February 20, 2007
P. Shields

Student Handout.

Demonstrate Knowledge of magnets and magnetism.

A magnet is an object or material that attracts certain metals, such as iron, nickel and cobalt. It can also attract or repel another magnet. All magnets have North-seeking (N) and South-seeking (S) poles. When magnets are placed near each other, opposite poles attract and like poles repel each other. Various electrical devices make use of magnets.

Types of magnets

There are permanent magnets, temporary magnets and electromagnets.

Permanent magnets

A permanent magnet is one that will hold its magnetic properties over a long period of time.
Magnetite

Magnetite is a magnetic material found in nature. It is a permanent magnet, but it is relatively weak.

Alloys
Most permanent magnets we use are manufactured and are a combination or alloy of iron, nickel and cobalt. Rare-earth permanent magnets are a special type of magnet that can have extreme strength.

Temporary magnets

A temporary magnet is one that will lose its magnetism. For example, soft iron can be made into a temporary magnet, but it will lose its magnetic power in a short while.
Electromagnet

By wrapping a wire around an iron or steel core and running an electrical current through the wire, you can magnetize the metal and make an electromagnet. If the core is soft iron, the magnetism will diminish as soon as the current is turned off. This feature makes electromagnets good for picking up and dropping objects. Typically DC electricity is used, but AC current will also result in an electromagnet.

Properties of magnets

Magnets always have two poles, come in various shapes, and attract or repel other magnets.
Names of poles

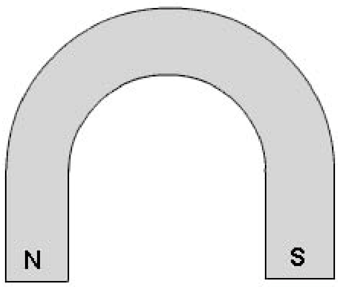
All magnets have a North-seeking pole (N) and South-seeking pole (S). In a compass, the side marked (N) will point toward the Earth's North magnetic pole. Thus, it is called the "North-seeking pole." Also note that the Earth's North magnetic pole is not the same thing as the North Pole. They are actually several hundred miles apart.

NOTE: To avoid confusion, you should try to be exact in what you are describing, especially concerning magnets.
Various shapes

The magnet can be made into various shapes. The bar magnet is the most common configuration.

Bar magnet

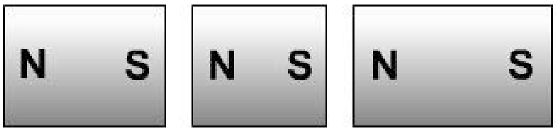
Magnets also can be square, spherical, shaped like a horseshoe, and even shaped like a donut.



Horseshoe magnet

If you put an iron plate across the N and S poles of a horseshoe magnet, that would essentially "short circuit" the effect of the magnetism, such that its strength would not be very great. As soon as the plate was removed, the magnet would regain its full strength. That method is sometimes used in magnets that are temporary to help keep their magnetic properties for a longer time.
Cutting a magnet

An interesting characteristic of magnets is that when you cut a magnet into parts, each part will have both N and S poles.



Bar magnet cut into three parts

Attraction and repulsion

Magnets strongly attract iron, nickel and cobalt, as well as combinations or alloys of these metals.

Also, unlike poles of two magnets will attract, but like poles will repel. Thus, N and S attract, while S and S will repel each other.

Applications There are numerous applications of magnets.

Creating a magnet

You can magnetize a piece of steel by rubbing a magnet in one direction along the steel. This lines up the many of the domains or sections of aligned atoms in the steel, such that it acts like a magnet. The steel often won't remain magnetized for a very long time, while the true magnet is "permanently" magnetized and retains its strength for a long time.

If you use soft iron or steel, such as a paper clip, it will lose its magnetism quickly. Also, you can disorient the atoms in a magnetized needle by heating it or by dropping the needle on a hard object. Compass

The first true application of a magnet was the compass, which not only helps in navigation by pointing toward the North magnetic pole, but it is also useful in detecting small magnetic fields. A compass is simply a thin magnet or magnetized iron needle balanced on a pivot. The needle will rotate to point toward the opposite pole of a magnet. It can be very sensitive to small magnetic fields.

Other uses

Magnets are found in loudspeakers, electrical motors and electrical generators.

