Wrocław University of Science and Technology

Physics

JZL1001913C

summer semester

2020/2021

Wednesday, 18:20 - 19:50

Friday, 18:20 - 19:50

virtual room (ZOOM)

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https://majsylw.netlify.app/

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Electric current

- short rewiev

Electric current $I = \frac{Q}{t}$	Unit 1 A/s = 1 A = 1 Ampere
Resistance $R = U/I$	Unit 1V/A = 1 Ohm = 1Ω
Resistivity $\rho = RA/l$	Unit 1Ωm²/m = 1 Ohm * m = 1Ωm
Electric power $P = UI$	Unit 1V*A = 1 Watt = 1 W

Quantities:

- Electric current
- Resistance
- Resistivity
- Electric power
- AC and DC

Ohm's law

$$\boldsymbol{R = \frac{U}{I}}$$

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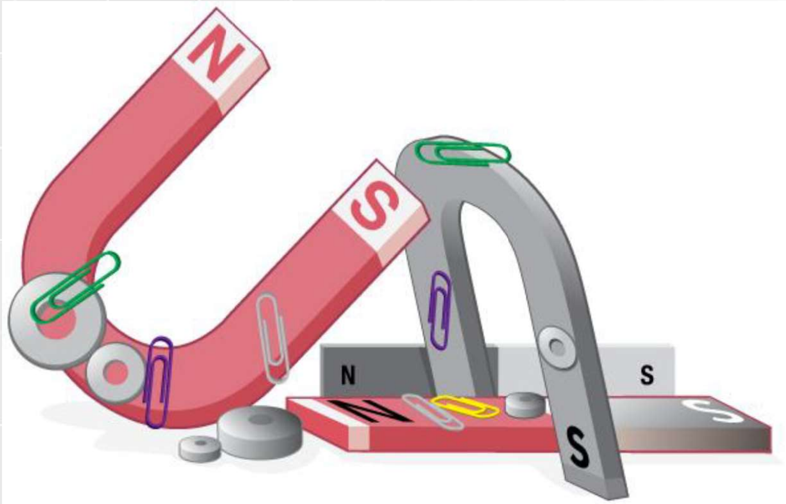
Magnetism

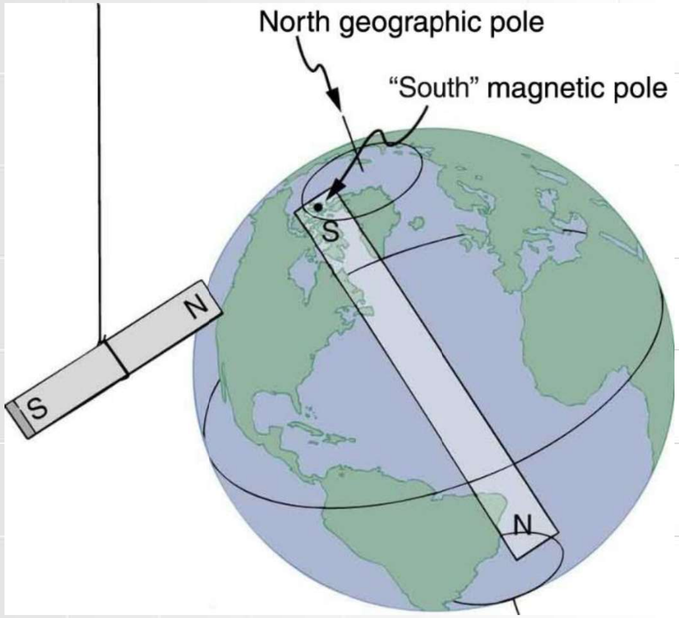
All magnets attract iron, such as that in a refrigerator door. However, magnets may attract or repel other magnets. Experimentation shows that all magnets have two poles. If freely suspended, one pole will point toward the north. The two poles are thus named the north magnetic pole and the south magnetic pole (or more properly, north-seeking and south-seeking poles, for the attractions in those directions).

Magnets come in various shapes, sizes, and strengths. All have both a north pole and a south pole. **There is never an isolated pole (a monopole).**



Earth magnetic poles

It is a universal characteristic of all magnets that *like poles repel and unlike poles attract*. (Note the similarity with electrostatics: unlike charges attract and like charges repel.) Further experimentation shows that it is *impossible to separate north and south poles* in the manner that + and − charges can be separated.



Earth acts like a very large bar magnet with its south-seeking pole near the geographic North Pole. That is why the north pole of your compass is attracted toward the geographic north pole of Earth—because the magnetic pole that is near the geographic North Pole is actually a south magnetic pole! Confusion arises because the geographic term "North Pole" has come to be used (incorrectly) for the magnetic pole that is near the North Pole. Thus, "north magnetic pole" is actually a misnomer—it should be called the south magnetic pole.

