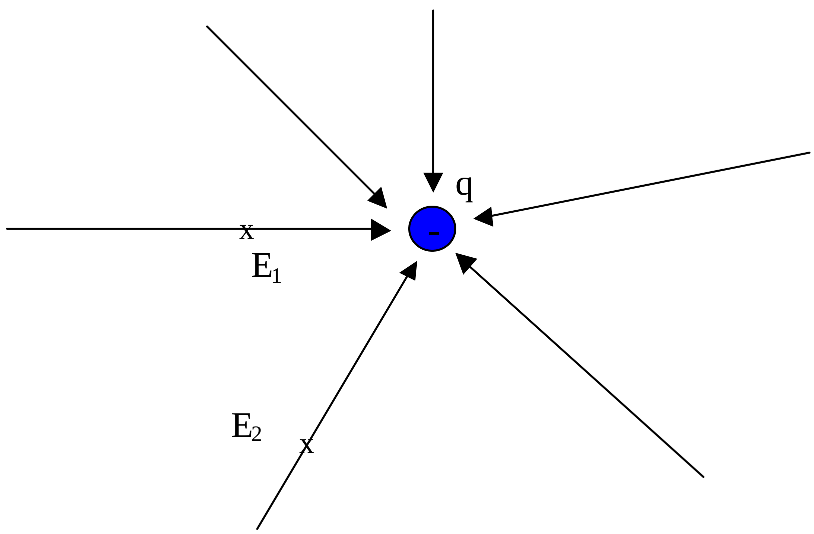
The unit of the electric field is N/C.

- If the charge is **positive,** the electric is directed radially **outward** from the charge.



$E_1 > E_2$

- If the charge is **negative,** the electric field is directed radially inward.



Also $E_1 > E_2$

3. Some measures of the electric charge:

In a one dimensional problem : $q = \lambda L$ where λ is the linear charge density with units of (C/m)

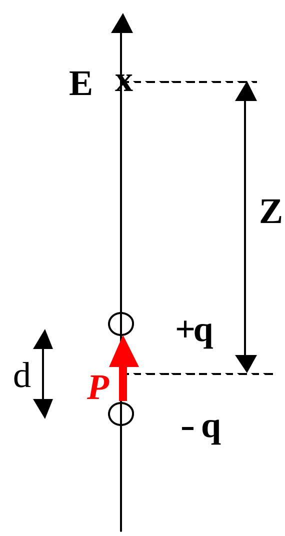
In a two dimensional problem: $q = \sigma A$ where s is the surface charge density with units (C/m^2)

In a three dimensional problem: $q = \rho V$ where ρ is the volume charge density with units (C/m^3)

4. The magnitude of the electric field due to a dipole (a charge +q and a charge –q separated by a distance d) is given by:

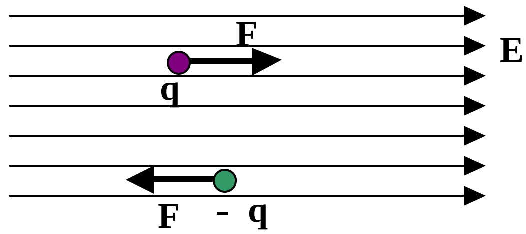
$$E = \frac{1}{2\pi\varepsilon_o}\frac{p}{z^3}$$

z is the distance of the center of the dipole and the point where we want to calculate the electric field and ***p = qd*** is called the **dipole moment**.



5. A point charge q in an external uniform electric field would experience a force F given by

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



- If the charge is **positive**, the direction of the force is the **same** as the direction of the electric field (The charge will move in the direction of the electric field).

- If the charge is negative, the direction of the force is opposite the direction of the electric field (it will move opposite to the direction electric field).

- ***In both cases the charge will move in a straight line.***

The particle of mass m and charge q experiences a **constant acceleration in a uniform electric field**. The acceleration is given by;

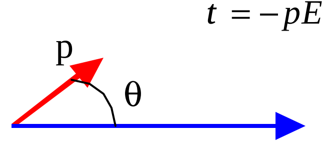
$$\vec{a} = \frac{q\vec{E}}{m}$$

because the electric force $\vec{F} = m\vec{a} = q\vec{E}$ (From Newton's second law).

- If the charge velocity is perpendicular to the electric field lines, then the motion is a parabola.

6. If an ***external electric field*** acts on an electric dipole, such as a water molecule, then a torque is produced. This torque can be evaluated by the relation

$$\tau = -pE\sin\theta$$



E (external electric field)

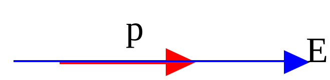
The minus sign is there because of the clockwise rotation of the dipole. **The direction of the torque, using the right hand rule, is inside the paper**. This is also the reason of the minus sign.

- The unit if the torque is **N.m.**
- ***If $\theta = 0$ or 180^o then the torque is zero, the dipole will not rotate.***
- ***If θ is 90^o, the torque is maximum and the dipole will rotate until $\theta = 0$.***

7. The electric dipole ***in an external electric field*** has a potential energy given by

$$U = -\vec{p}\cdot\vec{E} = pE\cos\theta$$

- The unit is **Joule**.
- W can see that $U_{min} = -pE$ when θ = 0



- *and* $U_{max} = pE$ when θ = 180^o