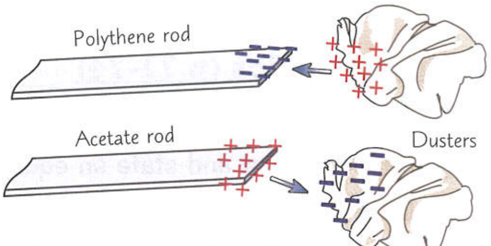
Static Electricity

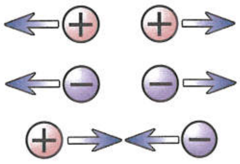
Static electricity builds up on insulating materials and often ends with a spark or a shock.

Build-up of Static is Caused by Friction



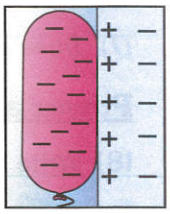
1) When certain insulating materials are rubbed together, negatively charged electrons will be scraped off one and dumped on the other.
2) As the materials are insulators, these electrons are not free to move — this build up of charge is static electricity. The materials become electrically charged, with a positive static charge on the one that has lost electrons and an equal negative static charge on the other.
3) Which way the electrons are transferred depends on the two materials involved. But whether an object has a positive or negative charge, it's always the negative electrons that have moved.
4) The classic examples are polythene and acetate rods being rubbed with a cloth duster (shown above).

Like Charges Repel, Opposite Charges Attract



1) Electrically charged objects exert a force on one another.
2) Two things with opposite electric charges are attracted to each other, while two things with the same electric charge will repel each other.
3) These forces get weaker the further apart the two things are.
4) One way to see these forces is to suspend a rod with a known charge from a piece of string (so it is free to move). Placing an object with the same charge nearby will repel the rod — the rod will move away from the object. An oppositely-charged object will attract the rod, causing it to move towards the object.

Electrically Charged Objects can Attract Uncharged Objects



1) Rubbing a balloon against your hair or clothes transfers electrons to the balloon, leaving it with a negative charge. If you then hold the balloon against a wall it will stick, even though the wall isn't charged.
2) That's because the charges on the surface of the wall can move a little — the negative charges on the balloon repel the negative charges on the surface of the wall.
3) This leaves a positive charge on the surface, which attracts the negatively charged balloon. This is called attraction by induction. And there are plenty more examples of it, too...
4) If you run a comb through your hair, electrons will be transferred to the comb making it negatively charged. It can then be used to pick up little pieces of uncharged paper — holding it near the little pieces of paper causes induction in the paper, which means they jump up and stick to the comb.

Too Much Static Causes Sparks

For more on how sparks actually jump across gaps, see page 84.

1) As electric charge builds on an object, the potential difference between the object and the earth (which is at 0 V) increases.
2) If the potential difference gets large enough, electrons can jump across the gap between the charged object and the earth — this is the spark.
3) They can also jump to any earthed conductor that is nearby — which is why you can get static shocks from clothes, or getting out of a car.
4) This usually happens when the gap is fairly small. (But not always — lightning is just a really big spark.)

Stay away from electrons — they're a negative influence...

Electrons jumping about the place and giving us all shocks, the cheeky so-and-sos.

Q1 Jake removes his jumper in a dark room. As he does so, he hears a crackling noise and sees tiny sparks of light between his jumper and his shirt. Explain the cause of this. [3 marks]

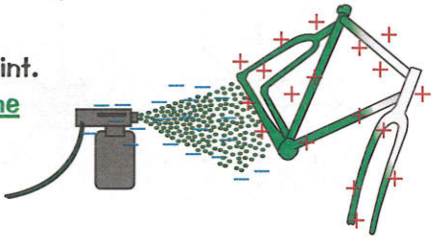
Uses and Dangers of Static Electricity

Static electricity can be a bit of a nuisance sometimes, but it also has some good uses, e.g. in industry. But don't get too happy clappy about how wonderful static electricity is — it can be pretty dangerous too.

Static Electricity Is Used in Electrostatic Sprayers

1) Photocopiers use static electricity to copy images onto a charged plate before printing them.
2) Static electricity can be used to reduce the dust and smoke that rises out of industrial chimneys.
3) Another use of static electricity is electrostatic sprayers:

- Electrostatic sprayers are used in various industries to give a fine, even coat of whatever's being sprayed. The classic examples are insecticide sprayers and paint sprayers.
- Bikes and cars are painted using electrostatic paint sprayers.
- The spray gun is charged, which charges up the small drops of paint. Each paint drop repels all the others, since they've all got the same charge, so you get a very fine, even spray.
- The object to be painted is given an opposite charge to the gun. This attracts the fine spray of paint.

