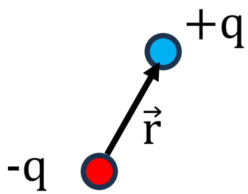
Dipoles

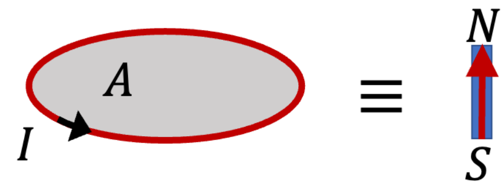
Electric dipole



- charges + q and – q shifted by vector $\vec{r}$
- Electric dipole moment : $\vec{d} = q\vec{r}$
- Energy in the electric field:

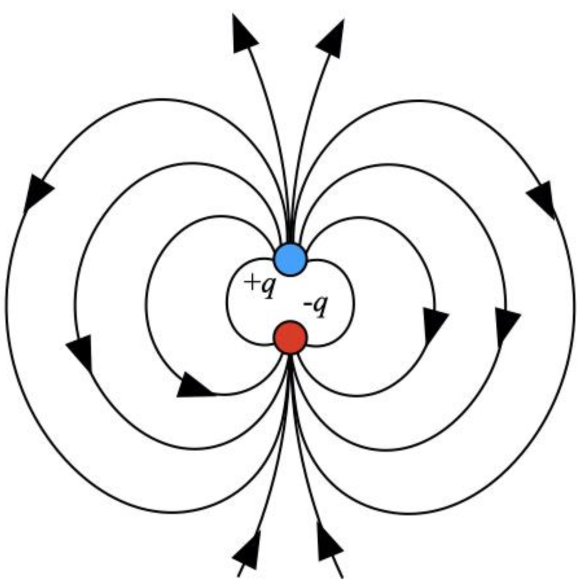
$$U = -\vec{d} \cdot \vec{E} = -dE \cos\theta$$

Magnetic dipole

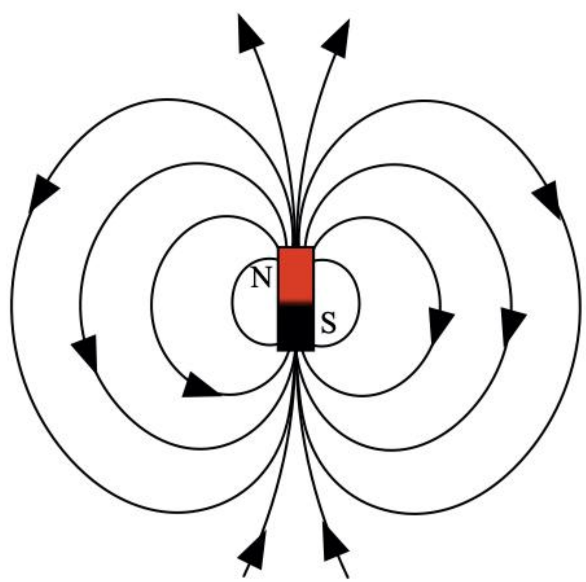


- Current I circulating in a looped wire
- Magnetic moment : $m = IA$
  (A is area inside the loop)
- Energy in the magnetic field:

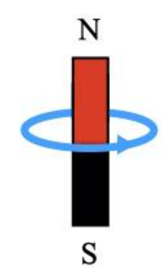
$$U = -\vec{m} \cdot \vec{B} = -mB \cos\theta$$



Electric dipole and electric field



Magnetic dipole and magnetic field



A current loop acts like a small bar magnet

Homework

In a water molecule, the electrons are not shared equally. The electron cloud is pulled a little closer to the oxygen atom than to the hydrogen atoms. To make a simple estimate, assume that one electron is shifted toward the oxygen by a distance of **0.1 Å**.

(a) Estimate the dipole moment of the water molecule.
What are the SI units of dipole moment?

(b) Now place the water molecule in a uniform electric field of strength

$$E = 1000\ V/m.$$

What is the **minimum possible potential energy** of the molecule in this field?
(Remember: the energy can be negative.)

(c) Express your answer in **electron-volts (eV)**.
1 eV is the energy gained by an electron moving through a potential difference of **1 volt**. For this problem, ignore the sign when converting to eV.
You may use:

$$1\text{Å} = 10^{-10}\ m, \qquad e = 1.6 \times 10^{-19}\ C.$$