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B.Sc (Part-II) (Hons)

An Electric Dipole in an Electric field

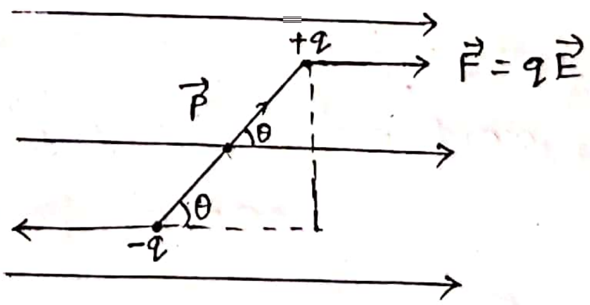
An Electric Dipole Consists of two equal and opposite charges $+q$ and $-q$ Separated by a very Small distance a. Although in electric dipole, the two charges are equal and opposite so as to give a zero net charge. yet they are displaced slightly. It produces a non-vanishing space field.

The electric dipole moment $\vec{p}$ is defined as

$$\vec{p} = q\vec{a}$$

where $\vec{a}$ is displacement from the negative to positive charge.

The electric dipole moment $\vec{p}$ directs along the axis of the dipole pointing from negative to positive charge.



Let an electric dipole is placed in a uniform external electric field $\vec{E}$, making an angle θ with the field. The charge $+q$ experiences a force $q\vec{E}$ in the direction of the field. While the charge $-q$ experiences an equal force in the opposite direction. These two equal and opposite forces parallel to each other form a clockwise couple. It tends to set the dipole in the direction of the electric field.

The torque τ of the couple is given by

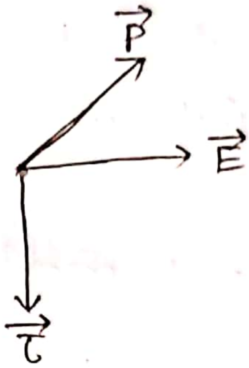
$$\tau = qE(a \sin\theta)$$

$$\tau = qa(E \sin\theta)$$

$$\tau = pE \sin\theta \qquad (\because p = qa)$$

In vector form, the above expression may be written as

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



In this figure shows the direction of the vector. Thus an electric dipole released in an electric field experiences a couple which tends to align the dipole parallel to the field.

When the dipole moment p is parallel to the field $\vec{E}$, it is in stable equilibrium. It is so because as soon as it is displaced through an angle θ. torque $pE \sin\theta$ brings it back parallel to the field.

When $\vec{P}$ and $\vec{E}$ are in opposite direction ($\theta = 180°$). The Torque on it is zero and the dipole is equilibrium. But the equilibrium is unstable because any displacement from this position gives a torque which sets it along the field.