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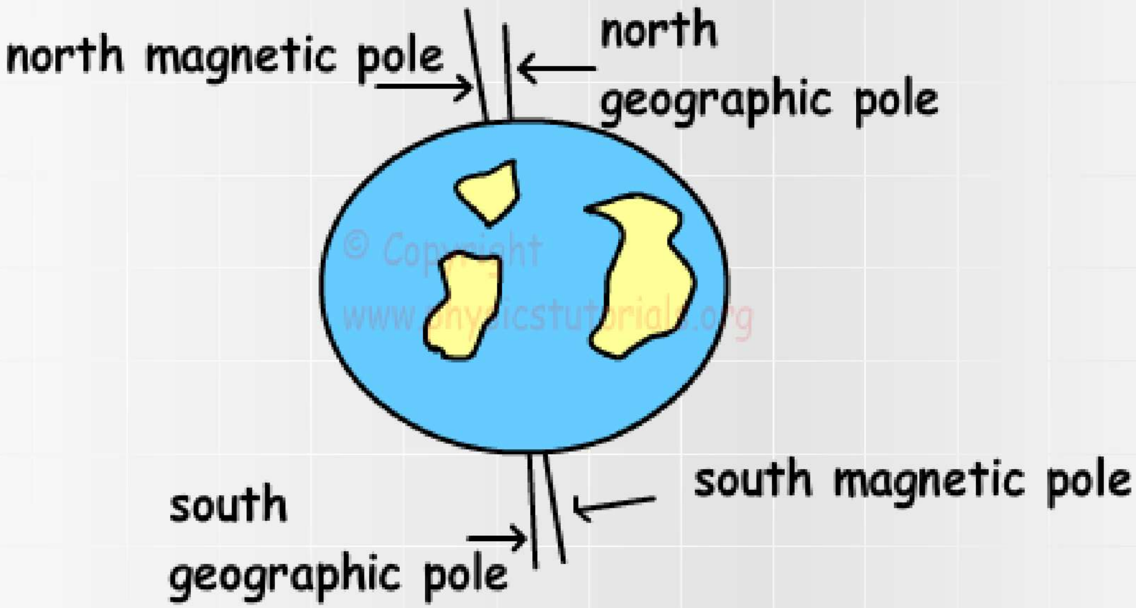
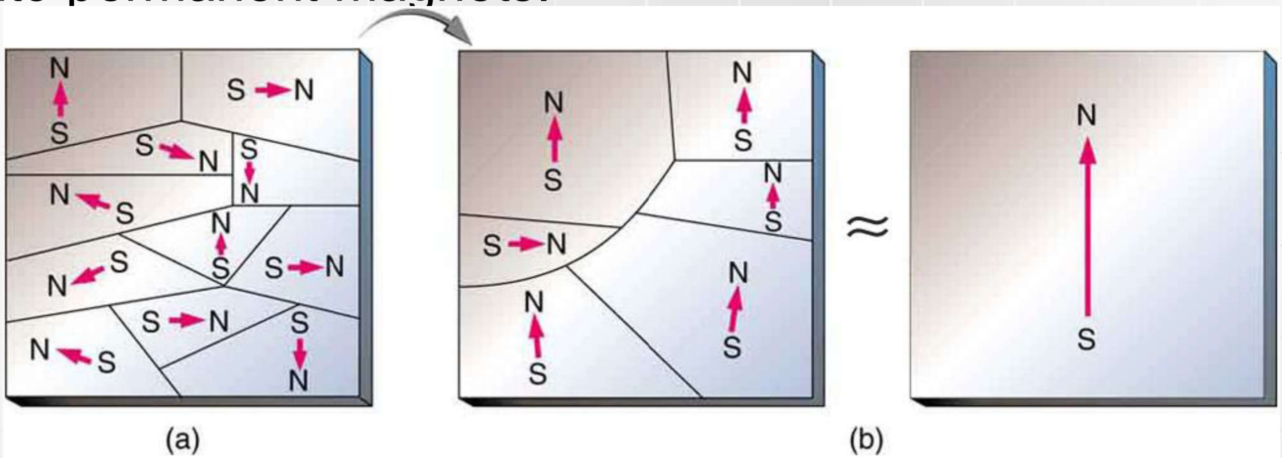
Earth magnetic poles



The geographic poles and magnetic poles do not coincide actually. There is a 11^o angle between the geographic poles and magnetic poles. We call magnetic declination this deviation. Picture given above shows the geographic poles and magnetic poles of earth.