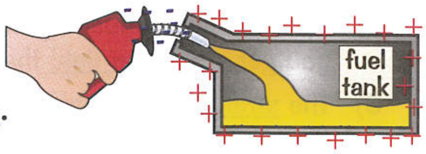


- This method gives an even coat and hardly any paint is wasted. In addition, parts of the bicycle or car pointing away from the spray gun still receive paint, i.e. there are no paint shadows.
- Insecticide sprayers work in a similar way, except the crops to be sprayed aren't given an opposite charge — the plants charge by induction as the insecticide droplets come near them (see p.82).

Static Electricity Can be Dangerous

Whilst there are some uses of static electricity, it can be inconvenient and sometimes even dangerous.

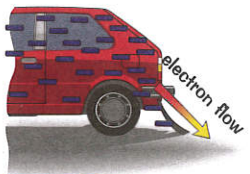
1) Refueling cars — as fuel flows out of a filler pipe, e.g. into an aircraft or tanker, then static can build up. This can easily lead to a spark (p.82) which might cause an explosion in dusty or fumey places — like when filling up a car with fuel at a petrol station.

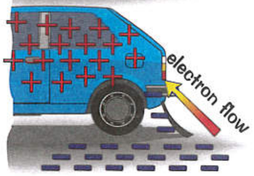


2) Static on airplanes — as planes fly through the air, friction between the air and the plane causes the plane to become charged. This build up of static charge can interfere with communication equipment.
3) Lightning — raindrops and ice bump together inside storm clouds, leaving the top of the cloud positively charged and the bottom of the cloud negative. This creates a huge voltage and a big spark, which can damage homes or start fires when it strikes the ground.
4) You can reduce some of these dangers by earthing charged objects (see below).

Objects Can be Earthed to Stop Electrostatic Charge Building Up

1) Dangerous sparks can be prevented by connecting a charged object to the ground using a conductor (e.g. a copper wire) — this is called earthing.
2) Earthing provides an easy route for the static charges to travel into the ground. This means no charge can build up to give you a shock or make a spark.
3) The electrons flow down the conductor to the ground if the charge is negative and flow up the conductor from the ground if the charge is positive.
4) Fuel tankers must be earthed to prevent any sparks that might cause the fuel to explode.





I know, I know — yet another shocking joke...

As useful as static electricity can be, you've got to be aware of the dangers — and how to prevent them.

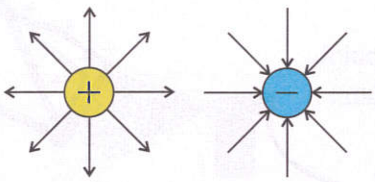
Q1 Give two uses of static electricity. [2 marks]

Electric Fields

Electric fields — much less green and much more shocking than the fields you're used to.

Electric Charges Create an Electric Field

1) An electric field is created around any electrically charged object. It's the region around a charged object where, if a second charged object was placed inside it, a force would be exerted on both of the charges (see below).
2) The closer to the object you get, the stronger the field is. (And the further from it, the weaker it is.)
3) You can show an electric field around an object using field lines. For example, you can draw the field lines for an isolated (i.e. not interacting with anything) point charge:

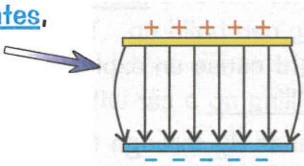


- Electric field lines go from positive to negative.
- They're always at a right angle to the surface.
- The closer together the lines are, the stronger the field is — you can see that the further from a charge you go, the further apart the lines are and so the weaker the field is.

Draw at least eight equally spaced field lines.

Electric Fields Cause Electrostatic Forces

1) When a charged object is placed in an electric field, it feels a force. This force is caused by the electric fields around two charged objects interacting.
2) If the field lines between the charged objects point in the same direction, the field lines 'join up' and the objects are attracted to each other.
3) When the field lines between the charged objects point in opposite directions, the field lines 'push against' each other and the objects repel each other.
4) Between two oppositely-charged parallel plates, you get a uniform field that looks like this.
5) The strength and direction of the field is the same anywhere between the two plates (it's only different at the very ends).



If you need to draw electric fields, don't forget the arrows on your field lines.

When you're drawing a uniform field, you need to show at least three field lines, parallel and all the same distance apart.