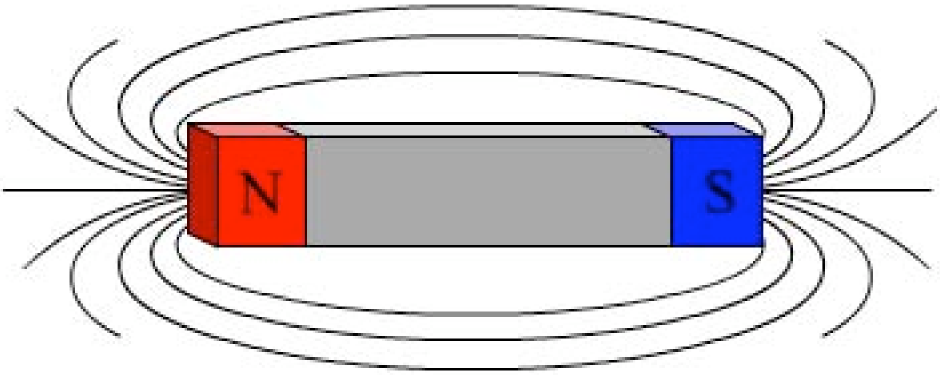
A very common application of magnets is to stick things to the refrigerator. Since the outer shell of most refrigerators is made of steel, a magnet will readily stick to it. The type of magnets used often consists of a thin sheet of a magnetic material.

As a novelty, magnetic disks can be stacked on a pencil to show magnetic levitation.

Levitating magnets

Magnetism

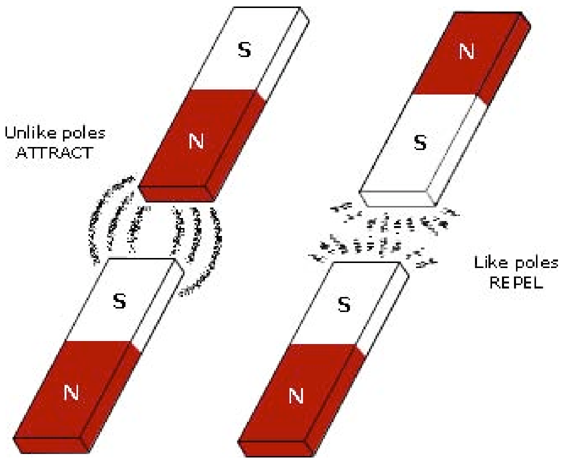
Magnets produce a magnetic field invisible to the eye but can be revealed by the effect these lines of force have on surrounding objects made of magnetic materials.



Lines of Magnetic Force.

These lines of force can be seen if we hold a magnet under a piece of paper and sprinkle iron filings on the top of the paper, try it!

The space surrounding a magnet, in which magnetic force is exerted, is called a magnetic field. If a bar magnet is placed in such a field, it will experience magnetic forces. However, the field will continue to exist even if the magnet is removed. The direction of magnetic field at a point is the direction of the resultant force acting on a hypothetical North Pole placed at that point.



When a small north magnetic pole is placed in the magnetic field created by a magnet, it will experience a force. And if the North Pole is free, it will move under the influence of magnetic field. The path traced by a North magnetic pole free to move under the influence of a magnetic field is called a magnetic line of force. In other words, the magnetic lines of force are the lines drawn in a magnetic field along which a north magnetic pole would move.

The direction of a magnetic line of force at any point gives the direction of the magnetic force on a north pole placed at that point. Since the direction of magnetic line of force is the direction of force on a North Pole, so the magnetic lines of force always begin on the N-pole of a magnet and end on the S-pole of the magnet. A small magnetic compass when moved along a line of force always sets itself along the line tangential to it. So, a line drawn from the South Pole of the compass to its North Pole indicates the direction of the magnetic field.

To summarise:

1. The magnetic lines of force originate from the North Pole of a magnet and end at its South Pole.
2. The magnetic lines of force come closer to one another near the poles of a magnet but they are widely separated at other places.
3. The magnetic lines of force do not intersect (or cross) one another.
4. 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.

Magnetic Flux.

The term flux was chosen because the power of a magnet seems to "flow" out of the magnet at one pole and return at the other pole in a circulating pattern, as suggested by the patterns formed by iron filings sprinkled on a paper placed over a magnet or a conductor carrying an electric current. These patterns are called lines of induction. Although there is no actual physical flow, the lines of induction suggest the correct mathematical description of magnetism in terms of a field of force. The lines of induction originate on the north pole of the magnet and end on the South Pole; their direction at any point is the direction of the magnetic field, and their density (the number of lines passing through a unit area) gives the strength of the field. Near the poles where the lines converge, the field and the force it produces are large; away from the poles where the lines diverge, the field and force are progressively weaker.

Flux Density:

The Magnetic Flux is the rate of flow of magnetic energy across or through a (real or imaginary) surface.

The Magnetic Flux Density is a measure of the amount of magnetic flux in a unit area perpendicular to the direction of magnetic flow, or the amount of magnetism induced in a substance placed in the magnetic field.

The SI unit of magnetic flux density is the Tesla, (T).

One Tesla, (1T), is equivalent to one Weber per square metre (1 Wb m2).