Ferromagnets

Only certain materials, such as iron, cobalt, nickel, and gadolinium, exhibit strong magnetic effects. Such materials are called **ferromagnetic**, after the Latin word for iron, *ferrum*. A group of materials made from the alloys of the rare earth elements are also used as strong and permanent magnets; a popular one is neodymium. Other materials exhibit weak magnetic effects, which are detectable only with sensitive instruments. Not only do ferromagnetic materials respond strongly to magnets (the way iron is attracted to magnets), they can also be **magnetized** themselves—that is, they can be induced to be magnetic or made into permanent magnets.



(a) An unmagnetized piece of iron (or other ferromagnetic material) has randomly oriented domains. (b) When magnetized by an external field, the domains show greater alignment, and some grow at the expense of others. Individual atoms are aligned within domains; each atom acts like a tiny bar magnet.

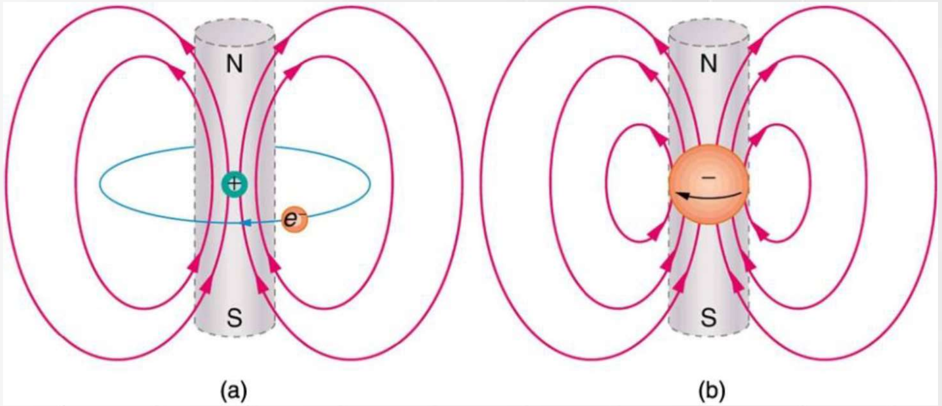
Electromagnets

Early in the 19th century, it was discovered that electrical currents cause magnetic effects. The first significant observation was by the Danish scientist Hans Christian Oersted (1777–1851), who found that a compass needle was deflected by a current-carrying wire. This was the first significant evidence that the movement of charges had any connection with magnets. **Electromagnetism** is the use of electric current to make magnets. These temporarily induced magnets are called **electromagnets**. Electromagnets are employed for everything from a wrecking yard crane that lifts scrapped cars to controlling the beam of a 90-km-circumference particle accelerator to the magnets in medical imaging machines

Instrument for magnetic resonance imaging (MRI). The device uses a superconducting cylindrical coil for the main magnetic field. The patient goes into this “tunnel” on the gurney.

The Source of All Magnetism

An electromagnet creates magnetism with an electric current. In later sections we explore this more quantitatively, finding the strength and direction of magnetic fields created by various currents. But what about ferromagnets? Figure shows models of how electric currents create magnetism at the submicroscopic level. Crucial to the statement that electric current is the source of all magnetism is the fact that it is impossible to separate north and south magnetic poles. (This is far different from the case of positive and negative charges, which are easily separated.) A current loop always produces a magnetic dipole—that is, a magnetic field that acts like a north pole and south pole pair.



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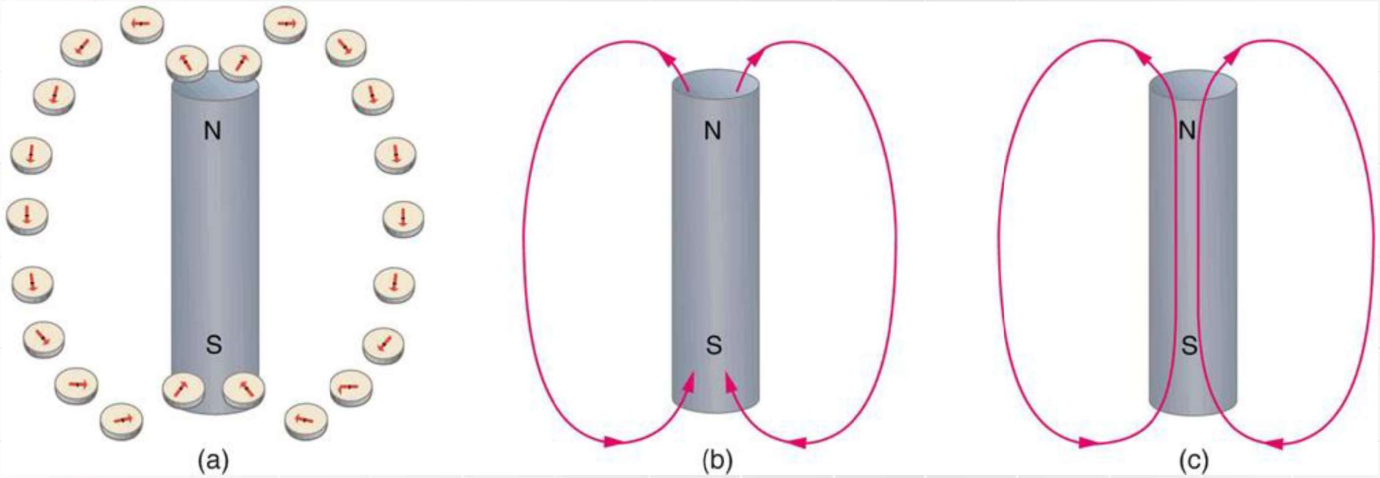
Magnetic field



