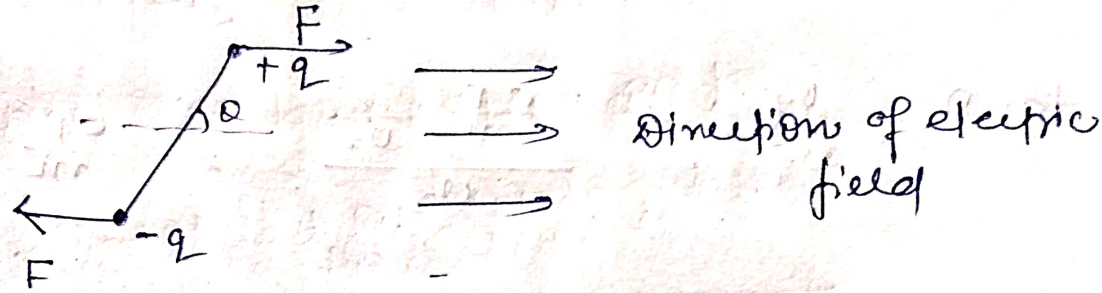
Electric dipole in an electric field:

The body carries equal positive and negative charges $\pm Q$, with the average position of these charges separated by a distance $l$. The body is called an electric dipole.




In above figure electric dipole is placed in electric field. The force on the positive charge is towards the right and an equal amount of force (since magnitude of charge is same) on the negative charge is toward the left, there is a torque on the body.

The torque of each force about the center of the body is $\tau = rF\sin\theta$

where $r = \frac{1}{2}l$

distance of charge from center.

so, $\tau = \frac{1}{2}Fl\sin\theta$

since $F = QE$

So net torque $\tau = \frac{1}{2} QE \sin\theta + \frac{1}{2} QE \sin\theta$

$= -lQE \sin\theta$
↳ Negative for clockwise

The direction of torque is clockwise.

~~QE~~ Ql can be written as p

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

The ~~p~~ quantity p is called as dipole moment of the body.

S.I unit of dipole moment ~~coulombs~~ coulomb - meter (C.m)

In vector notation

$\vec{\tau} = \vec{p} \times \vec{E}$

# If we choose $\theta = 90°$ as a reference position when dipole perpendicular to the field, then work done to rotate the dipole to some other angle $\theta$

$$w = \int_{90°}^{\theta} \tau \, d\theta = -\int_{90°}^{\theta} pE \sin\theta \, d\theta$$

$= +pE \cos\theta$

Potential energy is negative of the work done

$U = -W$

So, $U = -pE \cos\theta$

Note: The direction of the dipole vector is from the negative side of charge toward the positive side of charge.