Sparking Can Be Explained By Electric Fields

1) When an object becomes statically charged, it generates its own electric field.
2) Interactions between this field and other objects are the cause of events like sparking.
3) For example, for the comb from p.82 — after it's been run through your hair, it's charged and so produces an electric field. This electric field interacts with the pieces of paper (without touching them) and so they feel a force.
4) This force causes them to move towards the comb (and some will even stick to it).
5) Sparks are caused when there is a high enough potential difference between a charged object and the earth (or an earthed object). A high potential difference causes a strong electric field between the charged object and the earthed object.
6) The strong electric field causes electrons in the air particles to be removed (known as ionisation).
7) Air is normally an insulator, but when it is ionised it is much more conductive, so a current can flow through it. This is the spark.

Electric felines — lines between charged cats...

Electric fields may seem a bit weird at first — but the good news is they're very similar to magnetic fields (which are over on the next page), so if you understand one of them, you can understand them both.

Q1 Draw the field lines surrounding an isolated, uniform, positively-charged sphere. [3 marks]

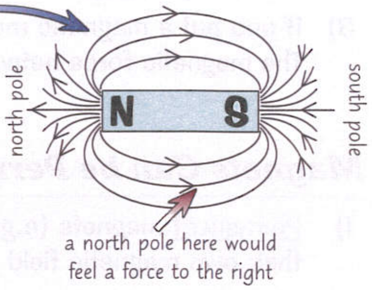
Magnets and Magnetic Fields

I think magnetism is an attractive subject, but don't get repelled by the exam — revise.

Magnets Produce Magnetic Fields

1) All magnets have two poles — north and south.
2) All magnets produce a magnetic field — a region where other magnets or magnetic materials (see next page) experience a force.
3) You can show a magnetic field by drawing magnetic field lines.
4) The lines always go from north to south and they show which way a force would act on a north pole at that point in the field.
5) The closer together the lines are, the stronger the magnetic field.
6) The further away from a magnet you get, the weaker the field is.
7) The magnetic field is strongest at the poles of a magnet. This means that the magnetic forces are also strongest at the poles.

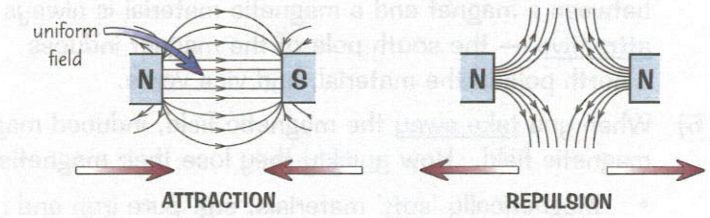
To see the shape of a magnetic field, place a piece of card over a magnet and sprinkle iron filings onto it. The filings line up with the field lines — but they won't show you the direction of the field.



a north pole here would feel a force to the right

Magnetic Fields Cause Forces between Magnets

1) Between two magnets the magnetic force can be attractive or repulsive. Two poles that are the same (these are called like poles) will repel each other. Two unlike poles will attract each other.
2) Placing the north and south poles of two bar magnets near each other creates a uniform field between the two poles. The magnetic field is the same strength everywhere between the poles.
3) If you're asked to draw a uniform magnetic field, you need to draw at least three field lines, parallel to each other and all the same distance apart.

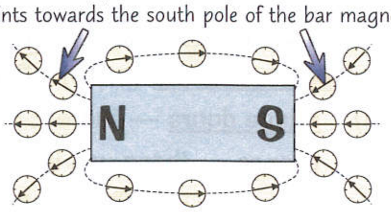


Don't forget the arrows on your field lines.

Plotting Compasses Show the Directions of Magnetic Fields

1) Inside a compass is a tiny bar magnet called a needle. A compass needle always lines up with the magnetic field it's in.
2) You can use a compass to build up a picture of what the field around a magnet looks like:
   - Put the magnet on a piece of paper and draw round it.
   - Place the compass on the paper near the magnet. The needle will point in the direction of the field line at this position.
   - Mark the direction of the compass needle by drawing two dots — one at each end of the needle.
   - Then move the compass so that the tail end of the needle is where the tip of the needle was in the previous position and put a dot by the tip of the needle. Repeat this and then join up the marks you've made — you'll end up with a drawing of one field line around the magnet.
   - Repeat this method at different points around the magnet to get several field lines. Make sure you draw arrows from north to south on your field lines.
3) When they're not near a magnet, compasses always point towards the Earth's North Pole. This is because the Earth generates its own magnetic field (and the North Pole is actually a magnetic south pole). This shows the inside (core) of the Earth must be magnetic.