Magnetic field lines are defined to have the direction that a small compass points when placed at a location. (a) If small compasses are used to map the magnetic field around a bar magnet, they will point in the directions shown: away from the north pole of the magnet, toward the south pole of the magnet. (Recall that the Earth's north magnetic pole is really a south pole in terms of definitions of poles on a bar magnet.) (b) Connecting the arrows gives continuous magnetic field lines. The strength of the field is proportional to the closeness (or density) of the lines. (c) If the interior of the magnet could be probed, the field lines would be found to form continuous closed loops.

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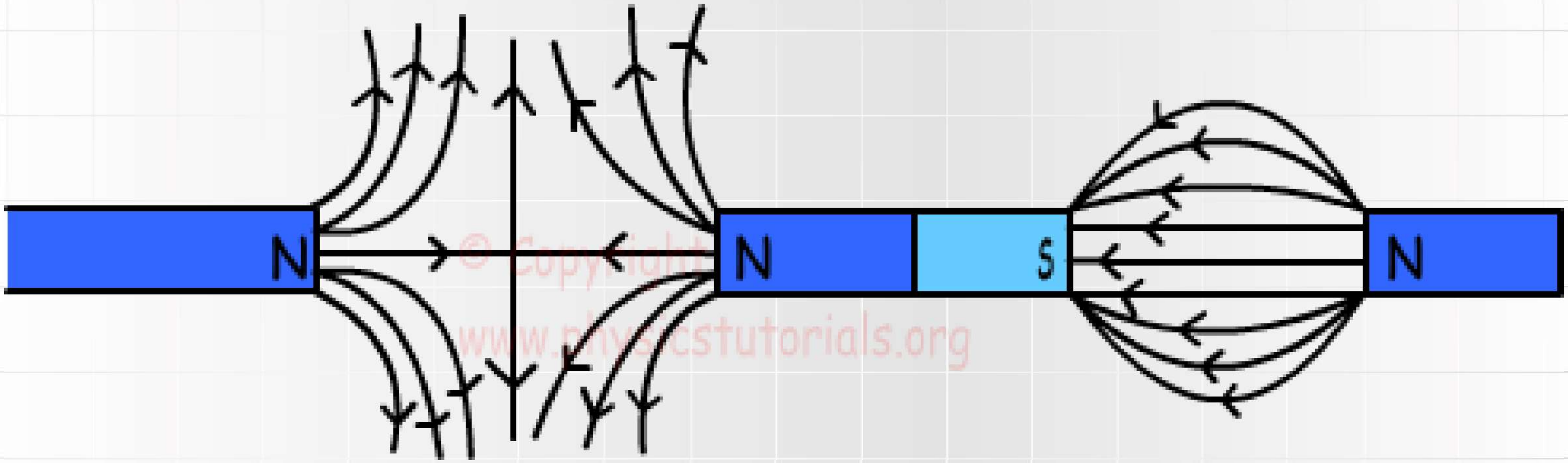
Magnetic field lines



When the lines get closer to each other, this means that magnetic field is strong in that region.

Magnetic field lines:

- Never intersect,
- If they are parallel we say that there is a regular magnetic field.

