Unit-4-Electrical Power

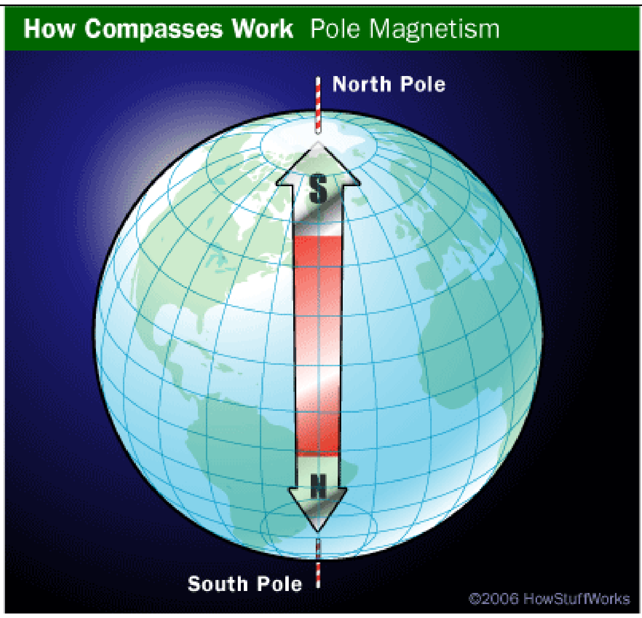
This is a quick summary of the main points from this unit.

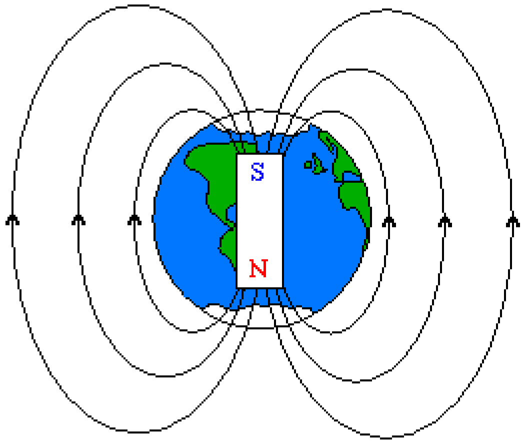
	Study Design 2009 – 2012 **Unit 4: Electric power**
1	apply a field model to magnetic phenomena including shapes and directions produced by bar magnets, and by current in wires, coils and solenoids
2	**calculate magnitudes and determine directions of** magnetic forces on current carrying wires, using F = **n**I*l*B where the directions of I and B are either perpendicular to, or parallel to, each other;
3	**investigate and explain** the operation of simple DC motors consisting of: – **one coil, containing a number of loops of wire, which is free to rotate about an axis** – **two magnets (not including radial magnets)** – **a commutator** – **a DC power supply;**
4	apply a field model to define magnetic flux ϕ, using ϕ = BA and the qualitative effect of differing angles between the coil and the field
5	**investigate and analyse** the generation of emf, including AC voltage and calculations using induced emf = , $\varepsilon = \frac{-n\Delta\Phi}{\Delta t}$, in terms of: - the rate of change of magnetic flux (Faraday's Law), - the direction of the induced current (Lenz's Law), - number of loops through which the flux passes;
6	**explain** the production of **DC** voltage in **DC** generators and AC voltage in alternators, including the use of commutators and slip rings, **respectively;**
7	compare DC motors, **DC** generators and **AC** alternators
8	**investigate and** compare sinusoidal AC voltages produced as a result of the uniform rotation of a loop in a constant magnetic flux in terms of frequency, period, amplitude, peak-to-peak voltage ($V_{p\text{-}p}$) and peak-to-peak current ($I_{p\text{-}p}$);
9	**identify** *rms* voltage as an AC voltage which produces the same amount of power as a DC voltage of the same magnitude
10	**convert** between rms, peak and peak-to-peak, values of voltage and current including conversions between peak power and average power
11	**analyse** transformer action, modelled in terms of electromagnetic induction for an ideal transformer, $\frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$
12	**analyse** the supply of power as P = VI and transmission losses using **potential difference** across transmission lines (V = IR) and power loss ($P = I^2R$)

13	explain the use of transformers in an electricity distribution system.

Now the quick review of notes regarding magnetism

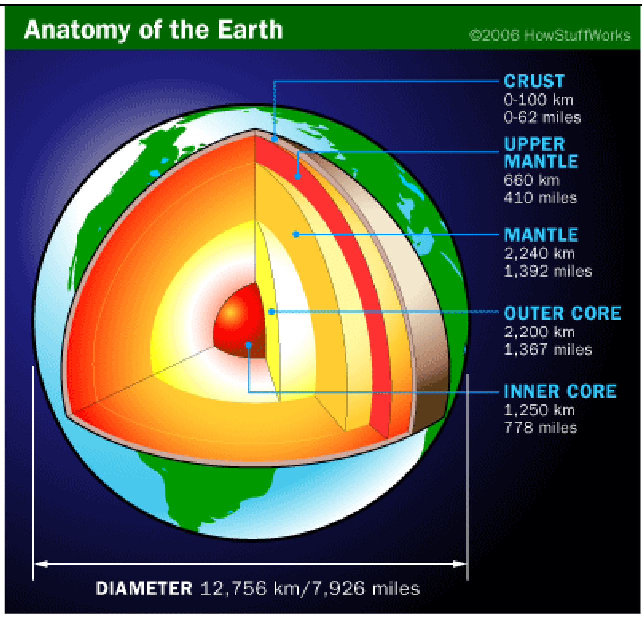
Compass	No matter where you stand on Earth, you can hold a compass in your hand and it will point toward the North Pole. Imagine that you are in the middle of the ocean, and you are looking all around you in every direction and all you can see is water, and it is overcast so you cannot see the sun... How in the world would you know which way to go unless you had a compass to tell you which way is "up"?  A compass is an extremely simple device. A **magnetic** consists of a small, lightweight magnet balanced on a nearly frictionless pivot point. The magnet is generally called a **needle**. One end of the needle is often marked "N," for north, or colored in some way to indicate that it points toward north. The reason why a compass works is more interesting. It turns out that you can think of the Earth as having a gigantic bar magnet buried inside. In order for the north end of the compass to point toward the **North Pole**, you have to assume that the buried bar magnet has its south end at the North Pole, as shown in the diagram at the right. If you think of the world this way, then you can see that the normal "opposites attract" rule of magnets would cause the north end of the compass needle to point toward the south end of the buried bar magnet. So the compass points toward the North Pole.





To be completely accurate, the bar magnet does not run exactly along the Earth's rotational axis. It is skewed slightly off center. This skew is called the **declination**, and most good maps indicate what the declination is in different areas (since it changes a little depending on where you are on the planet).

The magnetic field of the Earth is fairly weak on the surface. After all, the planet Earth is almost 8,000 miles in diameter, so the magnetic field has to travel a long way to affect your compass. That is why a compass needs to have a **lightweight magnet** and a **frictionless bearing**. Otherwise, there just isn't enough strength in the Earth's magnetic field to turn the needle.

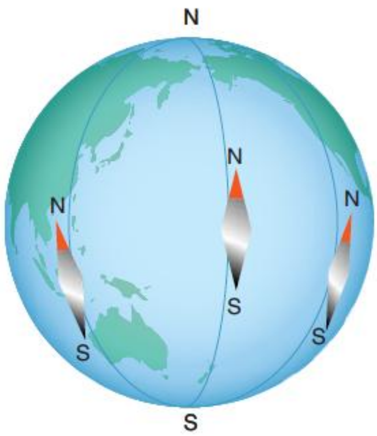


The "big bar magnet buried in the core" analogy works to explain why the Earth has a magnetic field, but obviously that is not what is really happening. So what *is* really happening?

No one knows for sure, but there is a working theory currently making the rounds. As seen on the above, the Earth's core is thought to consist largely of molten iron (red). But at the very core, the pressure is so great that this superhot iron crystallizes into a solid. Convection caused by heat radiating from the core, along with the rotation of the Earth, causes the **liquid iron** to move in a **rotational pattern**. It is believed that these rotational forces in the liquid iron layer lead to weak magnetic forces around the axis of spin.

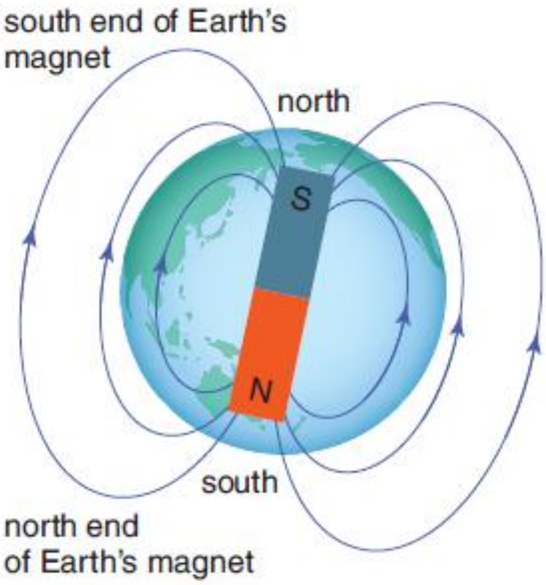
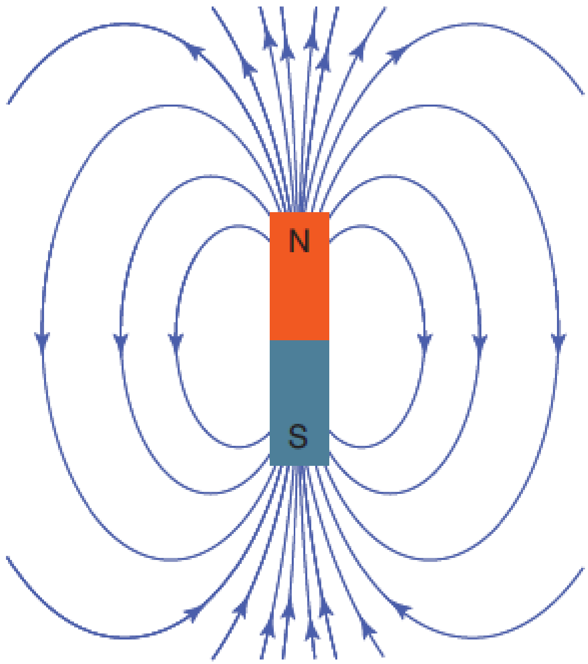
It turns out that because the Earth's magnetic field is so weak, a compass is nothing but a detector for very slight magnetic fields created by anything. That is why we can use a compass to detect the small magnetic field produced by a wire carrying a current

The end of the magnet marked S is called the South end of the magnet because it points generally towards the geographic south.