Weber = the magnetic flux which, linking a circuit of one turn, produces in it an electromotive force (emf) of 1 volt as it is uniformly reduced to zero in one second.

The intensity of the Magnetic Flux Density, (B), is affected by the intensity of the Magnetic Field, (H), the quantities of the substance and the intervening media between the source of the magnetic field and the substance.

The relationship between magnetic field strength and magnetic flux density is:

$$B = H \times \mu$$

Where μ is the magnetic permeability of the substance. Permeability is the ease at which magnetic lines of force can distribute through a material and is compared to its relative permeability when measured with the same force in a vacuum. When dealing with exposure of non-ferromagnetic material such as animals or cells, Magnetic Flux Density and Magnetic Field Strength can be assumed to be equal.

Electromagnets.

Faradays Laws.

Whenever the magnetic flux linking with the turns of a coiled conductor changes and e.m.f. Is induced in the coiled conductor.
The value of the e.m.f. Induced is directly proportional to the rate of change of flux to the number of turns in the coiled conductor.

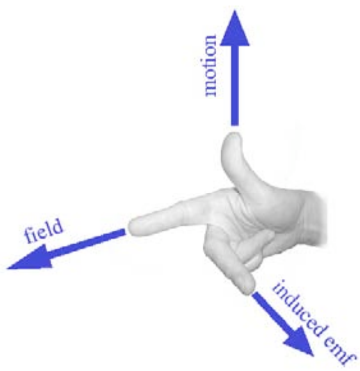
Lenz's Law

The direction of the induced e.m.f. Is such as to oppose the direction of the change in flux which brings it about.

To see this physics in action follow this link
http://www.launc.tased.edu.au/online/sciences/physics/Induction.html

The direction force induced can be determined by the following:

Fleming's Rule also known as the Generator Rule this is a way of determining the direction of the induced emf of a conductor moving in a magnetic field.

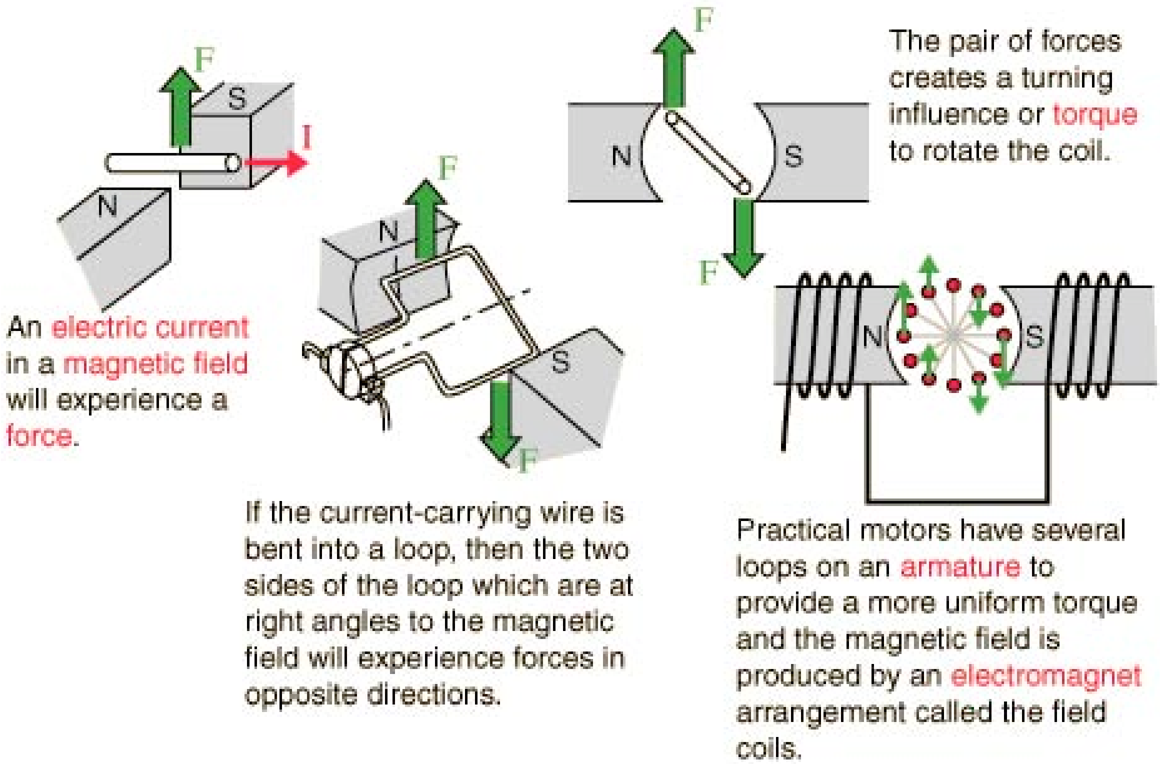


The thumb, the first and the second fingers on the right hand are held so that they are at right angles to each other.

