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**Electricity and Magnetism Topics**

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**Magnetism**   
The property of any object by virtue of which it can attract a piece of iron or steel is called **magnetism**.

**Natural Magnet**

A natural magnet is an ore of iron (Fe3O4), which attracts small pieces of iron, cobalt and nickel towards it.

Magnetite or lode stone is a natural magnet.

**Artificial Magnet**

A magnet which is prepared artificially is called an artificial magnet, e.g., a bar magnet, an electromagnet, a magnetic needle, a horse-shoe magnet etc.

According to molecular theory, every molecular of magnetic substance (whether magnetised or not) is a complete magnet itself. The poles of a magnet are the two points near but within the ends of the magnet, at which the entire magnetism can be assumed to be concentrated. The poles always occur in pairs and they are of equal strength. Like poles repel and unlike poles attract.

**Properties of Magnets**

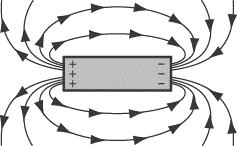
(i) A freely suspended magnet always aligns itself into north-south direction.

(ii) Like magnetic poles repel and unlike magnetic poles attract each other.

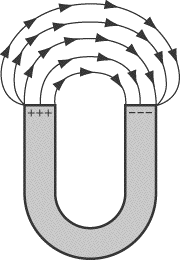
(iii) Magnetic poles exist in pair.

**Magnetic Field Lines**

Permanent magnets have positive and negative poles, often called “north” and “south,” respectively. Like electric field lines, magnetic field lines go from the positive, or north, pole, toward the negative, or south, pole. For example, the magnetic field of a bar magnet looks like this:



A horseshoe-shaped magnet creates a magnetic field like this:



It is possible to do a nifty experiment to see these magnetic field lines by scattering iron fillings around a permanent magnet—the filings will move to trace the lines.

**Properties of the magnetic lines of force**

• The magnetic lines of force originate from the North Pole of a magnet and end at its South Pole.

• The magnetic lines of force come closer to one another near the poles of a magnet but they are widely separated at other places.

• The magnetic lines of force do not intersect (or cross) one another.

• When a magnetic compass is placed at different points on a magnetic line of force, it aligns itself along the tangent to the line of force at that point.

**Key Formulas**

Magnetic Force on a Moving Charge

http://img.sparknotes.com/content/testprep/bookimgs/sat2/physics/0006/f=q(vb).gif

Magnitude of the Magnetic Force on a Moving Charge

http://img.sparknotes.com/content/testprep/bookimgs/sat2/physics/0006/f=qvbsintheta.gif

Radius of the Circle Described by a Charged Particle Moving Perpendicular to a Magnetic Field

http://img.sparknotes.com/content/testprep/bookimgs/sat2/physics/0012/r=mvqb.gif

Magnetic Force on a Current

http://img.sparknotes.com/content/testprep/bookimgs/sat2/physics/0006/f=ilbsintheta.gif

Magnetic Field Created by a Current

http://img.sparknotes.com/content/testprep/bookimgs/sat2/physics/0003/b=mu0i.gif

**Electrostatics**

**Electric Charge**

Laws of Electric Charges Opposite charges attract each other. Similar charges repel each other. Charged objects attract some neutral objects.

**Methods to induce electric charge**

* Charging by Friction Electrons are ripped off another surface and charges another object
* Induced Charge Separation distribution of charge that results from a change in the distribution of elections in an object
* Charging by Contact Electrons are passed through conductors once they touch. They are transferred and charge equalize each object.
* Charging by Induction The electrons in one object are pushed by the fields of a nearby charged object inducing it.

**Law of Conservation of change**

The total charge (the difference between the amounts of positive and negative charge) within an isolated system is conserved.

**Electric Fields**

* Field of Force: A field of force in a region of space when an appropriate object placed at any point in the field experienced a force.
* Coulombs is a unit measuring the magnitude of charges.

ε = kq1 / r2

* Electric Field: at any point is defined as the electric force per unit positive charge and is a vector quantity.
* Electric Field lines always come from positive to negative charges
  + Positive Fields never touch negative fields, they also never crossed

**Electric Potential**

* Electric Potential Energy (EE) the energy stored in a system of two charges a distance r apart.

EE = kq1q2 / r

* Electric Potential (V), the value, in volts, of potential energy per unit of positive charge. 1 V = 1 J/C

V = kq1 / r

* Electric Potential Difference: the amount of work required per unit charge to move a positive charge from one point to another in the prescience of another field.