Notice how the compass lines itself up

A compass needle is lined up by the Earth's magnet. The south seeking end of the needle points towards geographic south. But because unlike ends attract, this end of Earth's magnet must be a magnetic north end.

	
Magnetic fields around a magnet	Magnetic field- describes the property around a magnet that causes an object to experience a force due to the presence of the magnet. 
Facts about magnetic field lines	• Each field line is a continuous loop that leaves the north end of the magnet and enters at the south end • Field lines do not intersect • The direction of the magnetic field at a point is along the tangent to the field line • The closeness of the lines shows the strength of the magnetic field

<table>
<tr>
<td>Magnetic field pattern</td>
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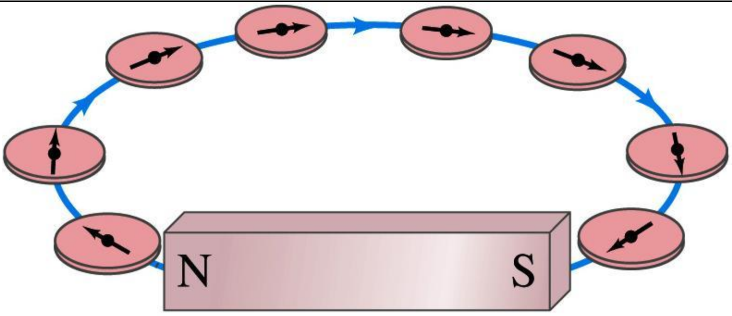
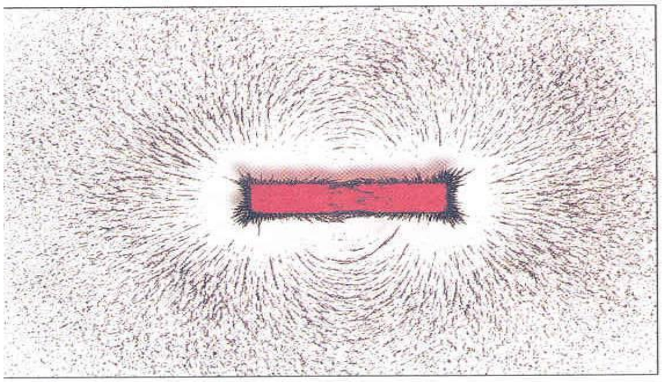
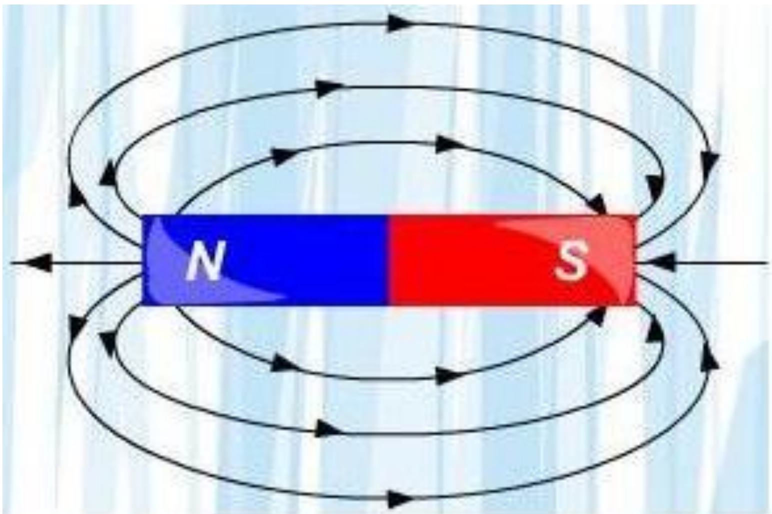


Sprinkling iron filing on paper produces the following pattern below



The pattern of the magnetic field can be determined by two methods-
Compass needles Or Sprinkling iron filings on paper

A bar Magnet



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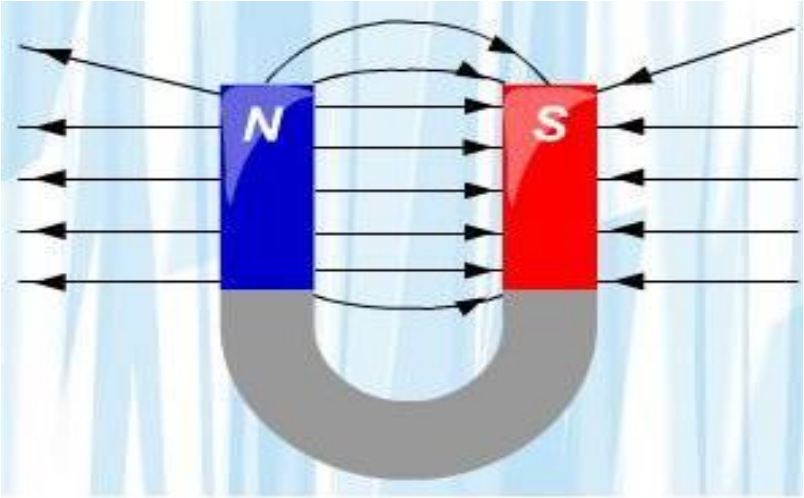
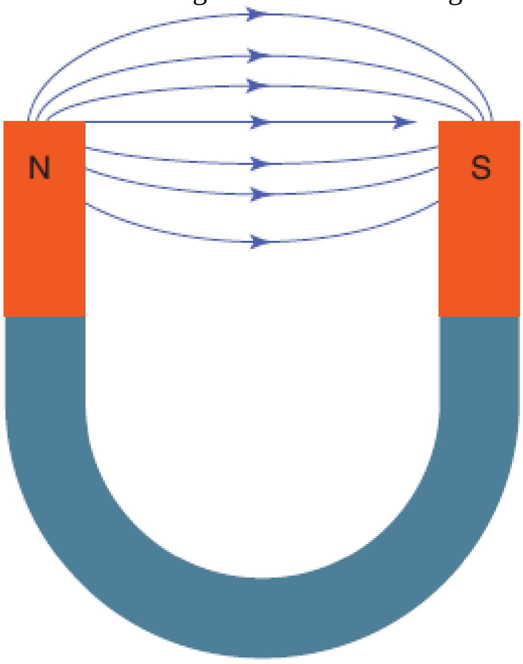
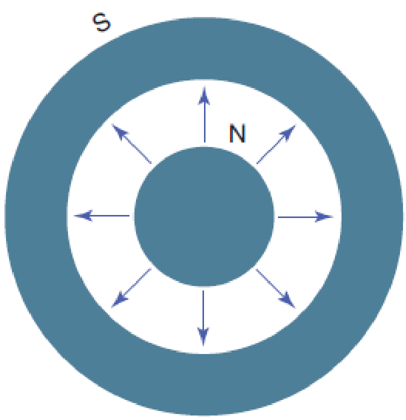
A U Magnet of Horseshoe Magnet

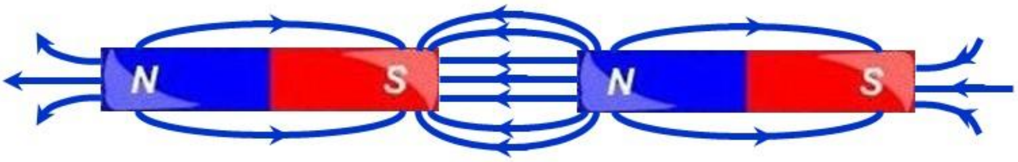
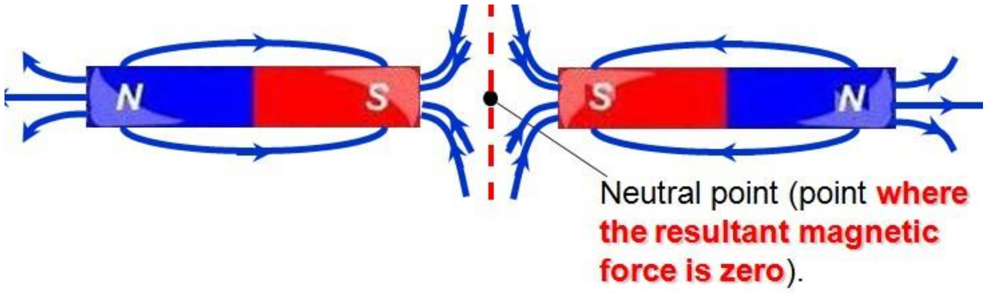
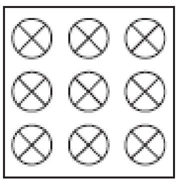
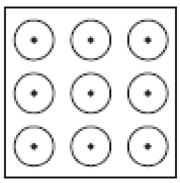


