

ELECTROSTATIC POTENTIAL ENERGY

**ELECTROSTATIC POTENTIAL ENERGY OF A DIPOLE IN A UNIFORM
ELECTRIC FIELD, SPECIAL CASES AND PROBLEMS**

- You know that if the dipole is placed in a uniform electric field it will experience a torque
- Assume we are going to rotate the dipole against the torque
- What must be done?

- An equal and opposite external torque must be applied
- For the above work must be done.

$$W = \int_{\theta}^{\theta'} \tau_{ex} d\theta$$

$\tau_{ex} = \tau_E$ (in magnitude and opposite in direction) $= |\vec{p} \times \vec{E}|$

$$W = \int_{\theta}^{\theta'} pE \sin \theta d\theta$$

$$W = pE(\cos\theta' - \cos\theta)$$

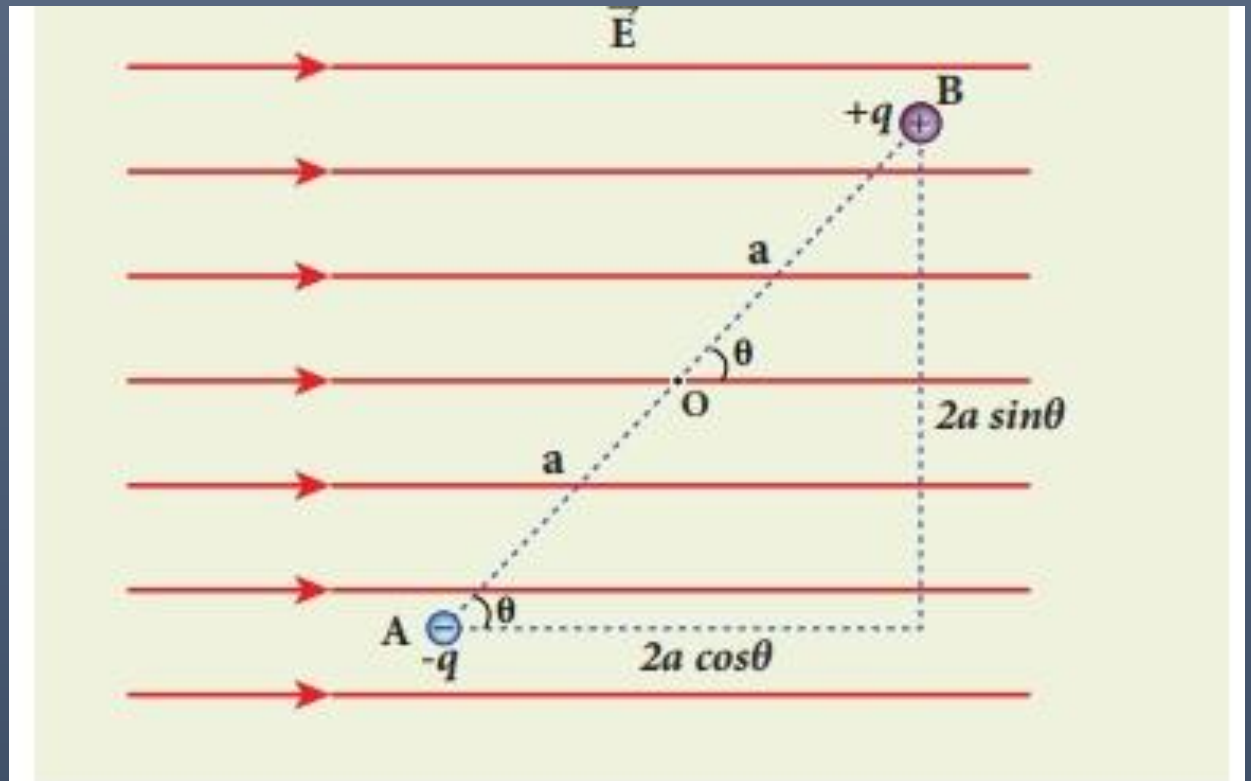


Figure 1.31 The dipole in a uniform electric field

- The above work done is equal to the potential energy.
- If the initial angle $\theta' = 90^\circ$ then the initial energy
 - $pE \cos 90^\circ = 0$
 - The potential energy of the system is
 - $U = -pE \cos\theta$
 - You can write the above as vector dot product
 - $U = -\vec{p} \cdot \vec{E}$ (ie, $-pE \cos\theta$)
- U is the electrostatic potential energy of the dipole

•Special cases:

❖If the dipole is aligned parallel to the electric field

$$\theta = 0, U = -pE \cos \theta$$

the potential energy is minimum $= -pE$ (since $\cos 0 = 1$)

❖If the dipole is aligned anti parallel to the electric field

$$\theta = 180, U = -pE \cos \theta$$

The potential energy is maximum $= pE$ (since $\cos 180 = -1$)

Problems:

1. A sample of HCl gas is placed in a uniform electric field of magnitude $3 \times 10^4 \text{ NC}^{-1}$. The dipole moment of each HCl molecule is $3.4 \times 10^{-30} \text{ C m}$. calculate the maximum torque experienced by each HCl molecule.

2. An electric dipole of moment p is placed normal to the electric field E , find the work done in deflecting it through an angle 180° . (hint: use the potential energy formula)