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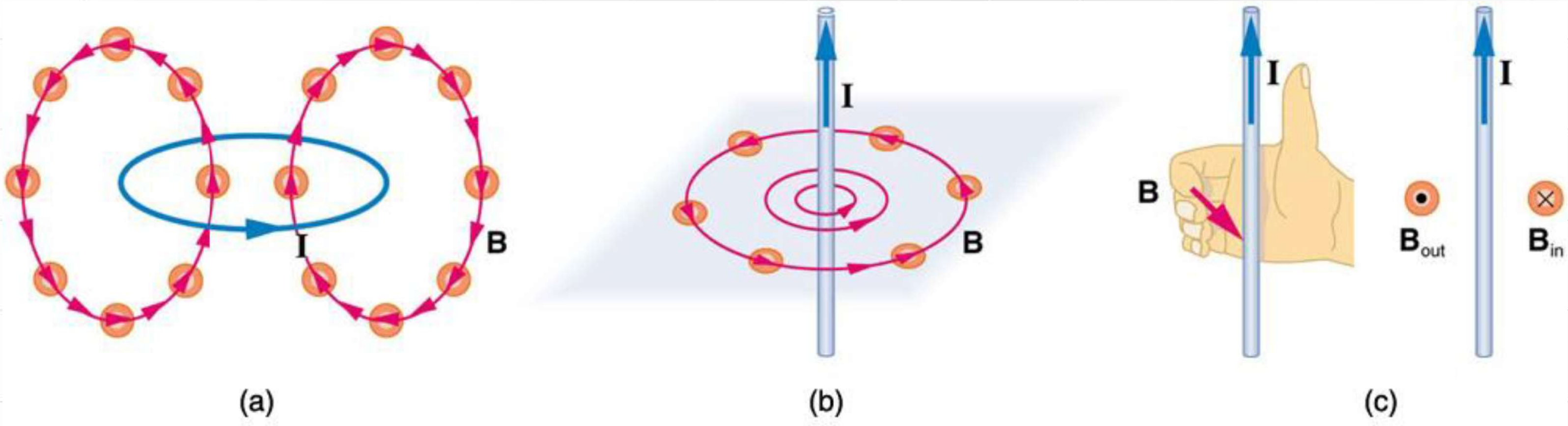
Magnetic Field around a Wire



Small compasses could be used to map the fields shown here. (a) The magnetic field of a circular current loop is similar to that of a bar magnet. (b) A long and straight wire creates a field with magnetic field lines forming circular loops. (c) When the wire is in the plane of the paper, the field is perpendicular to the paper. Note that the symbols used for the field pointing inward (like the tail of an arrow) and the field pointing outward (like the tip of an arrow).

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Magnetic fields

- summary

1. The direction of the magnetic field is tangent to the field line at any point in space. A small compass will point in the direction of the field line.
2. The strength of the field is proportional to the closeness of the lines. It is exactly proportional to the number of lines per unit area perpendicular to the lines (called the areal density).
3. Magnetic field lines can never cross, meaning that the field is unique at any point in space.
4. Magnetic field lines are continuous, forming closed loops without beginning or end. They go from the north pole to the south pole.

Magnetic Field Strength

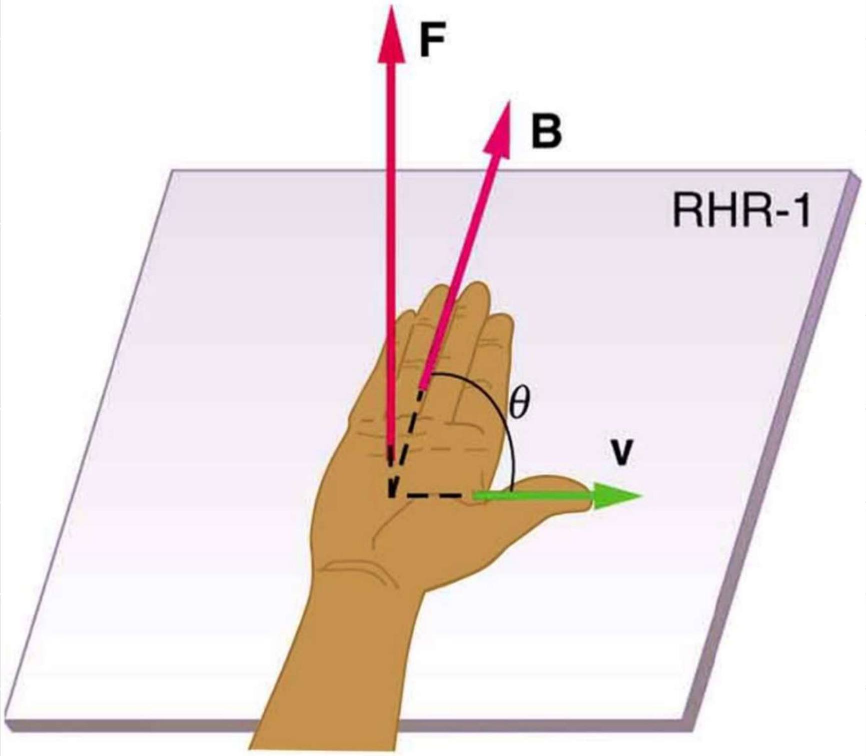
The magnetic force on a moving charge is one of the most fundamental known. Magnetic force is as important as the electrostatic or Coulomb force. Yet the magnetic force is more complex, in both the number of factors that affects it and in its direction, than the relatively simple Coulomb force. The magnitude of the magnetic force F on a charge q moving at a speed v in a magnetic field of strength B is given by

$$F = qvB \sin\theta$$

where θ is the angle between the directions of v and B. This force is often called the Lorentz force. In fact, this is how we define the magnetic field strength B —in terms of the force on a charged particle moving in a magnetic field. The SI unit for magnetic field strength B is called the tesla (T).