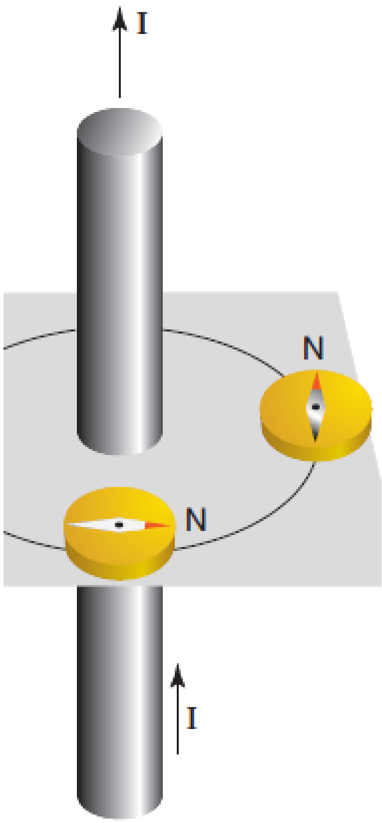
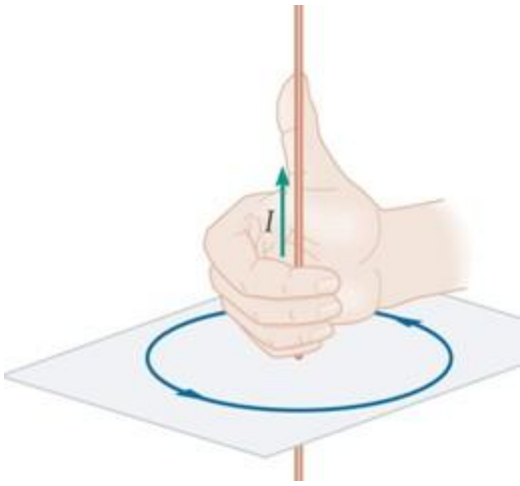
Another diagram of a horshoe magnet

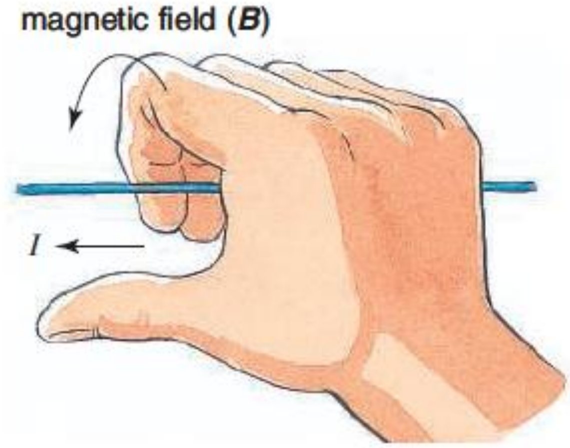
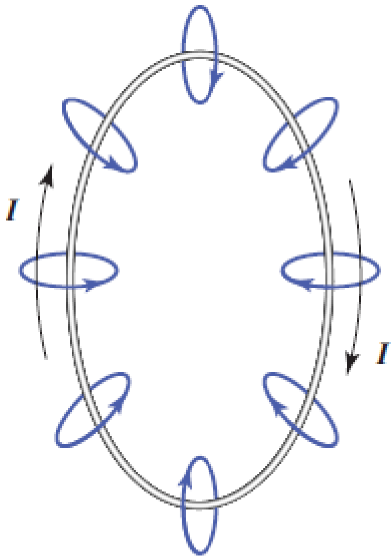


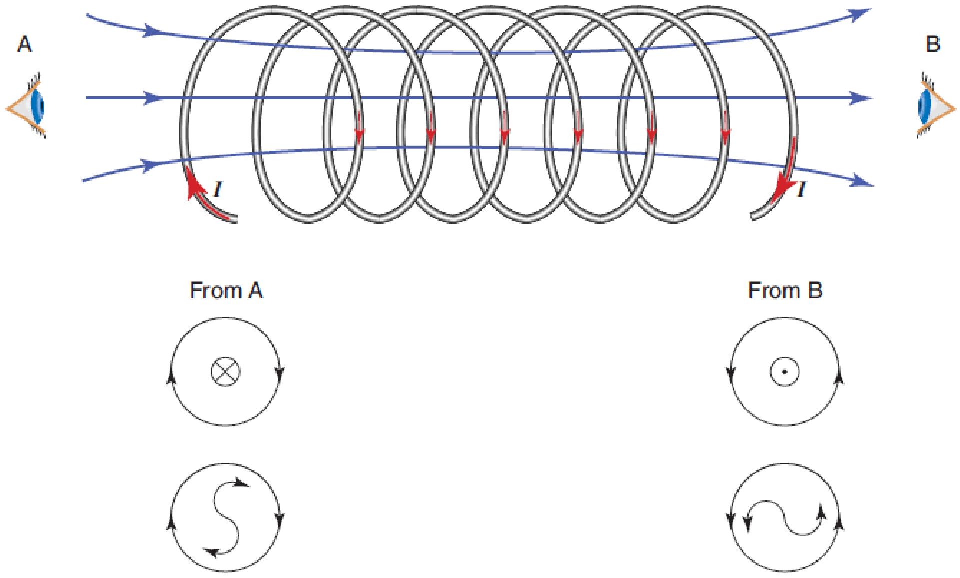
A circular magnet



Field between magnets	Two bar magnets-unlike poles- attractive force  Two bar magnets-like poles-repulsive force 
Units for Magnetic field	The strength of a magnetic field is measured in tesla The strength of Earth's magnetic field at its surface is 3.1×10^{-5} T(at equator) to 5.8×10^{-5} (at 50 degrees latitude) (16 T has been used to levitate a frog?) The magnetic field has many names which can confuse anyone Below are some of the common names -**Magnetic field**- used by Physicists -**Magnetic flux density-** Electrical engineers -**Magnetic induction-** Mathematicians
Convention s used to show magnetic fields	A convention is used to represent magnetic fields Magnetic field going **into the page**  Magnetic field coming out of the page 
Connection between current and magnetic field	Hans Christian Oersted (1820) discovered the connection between electricity and magnetism. When a current flows a magnetic field forms around the wire .

	 Notice the direction of the magnetic field from the compass needles – red shows North
Magnet field produced by a conductor	Magnetic field produced by a conductor When a **current flows in a conductor wire** or **coil**, the **magnetic field will be produced**. The **direction of magnetic field** around the wire or coil can be determined by using the **right hand grip rule**  Thumb-direction of the current Other fingers-direction of the magnetic field So let us go through that rule again

Right hand rule	The right hand holds the wire with the thumb pointing in the direction of the conventional current (+ to -), the fingers curl around the wire in the direction of the magnetic field  Remember conventional current flows from the positive terminal to the negative terminal
Solenoids applying the rule	Applying the right hand grip rule to a loop of wire shows that the magnetic field comes in one side of the loop and out the other side, all the way around the loop.  Joining loops together results in a solenoid. The magnetic fields from each loop add together to produce a stronger magnetic field.

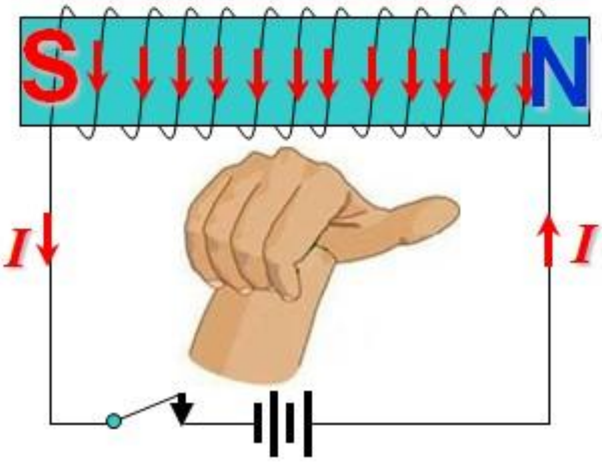
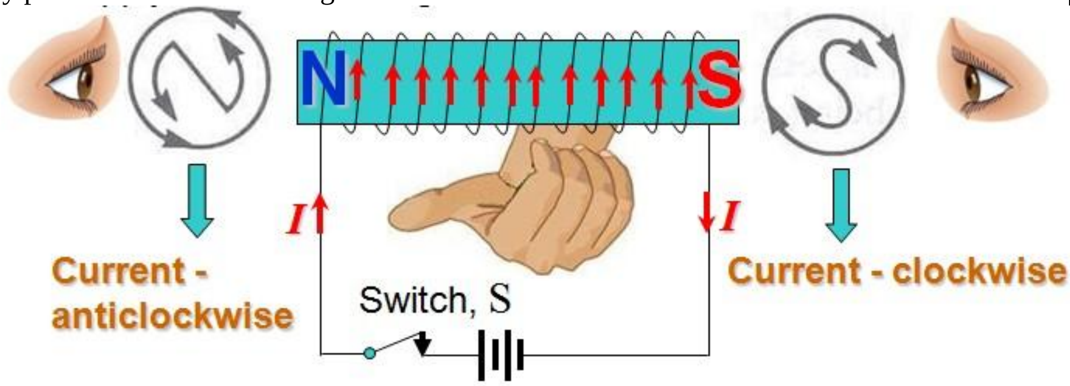
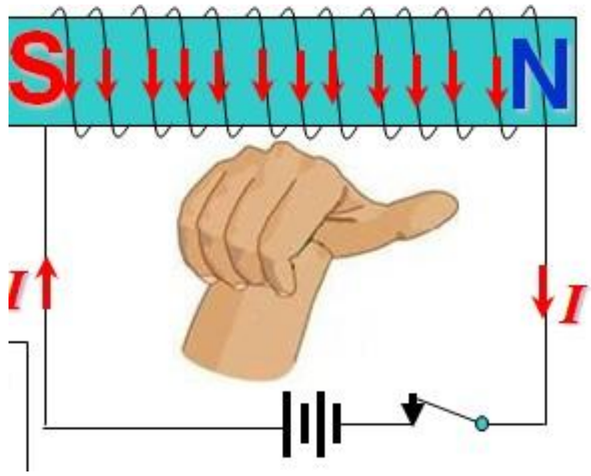


