Homework 17

Magnetism

We started discussing magnetism. Even long time ago people knew the property of some natural magnetic materials. In our everyday life natural and artificial magnets have numerous applications. What are the basic properties of a magnet we can learn from simplest experiments with two magnetic bars?

a) We can check that the ends of a magnetic bar (we will call them ***poles***) have different properties: when you try to get two poles belonging to different bars together you will feel that some poles are attract each other while another pole combination produce repelling force. We can mark them by the characters "N"(north) and "S"(south) in such a way that the attracting poles will be marked by different characters while repelling poles will bear same mark.

b) Magnetic bars can attract some materials (for example, iron) which are not magnets.
c) If you cut the bar in the middle you will not obtain two separate poles. Instead, you will have two magnets with both north and south poles.

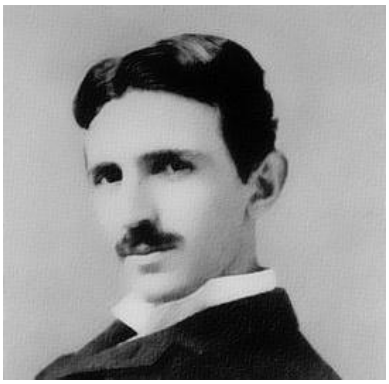
If electrical current flows in the wire, the wire is "magnetic" – it can be attracted or repelled by a magnet. Based on this experimental fact we can make an assumption that the "***magnetic force" is produced by moving charges.*** We can introduce magnetic field similarly to how we introduced electric field. As long as in a certain point of space there is a force exerted on a charge moving with respect to the "test magnet" we can say that there is magnetic field in this point.
Later we will learn that both electric and magnetic fields are the two sides of one phenomenon.

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

$$F_m=qVB \quad (1)$$

where q is the charge of the particle, V 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.

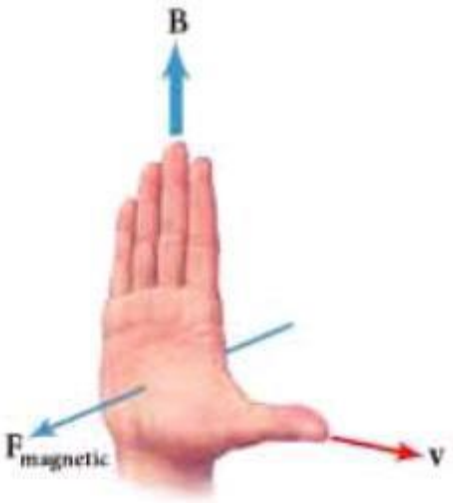


Tesla Nikola Tesla (1856-1943)

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.

Questions:

1. Does every magnet necessarily have a north and south pole?

2. Suggest a way to make magnetic field "visible"

3. If you bring a magnet close to the screen of old electron beam monitor or TV you will see that the picture on the screen is distorted. Try to explain the effect.

4. 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?

5. 2.The wire made from nonmagnetic material can be attracted to or repelled from the magnet as there is the electrical current in the wire. Could you explain the effect?

6. 3. Give an example of a physical situation where the force exerted on the object is perpendicular to the object's displacement.