Right Hand Rule 1

The direction of the magnetic force F is perpendicular to the plane formed by v and B, as determined by the right hand rule 1 (or RHR-1).



$F = qvB \sin\theta$

F $\perp$ plane of **v** and **B**

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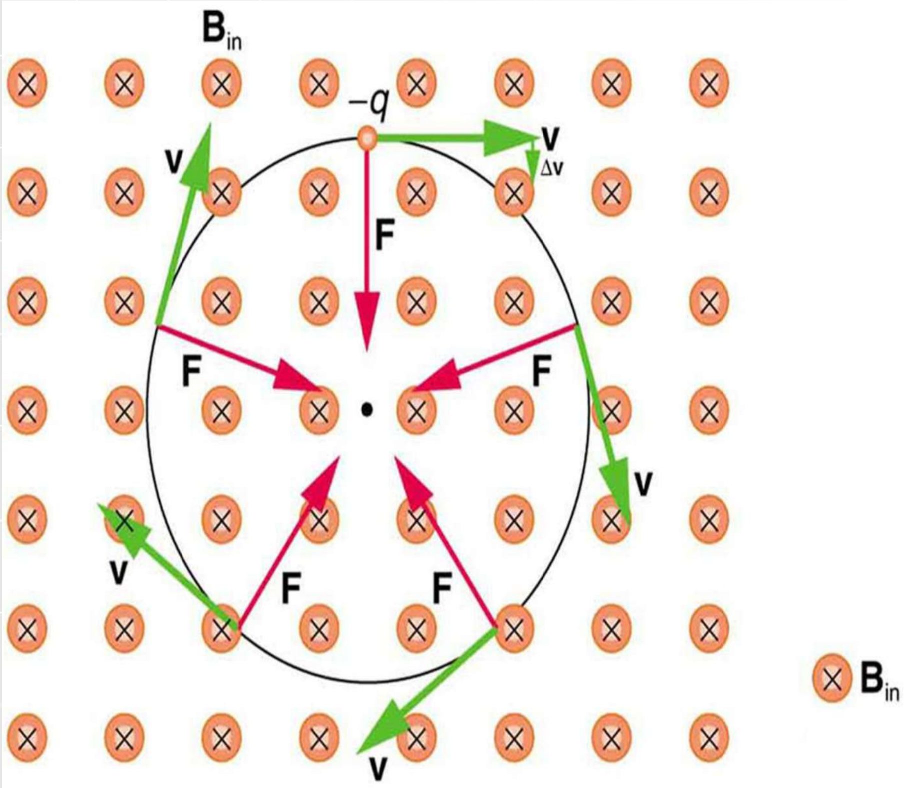
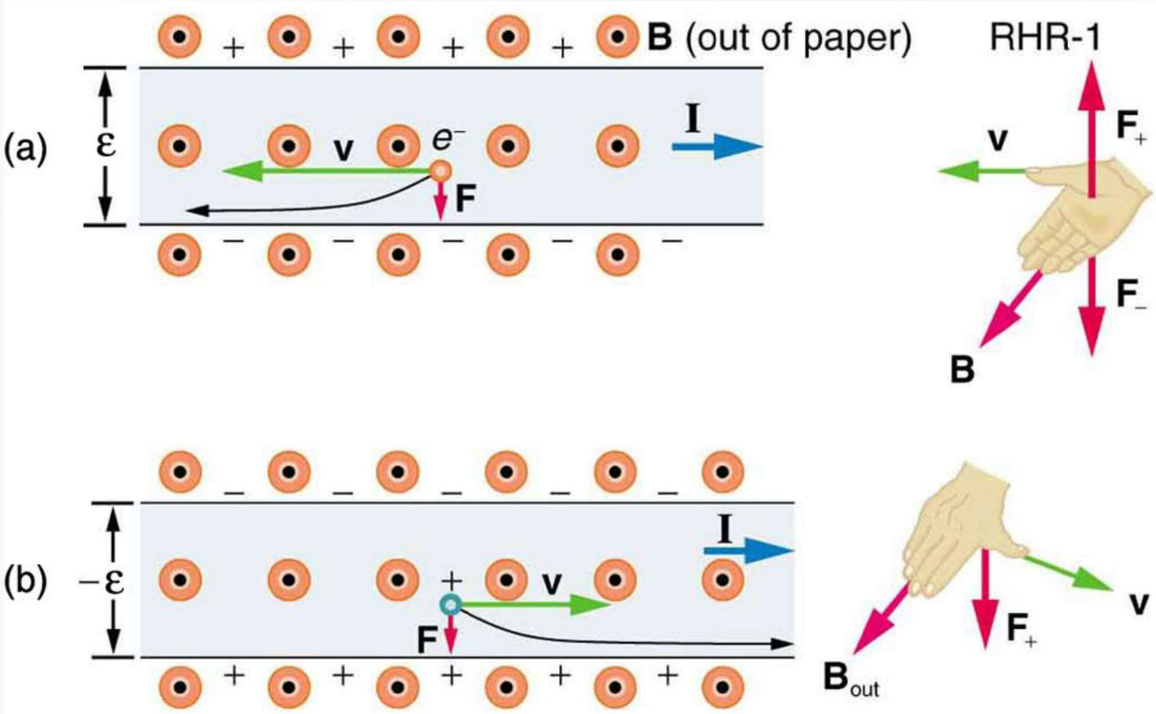
Moving Charge in a Magnetic Field