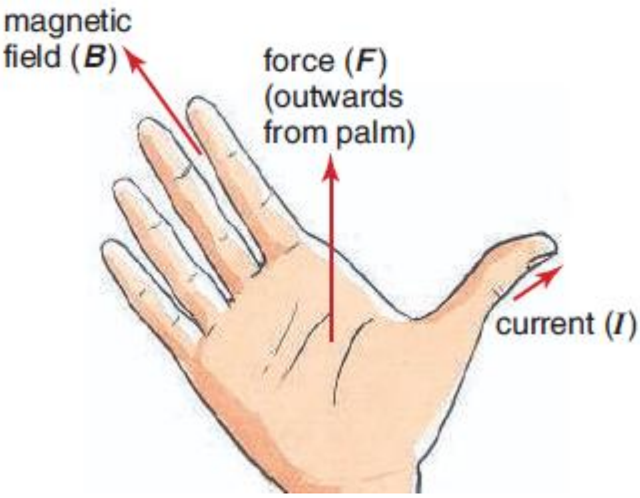
If the loops are very close together the field lines within the coil are parallel to the axis of the coil. The field lines then emerge from one end of the solenoid curve around and enter the other end of the solenoid, completing the path for the field lines.

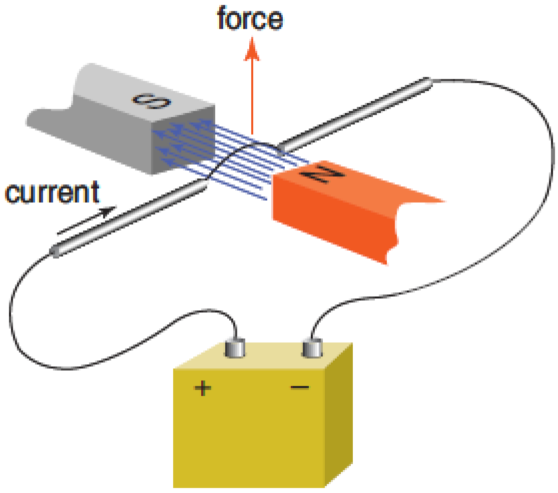
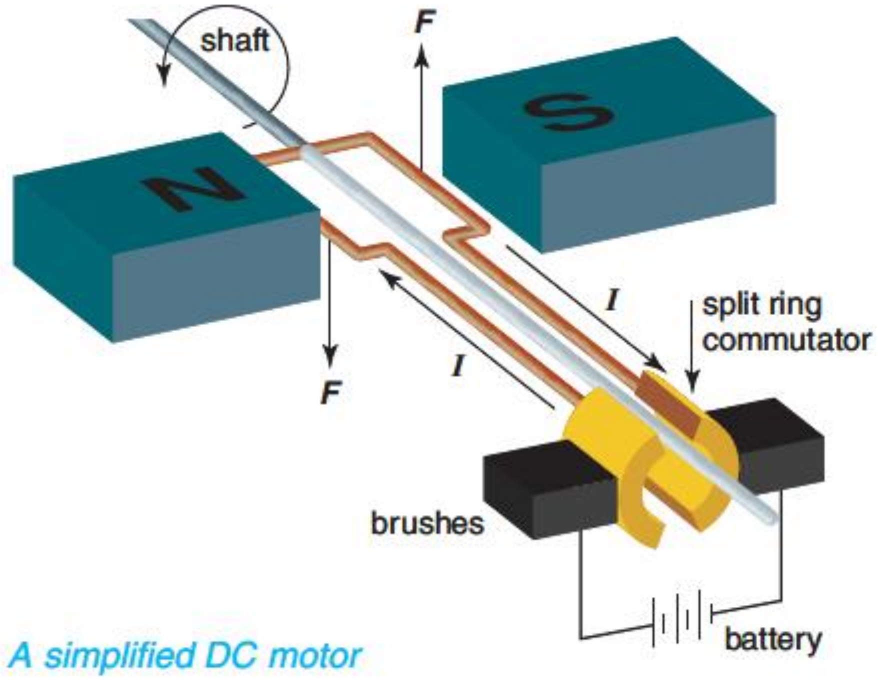
The shape of this field is similar to that of a bar magnet. The ends of the solenoid can be labeled north and south.
The field emerges from the north end. Looking from this end along the axis, the current is seen to be travelling anticlockwise. The other end is opposite.
We use the right hand grip rule with the solenoid

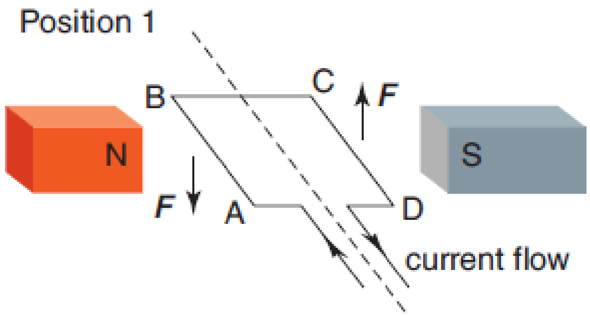
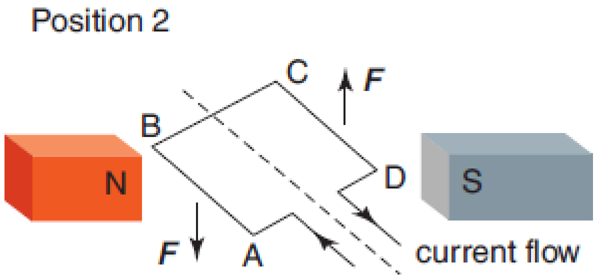
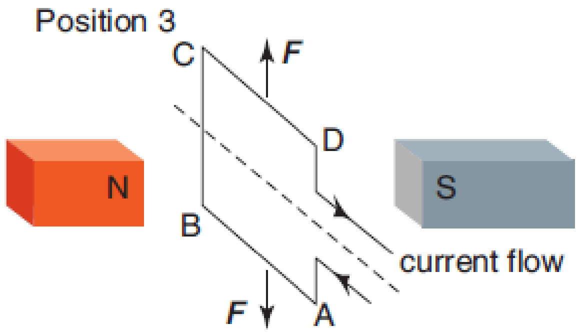
But Wait- I have found a way to do this with another rule

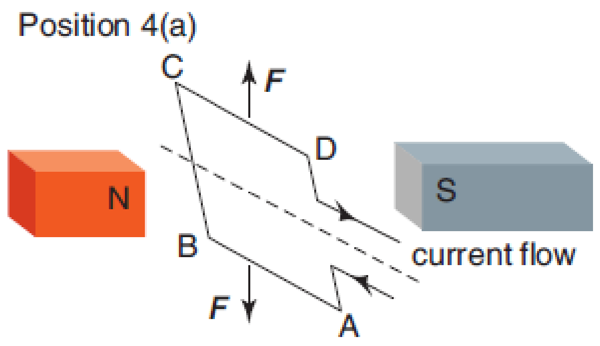
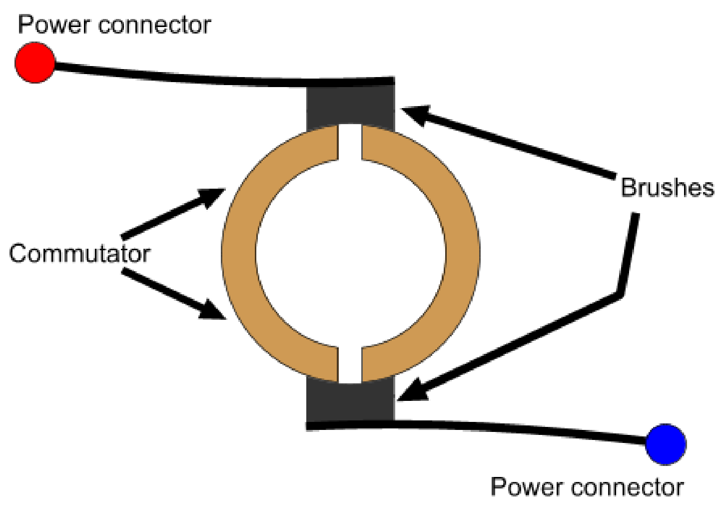
This time for solenoids we still use the right hand but the **thumb is direction of field**-N and the fingers curl in the direction of the conventional current

	 Pay particular attention to diagram below  Another diagram  So use this rule for solenoids and for straight wire use the other rule
Magnetic force	From Oersted experiments and the experiments of others we found that there was a relationship between magnetic field and current. We knew that a current created a magnetic field around a wire, we found a relationship of the magnetic force that was being created. It is summed up in the following formula below Experiment shows us that the force is proportional to: • The current; • The strength of the magnetic field ; • The length of wire within the magnetic field. This is summed up in a simple formula:

