- Electric dipole moment: $\vec{p} = q\vec{L}$

- Torque exerted by electric field: $\vec{\tau} = \vec{p} \times \vec{E}$

- Potential energy: $U = -\vec{p} \cdot \vec{E}$

$$U(\theta) = -\int_{\pi/2}^{\theta} \tau(\theta)d\theta = pE \int_{\pi/2}^{\theta} \sin\theta d\theta = -pE\cos\theta$$

Note: $\tau(\theta)$ and $d\theta$ have opposite sign.