So does the magnetic force cause circular motion? Magnetic force is always perpendicular to velocity, so that it does no work on the charged particle. The particle's kinetic energy and speed thus remain constant. The direction of motion is affected, but not the speed. This is typical of uniform circular motion. The simplest case occurs when a charged particle moves perpendicular to a uniform B -field, such as shown in Figure (if this takes place in a vacuum, the magnetic field is the dominant factor determining the motion).



The Hall Effect

Picture shows what happens to charges moving through a conductor in a magnetic field. The field is perpendicular to the electron drift velocity and to the width of the conductor. Note that conventional current is to the right in both parts of the figure. In part (a), electrons carry the current and move to the left. In part (b), positive charges carry the current and move to the right. Moving electrons feel a magnetic force toward one side of the conductor, leaving a net positive charge on the other side. This separation of charge creates a voltage ε , known as the Hall emf, across the conductor. The creation of a voltage across a current-carrying conductor by a magnetic field is known as the Hall effect, after Edwin Hall, the American physicist who discovered it in 1879.



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Magnetic Flux

Magnetic flux is the number of magnetic field lines passing through a surface placed in a magnetic field. We show magnetic flux with the Greek letter; **Φ.** We find it with following formula;

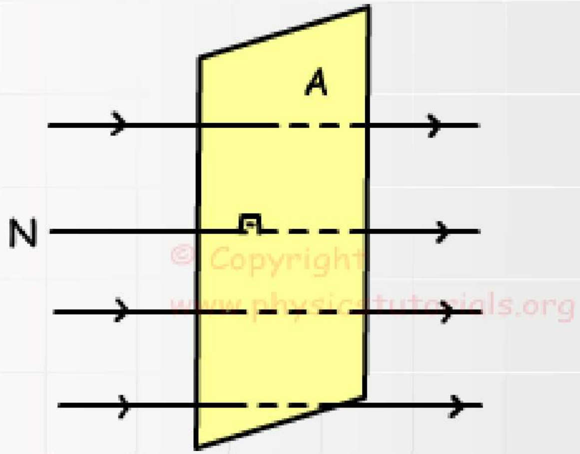
$\Phi = BA\cos\theta$

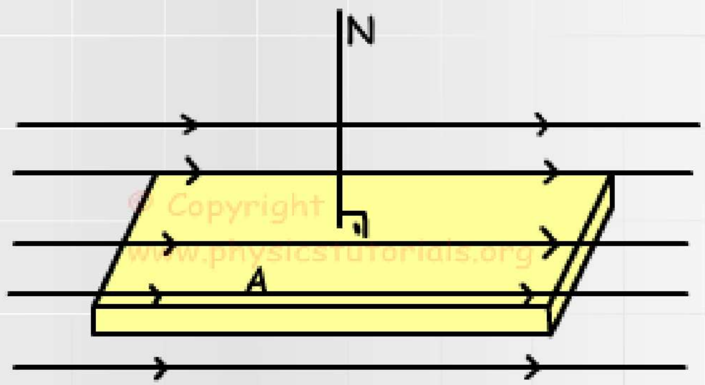
Where Φ is the magnetic flux and unit of Φ is Weber (Wb)