ΔV = εr

ε = ΔV / r  (for parallel plates)

ΔV = ΔEE/ q

**Electric Forces: Coulomb’s Law**

* Coulomb’s Law The force between two point charges is inversely proportional to the square of the distance between the charges and directly proportional to the product of the charges

FE= kq1q2 / r2

Where k = 9.0 x 109 N\*m2/C2

**Electromagnets**

**Magnetic Fields**

* Magnetic Force Field: the area around a magnet which magnetic forces are exerted.
* Domain Theory of Magnetism: theory that describes, in terms of tiny magnetically homogeneous regions (“domains”), how a material can become magnetized: each domain acts like a bar magnet.
* Principle of Electromagnetism: Moving electric charges produce a magnetic field
* Right hand Rule for a Straight conductor: If a conductor is grasped in the right hand, with the thump pointing in the direction of the current, the curled fingers point in the direction of the magnetic field lines.
  + Current flowing through a conductor produces a magnetic field that circles around the conductor based on the direction of the current
  + Right hand used for positive charges, left hand used for negative charges
* Right Hand Rule for a Solenoid: If a solenoid is grasped in the right hand, with the fingers curled in the direction of the electric current, the thumb points in the direction of the magnetic field lines in its core.
  + A solenoid flowing with current creates a magnetic field that points out of one end of the solenoid
* Relative Magnetic Permeability: the ability for some material to become magnetized

**Ampere’s Law**

* Ampere’s Law: Along any closed path through a magnetic field, the sum of the products of the scalar component of the magnetic field (B), parallel to the path segment with the length of the segment, is directly proportional to the net electric current passing through the area enclosed by the path.

B = μo ( I / 2π r)

* Where μois called the *permeability of free space*= 4π X 10-7 T\*m/A
* For conductors which were a solenoid, a slightly modified formula, based on the total length of wire and number of turns is used

B = μo ( N I / L )

## Faraday's Laws

### Faraday's First Law

Any change in the [magnetic field](http://www.electrical4u.com/what-is-magnetic-field/) of a coil of wire will cause an emf to be induced in the coil. This emf induced is called induced emf and if the conductor circuit is closed, the [current](http://www.electrical4u.com/electric-current-and-theory-of-electricity/) will also circulate through the circuit and this [current](http://www.electrical4u.com/electric-current-and-theory-of-electricity/) is called induced current. Method to change [magnetic field](http://www.electrical4u.com/what-is-magnetic-field/):

1. By moving a magnet towards or away from the coil
2. By moving the coil into or out of the [magnetic field](http://www.electrical4u.com/what-is-magnetic-field/).
3. By changing the area of a coil placed in the [magnetic field](http://www.electrical4u.com/what-is-magnetic-field/)
4. By rotating the coil relative to the magnet.

### Faraday's Second Law

It states that the magnitude of EMF induced in the coil is equal to the rate of change of flux that linkages with the coil. The flux linkage of the coil is the product of number of turns in the coil and flux associated with the coil.

**Lorentz force**

Lorentz force, the [force](http://www.britannica.com/science/force-physics) exerted on a charged particle *q* moving with [velocity](http://www.britannica.com/science/velocity) *v* through an [electric](http://www.britannica.com/science/electric-field) *E*and [magnetic field](http://www.britannica.com/science/magnetic-field) *B*. The entire electromagnetic force *F* on the charged particle is called the Lorentz force (after the Dutch physicist [Hendrik A. Lorentz](http://www.britannica.com/biography/Hendrik-Antoon-Lorentz)) and is given by*F* = *qE* + *qv* × *B*.

**Lenz’s Law**

Lenz's law is named after the German scientist H. F. E. Lenz in 1834. Lenz's law obeys Newton's third law of motion (i.e to every action there is always an equal and opposite reaction) and the conservation of energy (i.e energy may neither be created nor destroyed and therefore the sum of all the energies in the system is a constant). Lenz law is based on [Faraday's law](http://www.electrical4u.com/faraday-law-of-electromagnetic-induction/) of induction, so before understanding Lenz's law; one should know what is [Faraday’s law of induction](http://www.electrical4u.com/faraday-law-of-electromagnetic-induction/)? When a changing [magnetic field](http://www.electrical4u.com/what-is-magnetic-field/) is linked with a coil, an emf is induced in it. This change in [magnetic field](http://www.electrical4u.com/what-is-magnetic-field/) may be caused by changing the [magnetic field](http://www.electrical4u.com/what-is-magnetic-field/) strength by moving a magnet towards or away from the coil, or moving the coil into or out of the [magnetic field](http://www.electrical4u.com/what-is-magnetic-field/) as desired. Or in simple words, we can say that the magnitude of the emf induced in the circuit is proportional to the rate of change of flux.

Lenz's law states that when an emf is generated by a change in [magnetic flux](http://www.electrical4u.com/what-is-magnetic-field/#Magnetic-Flux-or-Magnetic-Lines-of-Force) according to [Faraday's Law](http://www.electrical4u.com/faraday-law-of-electromagnetic-induction/), the polarity of the induced emf is such, that it produces an [current](http://www.electrical4u.com/electric-current-and-theory-of-electricity/) that's [magnetic field](http://www.electrical4u.com/what-is-magnetic-field/) opposes the change which produces it.

The negative sign used in [Faraday's law of electromagnetic induction](http://www.electrical4u.com/faraday-law-of-electromagnetic-induction/), indicates that the induced emf ( ε ) and the change in [magnetic flux](http://www.electrical4u.com/what-is-magnetic-field/#Magnetic-Flux-or-Magnetic-Lines-of-Force) ( δΦB ) have opposite signs. http://electrical4u.com/electrical/basic-electrical-equation/lenz-law-of-electromagnetic-induction-2.gifhttp://www.electrical4u.com/equations/llem-2.gifWhere, ε = Induced emf δΦB = change in magnetic flux N = No of turns in coil