	$F = BiL$ [B – magnetic field strength; i – current in A; L – length in m] The term B is called the **magnetic field strength**, or the **flux density**, and is measured in Tesla, T. The magnetic flux density can be thought of as the concentration of field lines. We can increase the force by increasing any of the terms within the equation. If we coil up the wire, we increase its length within the magnetic field. This relationship is true as long as the current is $90°$ to the magnetic field. If the wire is at an angle to the field, the relationship takes this into account by changing to $F = BiL\sin\theta$ So looking at the formula and through experiments we know ▪ If strength of magnetic field increases there is a larger force on the wire ▪ It is only the component of the magnetic field that is perpendicular to the current that causes a force. ▪ If there are more wires in the magnetic field there is a larger force So the magnetic force on a current (F) = number of wires (n) ×current in each wire (I)×strength of the magnetic field (B) $F = n \times B \times i \times L$
How do we find the direction of the force?	Many rules but we will use the Right hand slap rule **RIGHT HAND SLAP RULE**  The fingers-out straight-show the magnetic field-B The thumb show the current-I The palm of the hand represents the force-F How to do it? Hold your hand flat with the fingers stereteched and the thumb out to the side. Now rotate your hand so that the field and current line up with the direction in your problem. The palm of your hand givers the direction of the force. Try it on the problem below

	 So the wire should move upwards
DC Motors application	One of the practical application of this is the use of DC motor  A DC moter uses the current from a battery flowing through a coil in a magnetic field to produce a continuous rotation of a shaft. How is this done? Let analyse it slowly and we will see the dynamics

Analysis of DC Part-1	This is the starting position  When the coil is in position 1 the forces will make it rotate. Remember on sides BA and CD experience a force since they are perpendicular to magnetic field , while the sides BC and AD do not experience a force (it is a torque really)
Part-2	Position 2  As the coil rotates, the force remain unchanged in size and direction.This is because the magnetic field and the current in the wire are still the same size. However their lines of action are closer to the axle, so they have a less turning effect.
Part-3	Position 3  When the coil reaches the position 3, at right right angles to the magnetic field, the forces are still unchanged in size and direction but in this case the lines of action of the forces pass through the axle and have no turning effect. But since the coil was already moving before it got to position 3 the momentum of its rotation will carry it beyond position 3 to positon 4

Part-4	Position 4  In position 4a the current is still travelling in the same direction so in this position the forces will act to bring the coil back to position 3. If this was the design of a DC motor the coil would turn $90°$ and then stop. If the coil was in position 3 when the battery was first connected the coil would not even move.
Part-5	So if the motor is to continue to turn it needs to be modified, this is done by reversing the direction of the current every time it reaches this position- every $180°$ The reversal is done with a commutator.
What is a commutator	It is a device that reverses the direction of the current. The commutator is made up of two semicircular metal pieces attached to the axle with a small insulating space between their ends. The ends of the coil are soldered to these metal pieces. Wires from the battery rest against the commutator pieces. As the axle turns these pieces turn under the battery contacts called brushes. This enables the current through the coil to change direction every time the insulating spaces pass the contacts.
	A better explanation of a commutator This kind of DC motor is called "Brushed DC motor". Why? Because it uses brushes... The brushes are the way that the motor provides the coils with power, and the geometrical characteristics and position of the brushes (and the commutator of course) will be responsible for changing the magnetic field of the two electromagnets according to the position of the rotor. So, how this is done? The brushes are two metallic pieces that act like springs. On one side, they have a piece of conductive material, usually made of carbon to stand against friction. On the other side, they have the pin that the power supply is applied to the motor. The brushes are pushed (by the spring action of the metallic part) against the commutator. The commutator is a metallic ring, also conductive and able to stand friction, that is divided in two parts. The following drawing explains how these parts are:  The commutator is fixed on the shaft of the motor. Each semi-ring has one pole of each coil. Giving thus power to both half-rings, is like giving power to the coils. But while the

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<td>shaft of the motor rotates, the commutator rotates as well. This causes the poles of the power supply provided to the coils to change. This change of the electric poles, has an affect on the magnetic poles as well. The current direction is changed and - due to the rule of the right-hand screw - the poles of the electromagnets will also change.</td>
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<tr>
<td>Inside a DC motor</td>
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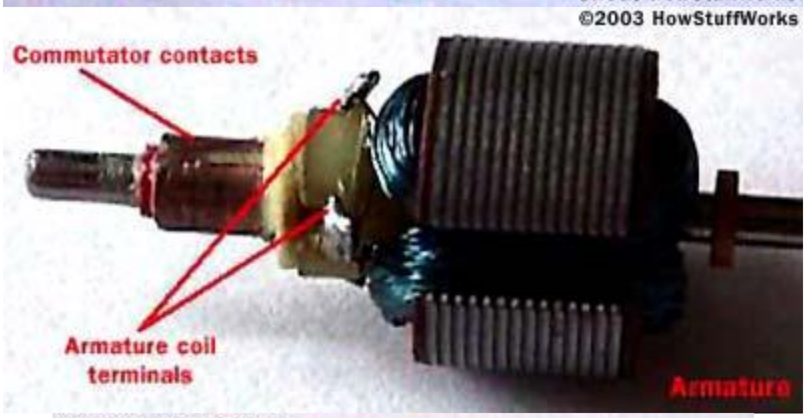

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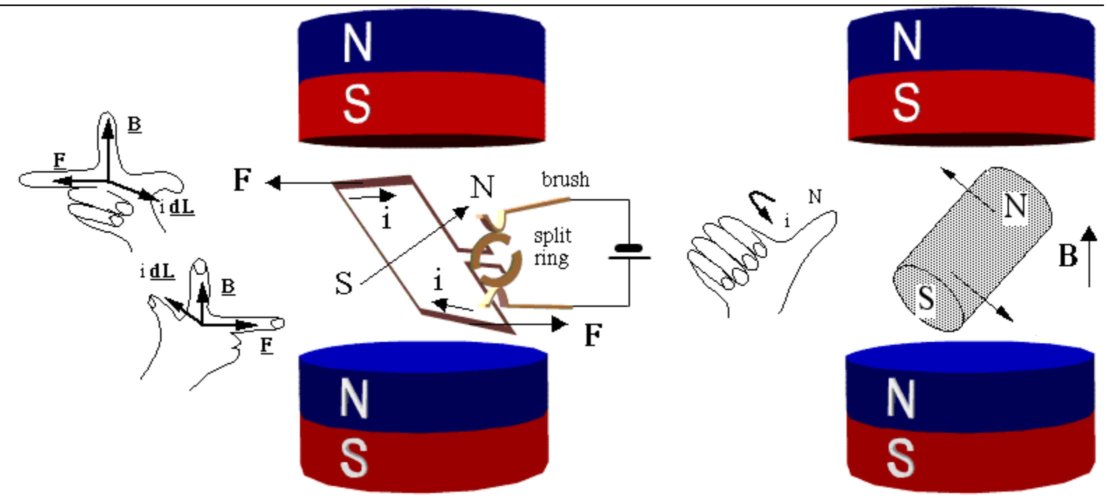
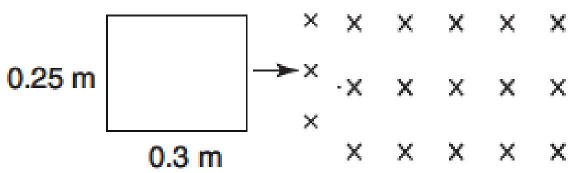
A few more explanations	
Important animations to see	Important at this point to view the following animations which will help students understand the dynamics better Go to the animation section http://www.animations.physics.unsw.edu.au/ Next go through the animations relating to electricity and magnetism Pay particular attention to the following 1. Electric motors and generators 2. Power 3. Transformers This link below takes you directly to motors section http://www.animations.physics.unsw.edu.au/jw/electricmotors.html#DCmotors Here are some other animations http://www.walter-fendt.de/ph14e/electricmotor.htm This page has quite a few animations that we can use http://www.walter-fendt.de/ph14e/ **Also go to this site** http://pcbheaven.com/wikipages/How_DC_Motors_Work/
	GENERATING VOLTAGE WITH A MAGNETIC FIELD
	Now we saw that a current creates a magnetic field but what would happen if we moved a wire in a magnetic field could we get a current? The answer is YES The current that is created and by extension the voltage that exists in the wire only lasts as long as there is movement. The person who discovered this was Faraday and he found that the relationship between emf and magnetic field was given by the following equation $\varepsilon = \frac{\Delta\phi}{\Delta t}$ When magnetic flux changes, an emf or voltage is induced, created. Obviously we need to define what we mean by magnetic flux

First definition of magnetic flux	Flux is the amount of magnetic field that flows through an area that is perpendicular to the field lines. $\phi = B_{\perp} \times A$ ▪ When all the area is perpendicular to the magnetic field lines the flux is a maximum ▪ When none of the area is perpendicular to the magnetic field lines the flux is zero ▪ In between these two extreme positions the flux changes from maximum to zero ▪ Magnetic flux can be positive or negative depending on which side of the area the magnetic field is coming from. The units of flux are-webers. (1Wb = amount of magnetic flux from a uniform magnetic field of strength 1 tesla passing through 1 metre square)
Now returning back to induced emf	Now we can use the concept of magnetic flux can be used to explain how the induced emf is created. The emf created depends: 1. If the magnetic flux passing through the coil changes 2. The size of the emf depends on how quickly the amount of magnetic flux changes $$\varepsilon = \frac{\Delta\phi}{\Delta t}$$ This is called Faraday’s law. Now if you get a voltage induced you also get a current induced as well. The direction this current flows is given by Lenz’s law which states: “The direction of the induced current is such that its magnetic field is in the opposite direction to the change in magnetic flux” – do not worry about this at this moment but this is shown with a negative sign in the formula as follows $$\varepsilon = -\frac{\Delta\phi}{\Delta t}$$ And if the coil consists of several turns of wire then the equation can be generalized further with the following formula $\varepsilon = -\frac{n\Delta\phi}{\Delta t}$, where , n = number of turns of the wire
Example	A rectangular loop shown below takes 2 seconds to fully enter a perpendicular magnetic field of 0.5 T strength. a) What is the magnitude of the emf induced in the loop? b) In which direction does the current flow around the loop?  Solution Step -1- Find the change in flux $\Delta\phi = B_{final} - B_{initial}$ Now we work out the flux for each stage $\Delta\phi = (0.5 \times .25 \times .3) - (0 \times .25 \times .3)$ $\Delta\phi = 0.0375$ Now remember to use faradays law