The compass follows the field lines and points towards the south pole of the bar magnet.



Magnets are like farmers — surrounded by fields...

Magnetism is one of those things that takes a while to make much sense. Learn these basics — you'll need them.

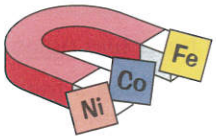
Q1 Draw the magnetic field lines for a bar magnet. Label the areas where the field is strongest. [3 marks]

Q2 Describe how to plot the magnetic field lines of a bar magnet using a compass. [4 marks]

Permanent and Induced Magnets

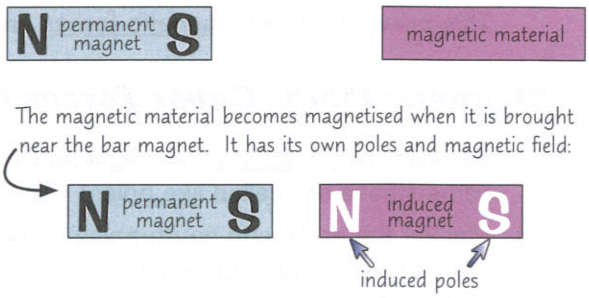
Magnetic fields don't just affect magnets — they affect a few special magnetic materials too.

Very Few Materials are Magnetic



1) The main three magnetic elements are iron, nickel and cobalt.
2) Some alloys and compounds of these metals are also magnetic.
For example, steel is magnetic because it contains iron.
3) If you put a magnetic material near a magnet, it is attracted to that magnet.
The magnetic force between a magnet and a magnetic material is always attractive.

Magnets Can be Permanent or Induced



The magnetic material becomes magnetised when it is brought near the bar magnet. It has its own poles and magnetic field:

1) Permanent magnets (e.g. bar magnets) produce their own magnetic field all the time.
2) Induced (or temporary) magnets only produce a magnetic field while they're in another magnetic field.
3) If you put any magnetic material into a magnetic field, it becomes an induced magnet.
4) This magnetic induction explains why the force between a magnet and a magnetic material is always attractive — the south pole of the magnet induces a north pole in the material, and vice versa.
5) When you take away the magnetic field, induced magnets return to normal and stop producing a magnetic field. How quickly they lose their magnetism depends on the material they're made from.
   - Magnetically 'soft' materials, e.g. pure iron and nickel-iron alloys, lose their magnetism very quickly.
   - Magnetically 'hard' materials, e.g. steel, lose their magnetism more slowly.
   Permanent magnets are made from magnetically hard materials.

Magnetic Materials have Lots of Uses

There are many different uses of magnetic materials, the number of which has grown since the invention of electromagnets (p.88). For example:

1) Fridge doors — there is a permanent magnetic strip in your fridge door to keep it closed.
2) Cranes — these use induced electromagnets to attract and move magnetic materials — e.g. moving scrap metal in scrap yards.
3) Doorbells — these use electromagnets which turn on and off rapidly, to repeatedly attract and release an arm which strikes the metal bell to produce a ringing noise.
4) Magnetic separators — these are used in recycling plants to sort metal items (like cans).
5) Maglev trains — these use magnetic repulsion to make trains float slightly above the track (to reduce losses from friction) and to propel them along.
6) MRI machines — these use magnetic fields to create images of the inside of your body without having to use ionising radiation (like X-rays, p.47).
7) Speakers and microphones — there's more about these on page 90.

Attractive and with a magnetic personality — I'm a catch...

Remember, induced magnets are also called temporary because they're only magnetic when in a magnetic field.

Q1 State three everyday uses of magnetic materials. [3 marks]

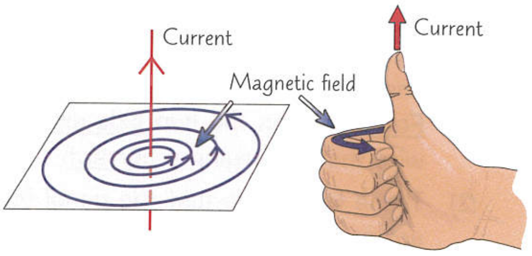
Q2 Give two differences between permanent and induced magnets. [2 marks]

Electromagnetism and the Motor Effect

On this page you'll see that a magnetic field is also found around a wire that has a current passing through it.

