

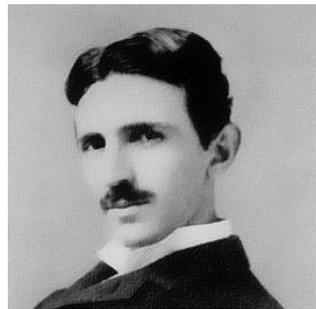
Homework 16

Magnetic force

As we remember the magnetic field applies the force to moving charges. As a charge particle which is moving perpendicularly to the magnetic field vector B at a velocity V , the magnitude of the magnetic force applied to the particle is

$$F_m = q \cdot V_{\perp} \cdot B \quad (1)$$

where q is the charge of the particle, V_{\perp} is the particle's velocity, B is the parameter which is characterized the "strength" of the magnetic field. It is called magnetic induction. Magnetic induction is measured in teslas (international system of units). If the force applied to a charged particle with 1C of charge which is moving in a magnetic field at a velocity of 1m/s is 1N, then the magnetic induction is 1T (tesla). This unit is named after a famous Serbian inventor and physicist Nicola Tesla.



Tesla Nikola Tesla (1856-1943)

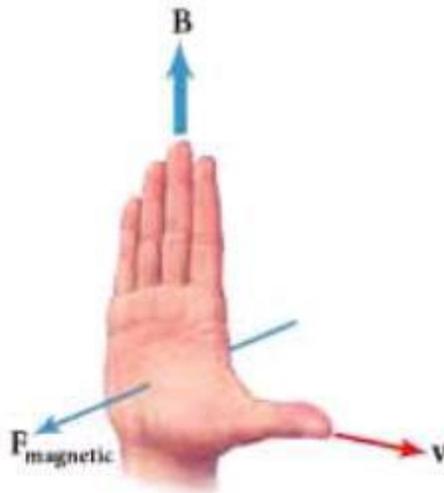
Important! Expression (1) is correct only if the velocity of the charged particle is perpendicular to the magnetic field. If the particle is moving along the direction of the magnetic field, then the particle "does not feel" the magnetic field. So " V_{\perp} " in the formula (1) represent the part of the particle velocity which is perpendicular to the magnetic field.

Magnetic force, described by formula 1, is also called Lorentz force. This name is given after a Dutch physicist Hendrik Antoon Lorentz..



Hendrik Antoon Lorentz (1853-1928)

Magnetic force is directed *perpendicularly* to both the magnetic field and the velocity of the particle. The direction of the force can be found using “right hand rule”.



Please remember that the picture above is for a positive charge. For a negative charge the direction of the force will be opposite.

Since the magnetic force is perpendicular to the particle velocity, the trajectory of a charge particle moving perpendicular to the magnetic field is a circle with a radius R :

$$R = \frac{V_{\perp} \cdot m}{q \cdot B} \quad (2)$$

Here V_{\perp} is the part of the particle’s velocity, perpendicular to the magnetic field, m is the particle mass, q is the particle charge and B is the magnetic field strength.

Problems:

1. An electron enters the area with magnetic field; the velocity of the electron is perpendicular to the magnetic field lines. Do the speed and the velocity of the electron change as it enters into the magnetic field?
2. The wire made from nonmagnetic material can be attracted to or repelled from the magnet as there is electrical current in the wire. Could you explain the effect?
3. A proton of mass $1.67 \cdot 10^{-27} \text{ kg}$ with positive charge of $1.6 \cdot 10^{-19} \text{ C}$ enters the 0.1 m thick area with uniform magnetic field of 1 T directed “to us” perpendicular to the plane of the picture. How fast the proton has to move to be “reflected back” from the layer?