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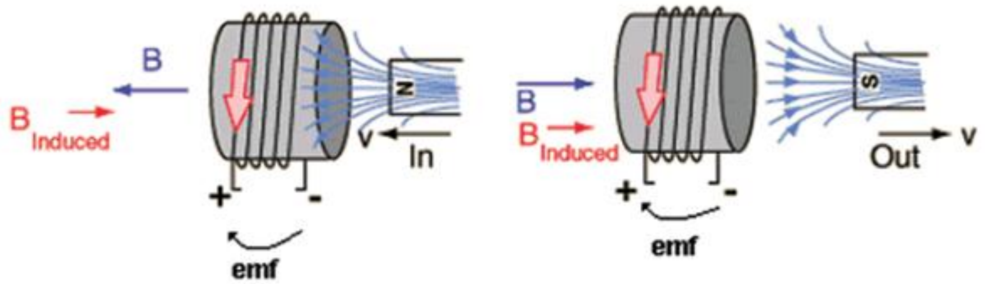
$$\varepsilon = -\frac{\Delta\phi}{\Delta t}$$

Put the things into (ignore the negative sign at this moment)

$$\varepsilon = \frac{0.0375}{2} = 0.01875$$

So the induced voltage is 0.01875 V
Now remember the negative signs indicates that the induced emf opposes the change in magnetic flux

b)
Change in flux = final – initial = flux into the page
So direction of induced magnetic field = out of page (Lenz's law)
Direction of induced current = anticlockwise using the right hand grip rule
</td></tr>
<tr><td>Remember the right hand grip rule to find direction</td><td>

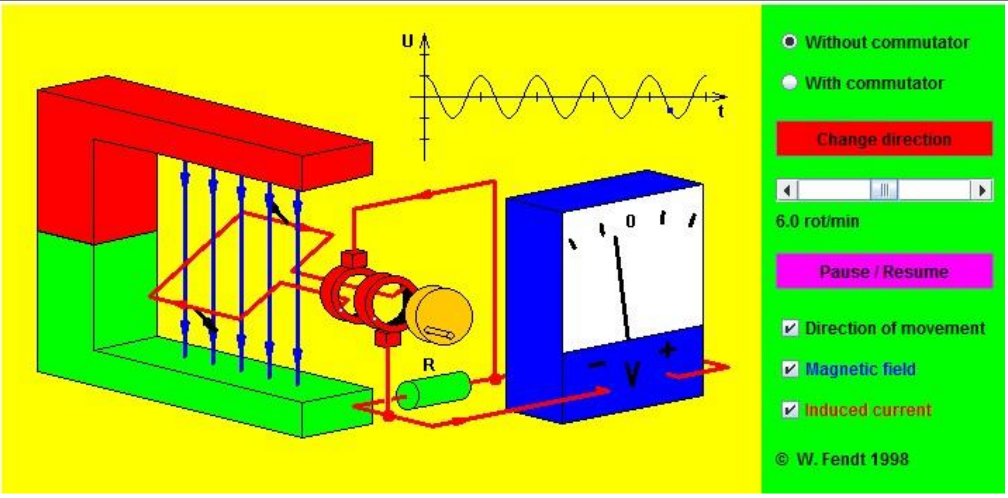
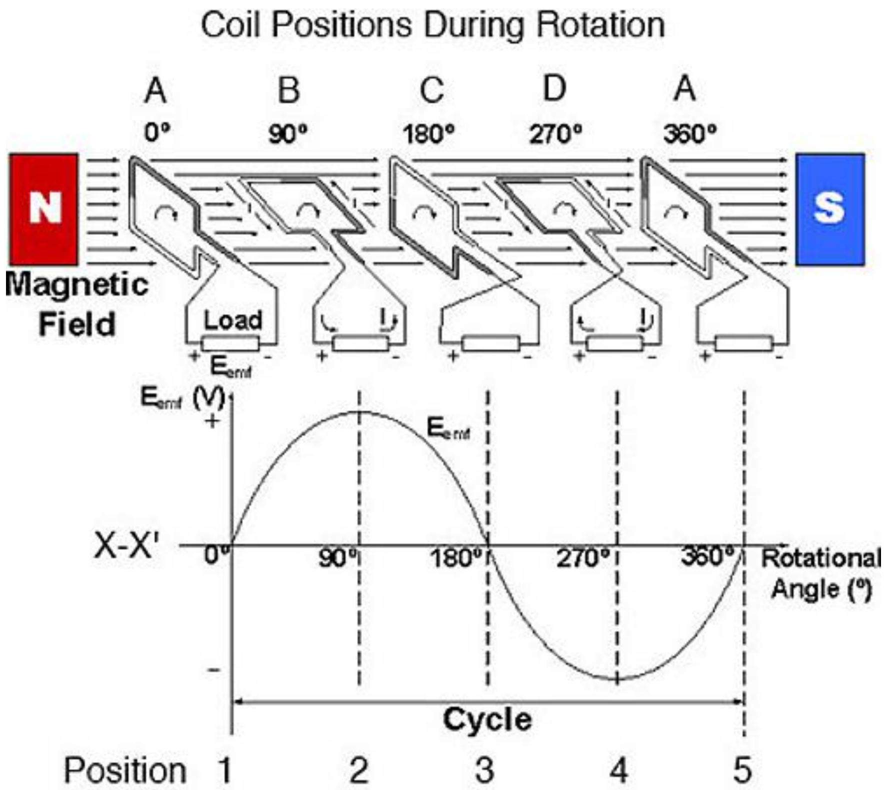


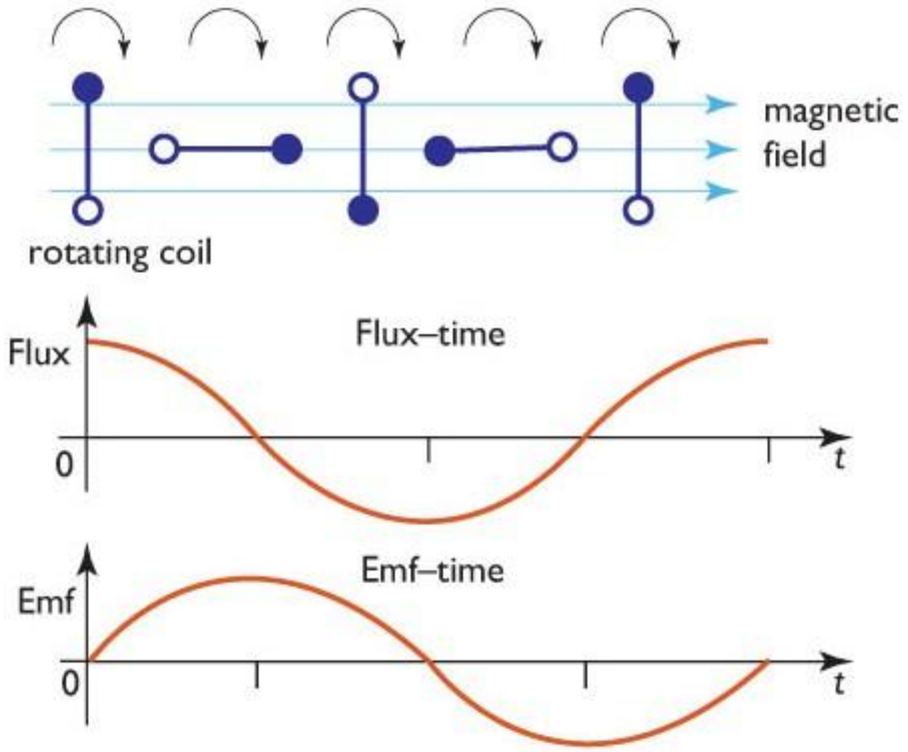
Use the right hand grip rule with the thumb showing the magnetic field (N) and the fingers showing the direction of the induced current.
WILL EXPLAIN A BIT MORE LATER ON
</td></tr>
<tr><td>The shape of the flux and emf produced if a coil is rotated in a magnetic field</td><td>