A Moving Charge Creates a Magnetic Field

1) When a current flows through a long, straight conductor (e.g. a wire) a magnetic field is created around it.
2) The field is made up of concentric circles perpendicular to the wire, with the wire in the centre.
3) Changing the direction of the current changes the direction of the magnetic field — use the right-hand thumb rule to work out which way it goes. (In experiments, you can use a plotting compass to find its direction, p.85.)
4) The larger the current through the wire, or the closer to the wire you are, the stronger the field is.



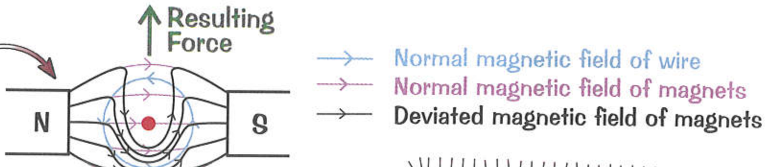
The Right-Hand Thumb Rule

Using your right hand, point your thumb in the direction of current and curl your fingers. The direction of your fingers is the direction of the field.

The Motor Effect — A Current in a Magnetic Field Experiences a Force

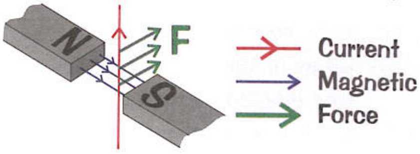
When a current-carrying conductor (e.g. a wire) is put between magnetic poles, the two magnetic fields interact. The result is a force on the wire.

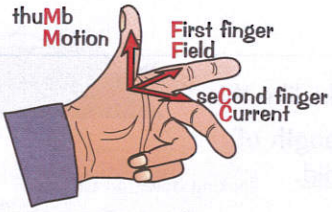
This is an aerial view. The red dot represents a wire carrying current "out of the page" (towards you). (If it was a cross ('×') then that would mean the current was going into the page.)



1) To experience the full force, the wire has to be at 90° (right angles) to the magnetic field. If the wire runs along the magnetic field, it won't experience any force at all. At angles in between, it'll feel some force.
2) The force always acts in the same direction relative to the magnetic field and the direction of the current in the wire. So changing the direction of either the magnetic field or the current will change the direction of the force.

The wire also exerts an equal and opposite force on the magnet (from Newton's Third Law, see p.19) but we're just looking at the force on the wire.





1) Fleming's left-hand rule is used to find the direction of the force on a current-carrying conductor.
2) Using your left hand, point your First finger in the direction of the magnetic Field and your seCond finger in the direction of the Current.
3) Your thuMb will then point in the direction of the force (Motion).

You Can Find the Size of the Force Using F = BIl

The force acting on a conductor in a magnetic field depends on three things:

1) The magnetic flux density — how many field (flux) lines there are in a region. This shows the strength of the magnetic field (p.85).
2) The size of the current through the conductor.
3) The length of the conductor that's in the magnetic field.

When the current is at 90° to the magnetic field it is in, the force acting on it can be found using the equation on the right.

Current (A)

Force (N)

$$F = B \times I \times l$$

Magnetic flux density (T, tesla or N/Am)

Length (m)

Left-hand rule for the motor effect — drive on the left...

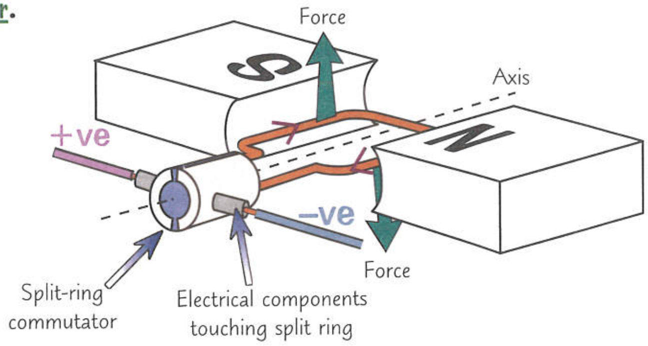
Learn the left-hand rule and use it — don't be scared of looking like a muppet in the exam.

Q1 A 35 cm long piece of wire is at 90° to an external magnetic field. The wire experiences a force of 0.98 N when a current of 5.0 A is flowing through it. Calculate the magnetic flux density of the field. [2 marks]

Motors and Solenoids

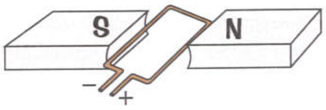
Electric motors might look a bit tricky, but it's really just applying the stuff you learnt on the previous page.