B is the magnetic field and unit of B is Tesla

A is the area of the surface and unit of A is m^2

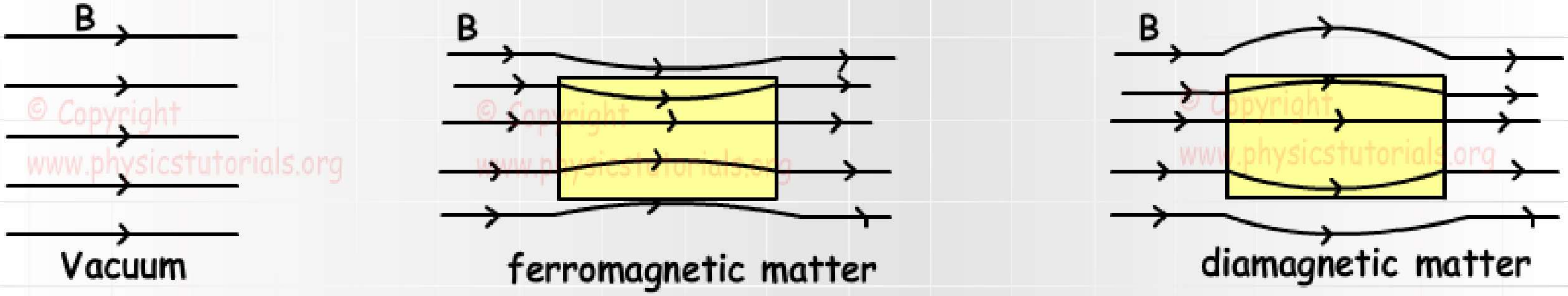
Following pictures show the two different angle situation of magnetic flux.





Magnetic Permeability

Magnetic permeability is the quantity of ability to conduct magnetic flux. We show it with μ. Magnetic permeability is the distinguishing property of the matter, every matter has specific μ. Picture given below shows the behavior of magnetic field lines in vacuum and in two different matters having different μ.



Magnetic permeability of the vacuum is denoted by $\boldsymbol{\mu_o}$ and has value;
$\boldsymbol{\mu_o = 4\pi . 10^{-7}}$ **Wb/Amps m**

Relative permeability is the ratio of a specific medium permeability to the permeability of vacuum.
$\boldsymbol{\mu_r = \mu / \mu_o}$

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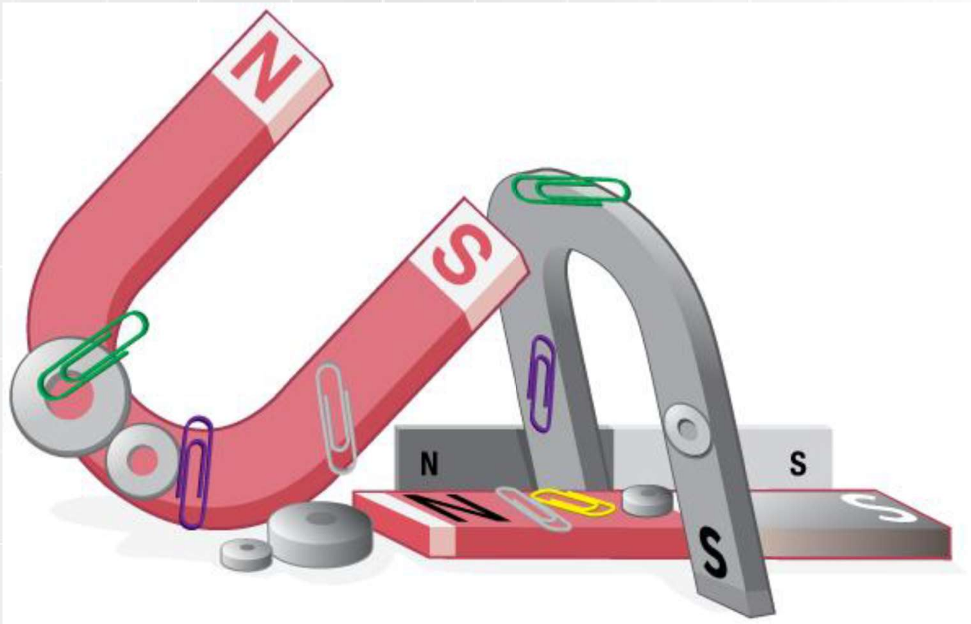
Magnetism

All right. So if you go to our website today, you will find I've assigned some problems and you should try to do them. They apply to this chapter.



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Quizz

Kahoot link:
https://kahoot.it/challenge/02000554?challenge-id=459c69ba-0699-474d-ae7d-12916780bd23_1621164013298

Deadline: 26th May 2021, 18:00