

Lorentz force

Lorentz force

Lorentz force \mathbf{F}_L is the force produced by action magnetic and electrostatic forces on a **charged** particle. Usually only the magnetic force acting on a moving charged particle v is referred to as the Lorentz force magnetic field.

Hendrik Antoon Lorentz

(18. července 1853 v Arnhemu – 4. února 1928 v Haarlemu)

Hendrik Antoon Lorentz was a Dutch physicist and winner of the *Nobel Prize* for physics in 1902. He won this prize with Pieter Zeeman for research into the effect of magnetism on radiation. At the age of 22, he defended his dissertation at the University of Leiden. The work was such a success that the university established a new department of theoretical physics for him. During his life, Hendrik Antoon Lorentz was involved in various fields of physics, such as mechanics, thermodynamics and research lights. His most important contributions are in the fields of electron theory, relativity theory and electromagnetism.

A charged particle in a magnetic field

Both positively and negatively charged particles moving in a magnetic field, which occur separately or in a **conductor**, are affected by this magnetic field. The magnetic field acts on them with a magnetic force, the magnitude of this force is given by the relation:

$$F_m = Bqv \sin \alpha$$

where:

- B is the magnitude of the magnetic induction (tesla unit T)
- q is the magnitude of the charge (unit coulomb C)

for electrons, the elementary charge of the electron is used $e = -1,602 \cdot 10^{-19} \text{ C}$

- v is the velocity of the particle (unit m/s)
- $\sin \alpha$ is the angle that the direction of motion of the particle makes with the magnetic induction lines

Practically, the action of the magnetic force can be represented by using a current-carrying conductor and a horseshoe magnet or in a so-called Wehnelt tube.

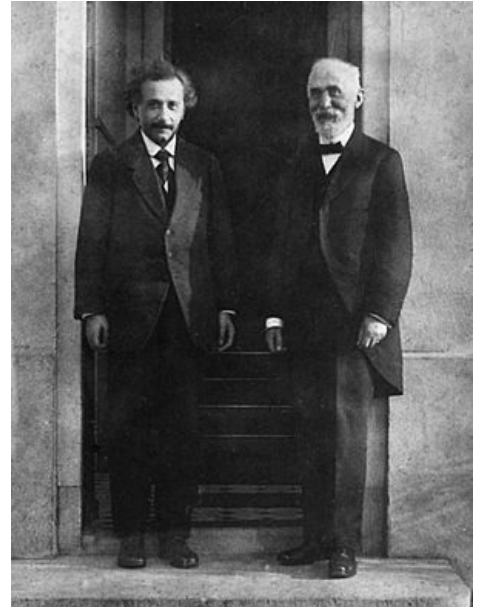
Vector notation

The vector notation for the magnetic force is:

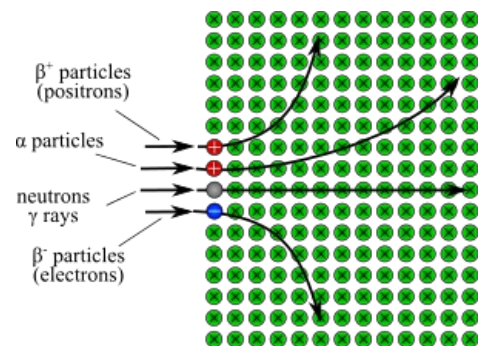
$$\mathbf{F}_m = q\mathbf{v} \times \mathbf{B}$$

The direction of the magnetic force, as derived from the vector product, is perpendicular to both the direction of motion and the direction of magnetic induction. The direction can be determined using **Fleming's Left Hand Rule** which reads:

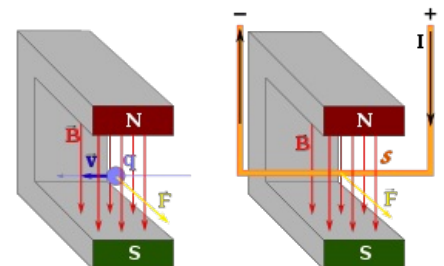
If we place the open left hand to the direct conductor like this, so that the fingers show the (agreed) direction of the current and the induction lines enter the palm, shows the withdrawn thumb the direction of the force exerted by the magnetic field on the current-carrying conductor.



Einstein and Lorentz



Trajectories of positively, negatively and neutrally charged particles in a homogeneous magnetic field



The effect of a horseshoe magnet on a particle and on a current-carrying conductor

Attention, it is necessary to remember the fact that electrons move against the direction of the current.

Calculation of the Lorentz force

If not only the magnetic but also the electrostatic force acts on the particle, the Lorentz force is calculated from the relation:

$$\mathbf{F}_L = q\mathbf{E} + q\mathbf{v} \times \mathbf{B}$$

where:

- \mathbf{E} is the electric field strength

The vector notation of the formula is:

$$\mathbf{F}_L = q\mathbf{E} + q\mathbf{v} \times \mathbf{B}$$

Usage

In practice, this phenomenon is widely used, e.g.:

- measurement in a fog chamber
- cathode ray tube (CRT) screens)
- Hall Effect and Hall Probe

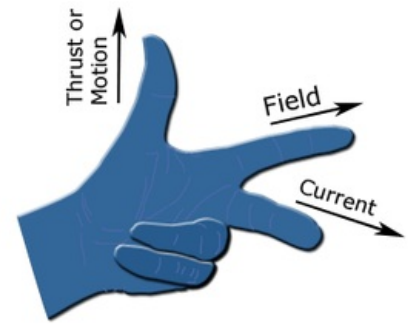
Links

External links

- Mlžná komora (<http://fyzika.jreichl.com/main.article/view/847-wilsonova-mlzna-komora>)
- Hallův jev (<http://fyzika.jreichl.com/main.article/view/294-halluv-jev>)
- Experiment s podkovovitým magnetem (http://www.walter-fendt.de/ph14cz/lorentzforce_cz.htm)
- Wehneltova trubice (<http://82.114.195.35:90/Vyuka/%C5%BDelezn%C3%BD%20Pavel/Fyzika/3Rocnik/Elektrina%20a%20magnetismus/14-Stacionarni%20magneticke%20pole/08-Wehneltova%20trubice.pdf%20http://82.114.195.35:90/Vyuka/%C5%BDelezn%08-Wehneltova%20trubice.pdf>)

Resources

- LEPIL, O. a ŠEDIVÝ, P. Fyzika pro gymnázia - Elektřina a magnetismus. 5. vydání. Praha : Prometheus, 2008. ISBN 978-80-7196-202-1.
- SVOBODA, E. Přehled stredoškolské fyziky. 4. upravené. Praha : Prometheus, 2006. ISBN 80-7196-307-0
- REICHL, J.. Encyklopedie fyziky [online]. [cit. 2013-11-29]. <http://fyzika.jreichl.com/main.article/view/293-castice-s-nabojem-v-magnetickem-poli>



Fleming's Left Hand Rule