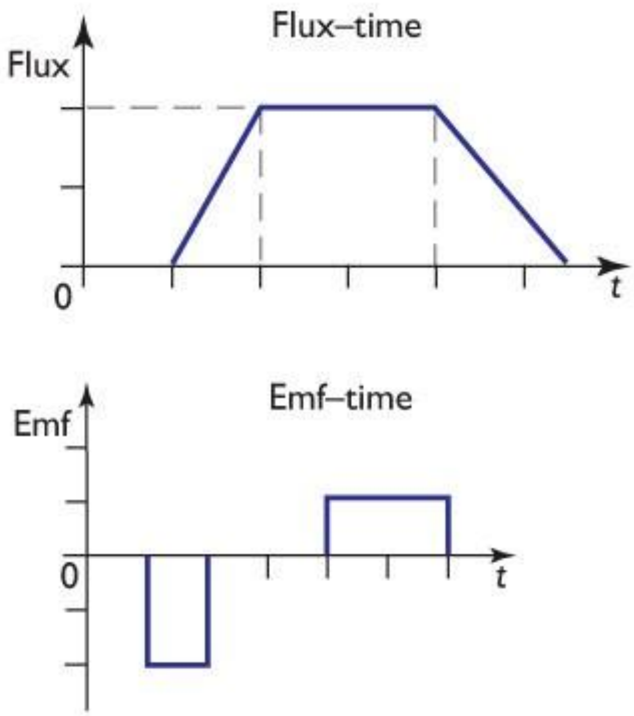
Remember how the DC motor rotated in a magnetic field. Well we can turn a coil in a magnetic field and get emf induced and in turn an current induced. This is a generator in essence. IF w e can get the coil to rotate then we can produce electricity.The electricity produced would be AC since it would alternate

Check out this animation of a generator

http://www.walter-fendt.de/ph14e/generator_e.htm
An electric generator is a device or machine that is used to convert mechanical energy into electrical energy. It is based on the principle of electromagnetic induction, a scientific law that was discovered by British scientist Michael Faraday and American scientist Joseph Henry in 1831. The principle states that when an electric conductor, such as a copper wire, is moved through a magnetic field, electric current will flow through the conductor. The mechanical energy of the moving wire is converted into the electric energy. Faraday and Henry also found that when you move a magnet in a coil of wire, electric current is generated.
</td></tr>
</table>

	 Notice we are using slip rings- in other words we are not using a commutator The graph shows the emf induced and it follows a sine graph.
Relationship between emf induced and flux	 In the loop diagrams below, the loop is rotating in a clockwise direction. At position A, the top leg (black) is moving toward the south pole, and the lower leg (white) toward the north pole. In position A, no flux lines are being cut since both legs are moving parallel to the lines of flux. Since no flux is cut, no voltage is induced. In position B, the loop has rotated 1/4 of a turn (90°). The black leg is now moving downward, and the white leg is moving upward. In this position, both legs are cutting across a maximum number of lines of flux, and the emf is maximum. At position C the loop has rotated 1/2 of a turn. The two legs are once more moving parallel to the lines of flux, and again no voltage is induced. At position D, the black leg is moving upward, and white leg downward. Both legs are again cutting a maximum number of lines of force, but in the direction opposite to that of position B. Since the legs are cutting the field in the opposite direction, the emf induced causes the current to flow in the opposite direction. The next 1/4 turn brings the loop back to position A, and the cycle starts over again.

<table>
<tr>
<td>Here is another diagram to show how flux and emf are related</td>
<td>Here is another diagram showing how the flux changes


Notice that the emf is at a maximum when the flux is zero
The emf is zero when the flux is at a maximum
So the induced emf is given by the gradient of the flux time graph


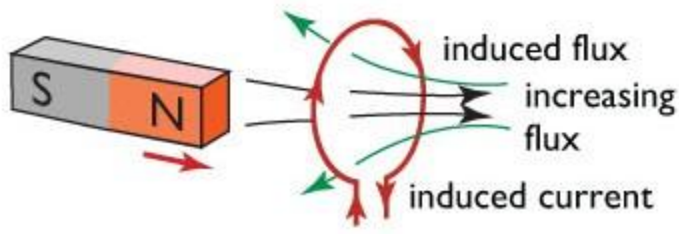
Look at the above diagram to verify the fact</td>
</tr>
<tr>
<td>What can we see then</td>
<td>When flux is zero, the flux time graph is steepest so the gradient is a maximum so emf is max
The amount of magnetic flux passing through the loop varies like a sine graph.
The induced emf is equal to the change of magnetic flux with time. So the induced emf is the gradient of the flux time graph</td>
</tr>
</table>

<table>
<tr><td></td><td></td></tr>
<tr><td>So how do we work out the direction of the current in the coil?</td><td>
We can use the right hand grip rule remember that thumb points in direction of N and fingers curl in the direction of the current

Lenz's law states- the induced current in the loop will be in such a direction that its magnetic flux will oppose the change in magnetic flux that produced it.

Examine the two situations below

Situation -1

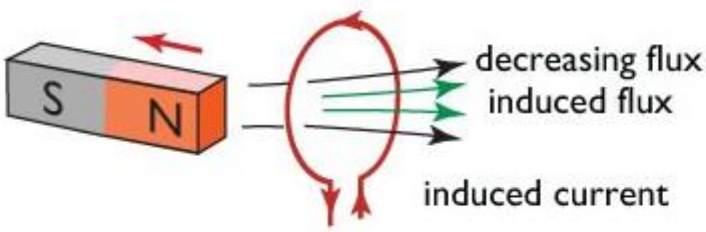


original flux increasing

Notice how the magnets North pole is approaching the loop. Hence we can say that the flux in the coil is increasing. So the induced magnetic field will be opposite in direction to the magnetic field

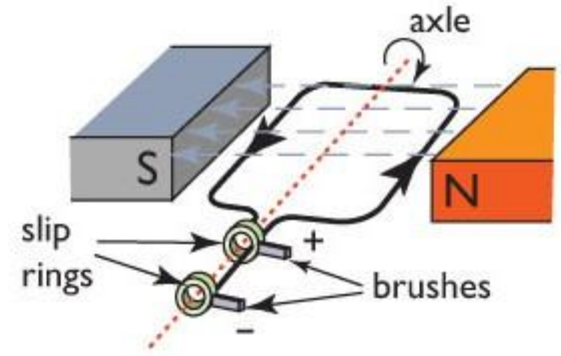
So a North magnetic field will be produced to push the magnet out, ie thereby oppose it.
Now use the right hand rule
Thumb point towards the Magnet coming in and the current will be going clockwise

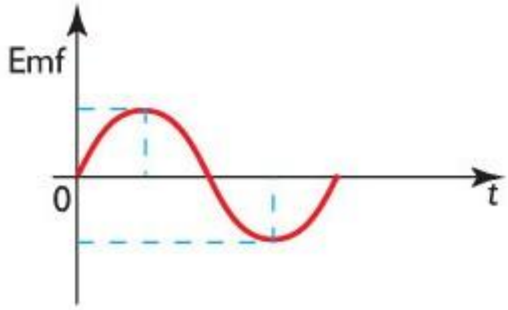
Situation -2

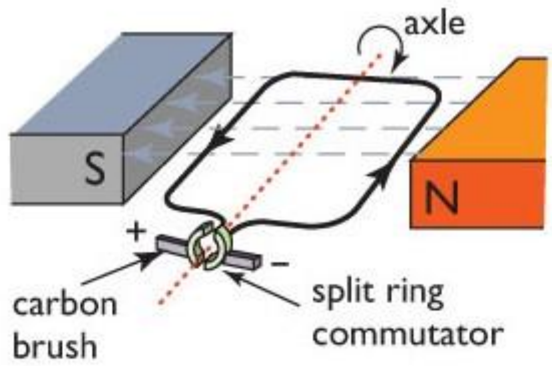


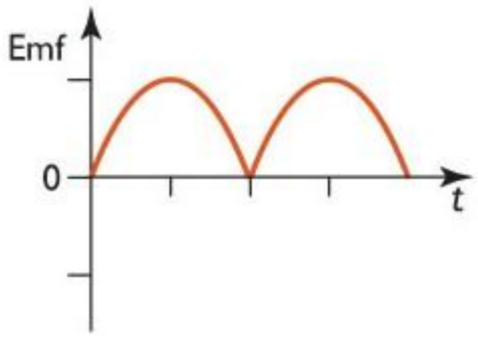
original flux decreasing

Explanation
Now the North power is moving away from the loop so the flux is decreasing. So the induced magnetic field will do the opposite it will try to attract that magnet, by creating a south pole
Then point the thumb to the right and the current is now moving anticlockwise
</td></tr>
<tr><td>The alternator</td><td>So a coil rotating in a magnetic field creates a sine wave emf. In an alternator the induced current is taken from the coil through slip rings rubbing against carbon brushes.
The output is an alternating current AC and the voltage that goes in one direction for half a cycle and then reverses direction for the next half cycle</td></tr>
</table>

<table>
<tr>
<td></td>
<td>


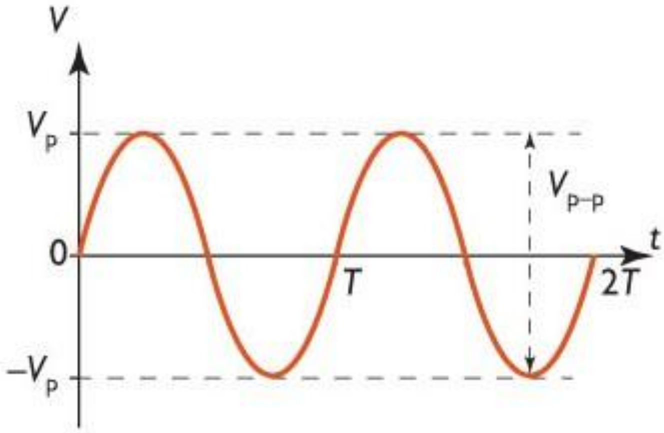


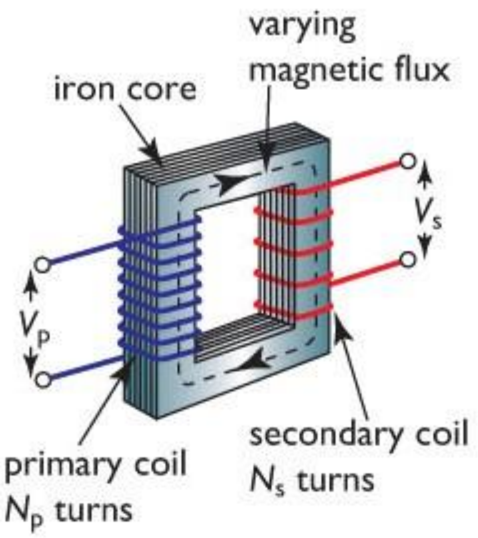
Notice the arrangement
</td>
</tr>
<tr>
<td>The DC generator</td>
<td>
In a DC generator the coil is connected to the output terminals through a split ring commutator.
This reverses the connection of the coil to the output terminals every half turn
We get the following emf induced.


