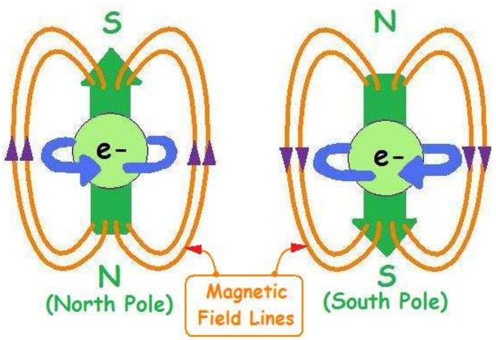
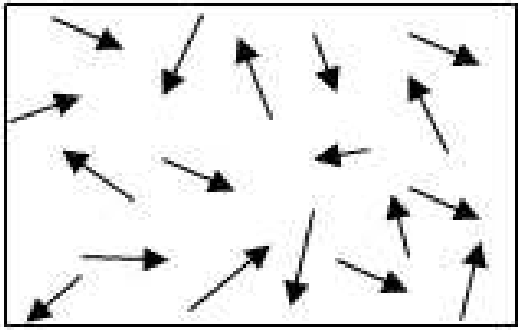
Magnetism

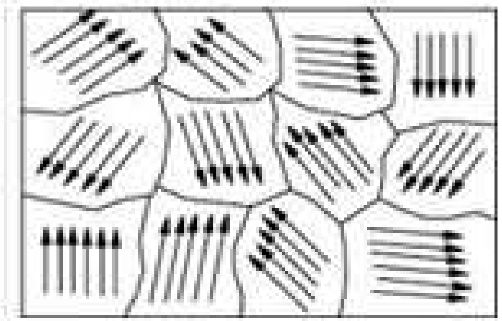
Magnetism: are any physical phenomena that are mediated/effected by **magnetic field.** The **magnetic field** is a region in space near a magnet or electric current within which a **magnetic material** will experiences a force. The magnetic property in a material is caused by the movement of electrons. Electron are revolving around the nucleus while spinning at the same time. The spinning effect is what is responsible for magnetic property.



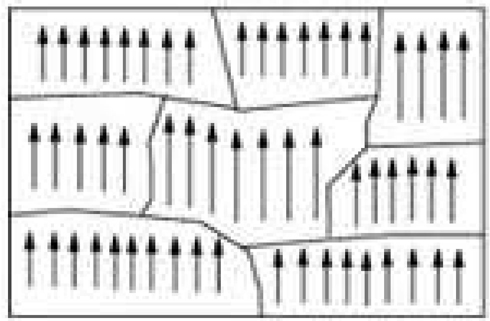
Spinning electrons generate tiny magnetic field. A region within a magnetic material consisting of a group of atoms whose magnetic fields are aligned is called a **magnetic domain.** When there is no external magnetic field present, the domains are randomly oriented. However, when an external magnetic field is present, the domains will rotate and align with the external magnetic field. When domains are aligned with the field, the magnetic material is then converted into a magnet.



Non-Magnetic Material
No domains

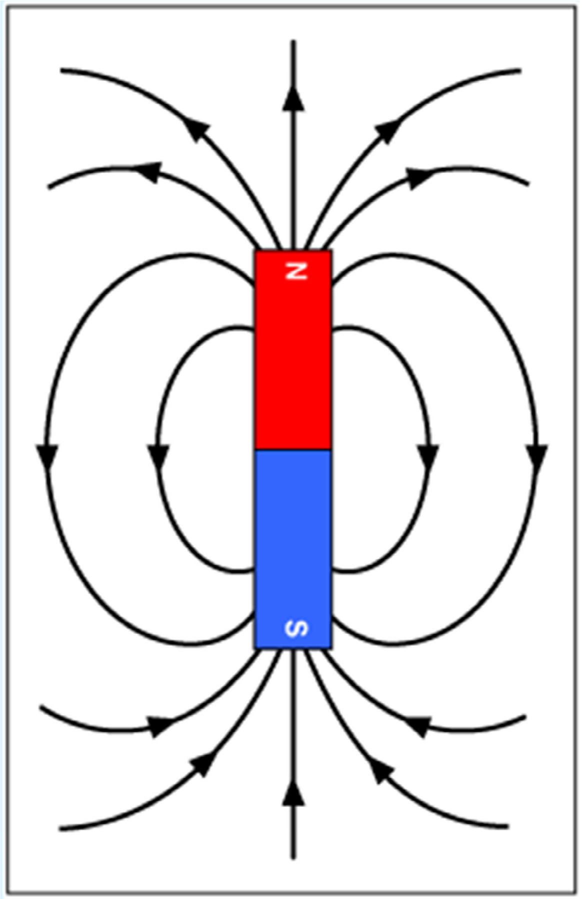


Magnetic Material
Domains, but not lined up



Magnet
Domains and lined up

Magnetic poles



Two ends of the magnet are termed North and South pole.

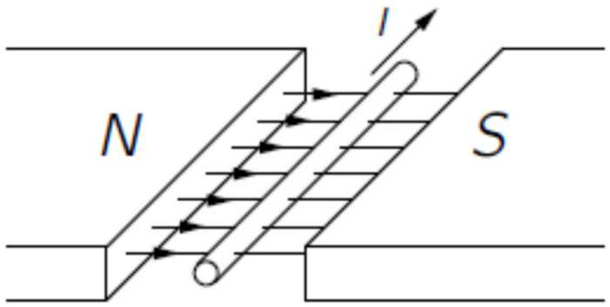
Like poles repel and unlike pole attract

Single isolated poles are physically not possible

Represent magnetic field using field lines. Field lines point away from a north pole and towards a south pole. It is strongest when the lines are close together.