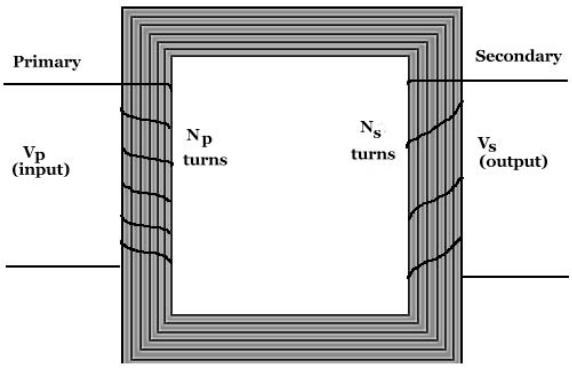
If the first finger points in the direction of the magnetic field and the thumb in the direction of the motion of the conductor then the second finger will point in the direction of the induced emf in the conductor.

Electric Motors.

How electric motors work is to use the fact that a current flowing through it induces a magnetic field in a coil. If we put this could in the field of some strong permanent magnets the tendency is for the two fields, the coil and the magnets, to oppose each other resulting in a motion of the coil /loop of wire away from the stationary magnetic flux produced by the fixed permanent magnets, You called also reverse this by making the coil fixed and the magnets movable if you wanted to have a different mechanical action.



Transformers:



Another use for electromagnetic induction is by magnetically linking two or more coils in a many simular to the above diagram. The input side of the transformer is called the primary winding and the output(s) side is called the secondary winding. Transformers can be used to induce a larger e.m.f in the secondary windings "Step-up" or a lower e.m.f. Than the primary input "Step-down". This ability to "link" fluxes caused by varying direct or alternating currents in a primary and induce the desired e.m.f. Is sometimes called mutual induction.

Transformer ratio can be determined by the following

$\frac{Ep}{Es} = \frac{Np}{Ns}$ + T Transformation Ratio,

This is also the way the ratio of the applied e.m.f. To the induced e.m.f can be determined. This is not completely accurate as all transformers have losses this is usually about 5%. This loss is caused by heat, magnetic leakage and Hysteresis the energy lost during changes in magnetic direction.

Magnetic Shielding:

Since most non magnetic materials although unaffected by magnetic fields happily allow them to pass through them some other way is needed to 'shield' magnetic fields from sensitive instruments and other circuits that would be damaged. In order to protect something from magnetic fields, the magnetic shield must be made of materials that cannot become magnetized. The most effective material for constructing a magnetic shield is a specially designed magnetic shielding material (with such brand names as MuMetal), a special alloy composed primarily of nickel. This alloy creates a protective shield that blocks outside magnetic fields, while remaining immune to magnetism. Such effectiveness also makes it the most expensive material available, but some situations call for the highest quality material. Other materials are available, though they may not be as effective at blocking all magnetic fields or from becoming magnetized themselves.

When magnetic lines of flux encounter high permeability material, the magnetic forces are both absorbed by the material and redirected away from its target, much as a beavers dam absorbs and reroutes water from its den.

The most effective shields are constructed as enclosures such as boxes or better yet, cylinders with end caps. Because the field follows the line of the enclosure, an enclosed shape keeps stray fields from finding gaps, which could cause unintended interference.

Permeability: Imagine a sponge. Some sponges have big holes, some are more tightly structured, and each absorbs liquid to a point of saturation. Magnetic shielding material is similar. Depending upon its structure, magnetic shielding material absorbs magnetic interference to a point of saturation. As magnetic interference increases, so too should the permeability of the material.
EMI is the abbreviation for Electro Magnetic Interference. It can mean different things to different engineers. Essentially, EMI is an electrical or magnetic disturbance that causes unwanted interference.

Magnetic shielding is more beneficial than is often realized. Magnetic shielding is a used to help protect areas in which magnetic forces would cause interference or damage by either preventing a magnetic force from entering or exiting a specific area. It is used in objects such as computers and laser technology. Magnetic shielding can even be used to insulate walls or entire rooms from magnetic interference. Because few objects can block magnetic fields as well as avoid magnetism themselves, it seems nearly impossible to construct a magnetic shield. However, there are specially designed materials that can be used.

Student Assessment Questionnaire.

Note: This part of the assessment is open book and 100% is the required result.

Choose two or more of the following devices and describe their electromagnetic and magnetic properties and operation in simple terms.
(Note: Internet research is allowed)

Device	
Loudspeaker	
Relay	
Electric Bell	
Moving Coil Meter	
Electric Door Lock	
Lifting magnet	

Name: ___________________________________

Course: ___________________________________

Date: ___________________________________

NSN #: ___________________________________

Tutors Signature: ______________________________