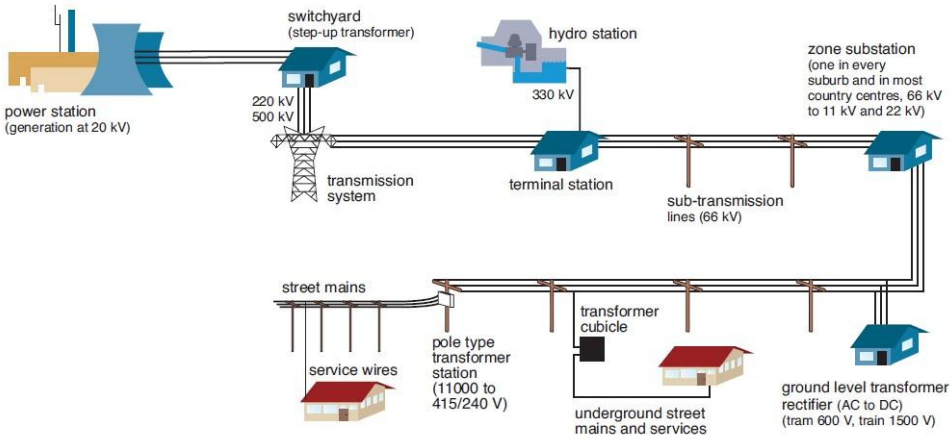


A DC generator is essentially the same as a DC motor run in reverse
</td>
</tr>
<tr>
<td>RMS values and AC power</td>
<td>
Since AC voltage varies we need to have a way of working out the average value. This is where RMS-root mean square value comes in useful. But a few facts before we get to it.

This below is a typical AC voltage wave form
</td>
</tr>
</table>

	 The **period (T)** is the time for one complete cycle . Here in Australia the frequency is 50 hz so then the period is $T = \frac{1}{f}$ so for Australia the period is $T = \frac{1}{50} = 0.02\sec$ **The frequency (f)** is the number of cycles in one second. For Australia $f = 50$ The Peak Voltage (V_p) is the amplitude of the waveform. In Australia $V_p = 339V$ The Peak to Peak voltage (V_{p-p}) is $V_{p-p} = 2V_p$ The Peak current that would flow through a resistor , R is $I_p = \frac{V_p}{R}$ Now returning to the root-mean-square, RMS. The RMS is the average power supplied over the complete cycle $$V_{RMS} = \frac{V_p}{\sqrt{2}}$$ $$I_{RMS} = \frac{I_p}{\sqrt{2}}$$ $$P_{RMS} = V_{rms} \times I_{rms}$$ The V_{RMS} represents the value of a steady DC voltage that provides the same average power as a AC supply. So in Australia the mains supply voltage has a peak voltage of 339 V and a RMS value of 240V Normally the quoted value of an AC voltage is usually its RMS value
Transformer	A transformer consists of an primary (input) coil of N_P turns and a secondary (output) coil of N_S How it works 1. It needs an AC input voltage to set up a changing current and therefore a changing magnetic field in the primary coil. 2. Then the iron core conducts this changing magnetic flux through the secondary coil which in turn induces a AC voltage at the output. 3. If a DC voltage is used in the input then NO induced voltage and thereby no changing magnetic flux is created and it does not work.

	 The main formula are Assuming that no energy is lost between input and output then we have the following Power supplied at input = Power drawn at the output $$V_P I_P = V_S I_S$$ Normally we write these formula this way $$\frac{V_P}{V_S} = \frac{I_S}{I_P} = \frac{N_P}{N_S}$$ Step up transformer- voltage at secondary is increased, which means current at secondary is decreased Step down transformer-voltage at secondary is decreased which means current at the secondary is increased
Why use transformers?	We create electricity at the power station then we step up the voltage high which means that the current will be low and transmit it over large distances. When it arrives at the city we then step it down and use the voltage but increase it current. Look at the diagram



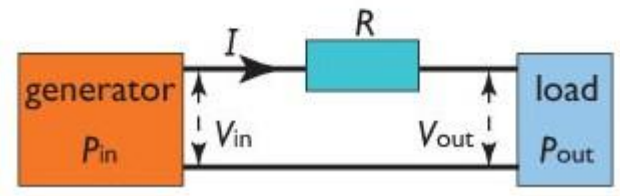
Let examine a few facts

The most practical way to reduce the power loss in a transmission line is to reduce the current and that is the reason why it must operate at a high voltage.

Now lines do have some resistance so we can find the power loss in the transmission lines by using the equation

$P_{loss} = I^2 R$

Let examine the following diagram



So a generator operating at a voltage V_{IN} supplies power P_{IN} .

The load is connected to the generator by a transmission line of two long wires with a total resistance of R

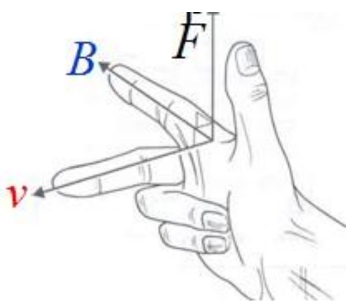
The the current in the line is $I = \frac{P_{IN}}{V_{IN}}$

The voltage drop across the line is $V_{DROP} = I \times R$

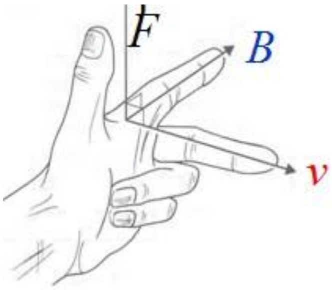
$V_{OUT} = V_{IN} - V_{DROP} = V_{IN} - IR$

The End of the Unit

The direction for negative charges given by Fleming right hand rule

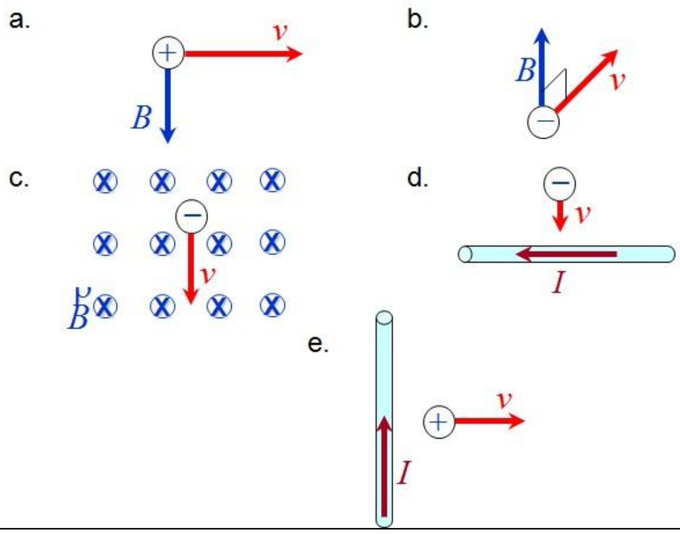


The direction of the magnetic force on a positive charge can be given by Fleming left hand rule below

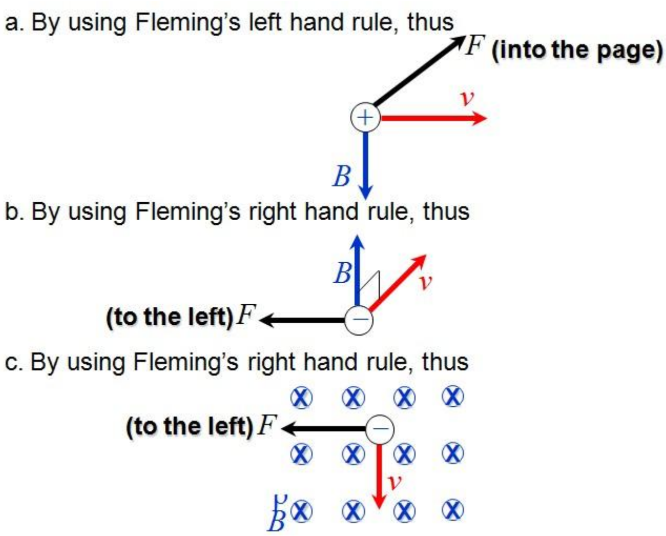


Thumb-direction of force
First finger-direction of the field
Second finger-direction of velocity

Problems to try the new rules

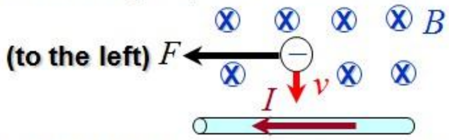


Solution



Solution :

d. Using right hand grip rule to determine the direction of magnetic field produces by the current I on the charge position. Then apply the Fleming's right hand rule, thus



e. Using right hand grip rule to determine the direction of magnetic field forms by the current I on the charge position. Then apply the Fleming's left hand rule, thus