We shall use a symbol **B** to denote magnetic field. **B is a vector.**

Force on a current-carrying wire

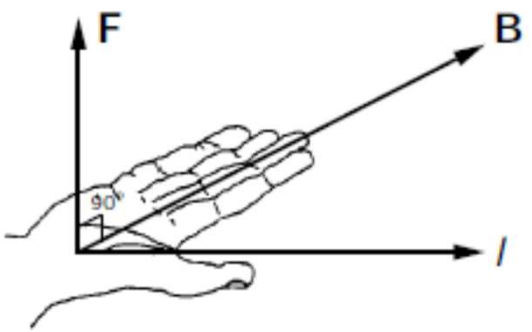


Experiment shows that a current I in a straight wire of length ℓ perpendicular to a magnetic field experiences a force F that is directly proportional to both **B** and ℓ. So

$$F \propto I\ell \; or$$
$$F = BI\ell sin\theta.$$

where θ is an angle between the wire and **B**. The units of B are $NA^{-1}\,m^{-1}$ and SI unit is tesla (T) where $1T = NA^{-1}\,m^{-1}$.

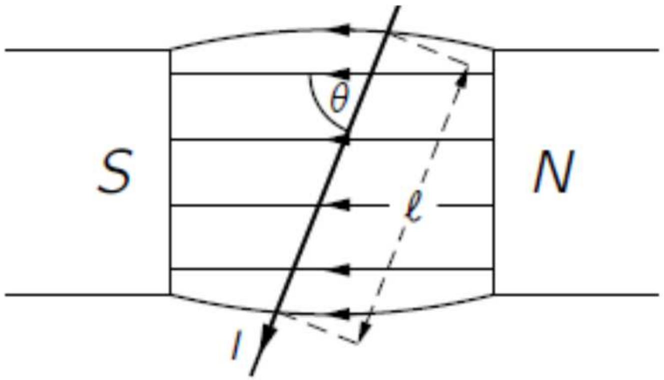
We find the direction of the force using a **right hand rule**



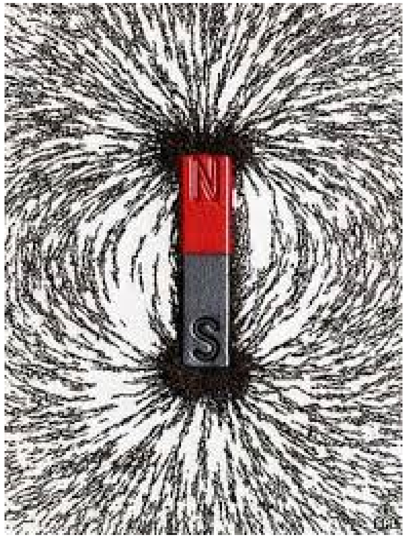
Example

Example 3.1: Wire carrying current in a uniform magnetic field

A wire carrying 30 A has a length $\ell = 12$ cm between the faces of a magnet at an angle $\theta = 60^{o}$ as shown. The field is approximately uniform at 0.90 T. Calculate the force on the length ℓ of the wire.



Magnetic field of a straight wire

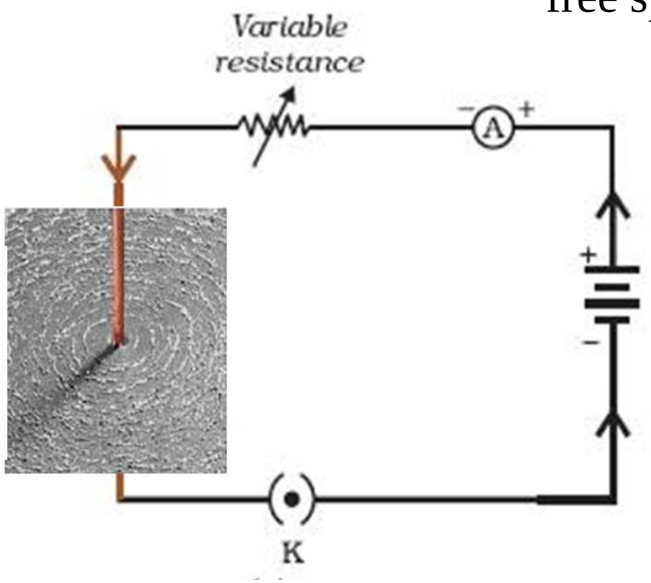


Consider a long straight wire carrying a current I. Experiments show that B at a distance r from the wire is directly proportional to I and inversely proportional to r, that is

$$B \propto \frac{I}{r}$$

$$B = k\frac{I}{r}$$

where $k = \frac{\mu_o}{2\pi} = 2 \times 10^{-7} TmA^{-1}$. The constant μ_o is known as the permeability of free space.



To find the direction of the magnetic field we use **Right-hand rule No. 2**

Example

70. Calculate the magnitude and the direction of the magnetic field **B,** 32 cm from a long, straight wire carrying 8.0 A in an upward direction.

71. How much current does a wire carry if B = 0.03T at a point 12 cm from it?