A Current-Carrying Coil of Wire Rotates in a Magnetic Field

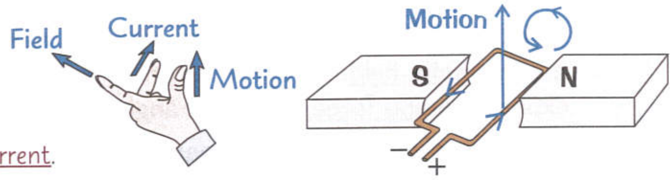


1) The diagram on the right shows a basic d.c. motor. Forces act on the two side arms of a coil of wire that's carrying a current.
2) These forces are just the usual forces which act on any current in a magnetic field (p.87).
3) These forces act in opposite directions on each side, so the coil rotates.
4) The split-ring commutator is a clever way of swapping the contacts every half turn to keep the motor rotating in the same direction.
5) The direction of the motor can be reversed either by swapping the polarity of the d.c. supply (reversing the current) or swapping the magnetic poles over (reversing the field).
6) You can use Fleming's left-hand rule to work out which way the coil will turn.

EXAMPLE: Is the coil turning clockwise or anticlockwise?

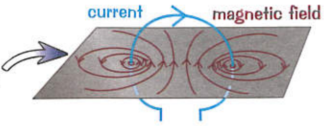


1) Draw in current arrows (from positive to negative, p.71).
2) Use Fleming's left-hand rule on one branch (here, I've picked the right-hand branch).
3) Point your first finger in the direction of the magnetic field (remember, this is north to south).
4) Point your second finger in the direction of the current.
5) Draw in the direction of motion (the direction your thumb is pointing in).

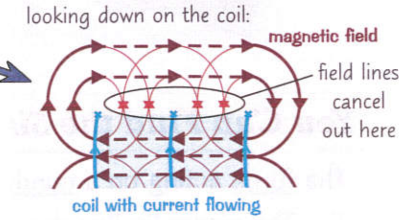


The coil is turning anticlockwise.

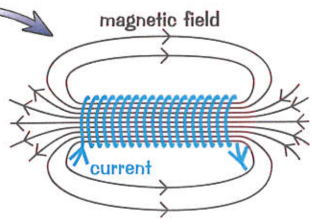
A Solenoid is a Long Coil of Wire



1) Around a single loop of current-carrying wire, the magnetic field looks like this:
2) You can increase the strength of the magnetic field produced by a length of wire by wrapping it into a long coil with lots of loops, called a solenoid.
3) The field lines around each separate loop of wire line up.
   - Inside the solenoid, you get lots of field lines pointing in the same direction. The magnetic field is strong and almost uniform.
   - Outside the coil, the overlapping field lines cancel each other out — so the field is weak apart from at the ends of the solenoid.



4) You end up with a field that looks like the one around a bar magnet. The direction of the field depends on the direction of the current (p.87).
5) A solenoid is an example of an ELECTROMAGNET — a magnet with a magnetic field that can be turned on and off using an electric current.
6) You can increase the field strength of the solenoid even more by putting a block of iron in the centre of the coil. This iron core becomes an induced magnet (see p.86) whenever current is flowing.



Give me one good raisin why I should make the currant joke...

Motors and solenoids are used in loads of everyday things from speakers to alarm clocks.

Q1 Sketch the magnetic field in and around a solenoid. [3 marks]

Electromagnetic Induction in Transformers

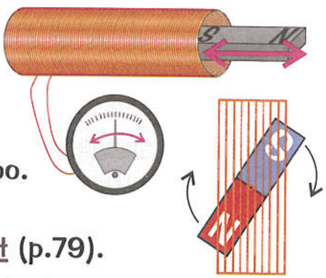
Transformers use electromagnetic induction — don't panic, it's not as bad as it sounds.

A Changing Magnetic Field Induces a Potential Difference in a Conductor

Electromagnetic Induction: The induction of a potential difference (and current if there's a complete circuit) in a wire which is experiencing a change in magnetic field.

Induces is a fancy word for creates.

1) There are two different situations where you get electromagnetic induction. The first is if an electrical conductor (e.g. a coil of wire) and a magnetic field move relative to each other.
   - You can do this by moving/rotating either a magnet in a coil of wire OR a conductor (wire) in a magnetic field ("cutting" magnetic field lines).
   - If you move or rotate the magnet (or conductor) in the opposite direction, then the p.d./current will be reversed. Likewise if the polarity of the magnet is reversed, then the potential difference/current will be reversed too.
   - If you keep the magnet (or the coil) moving backwards and forwards, or keep it rotating in the same direction, you produce an alternating current (p.79).

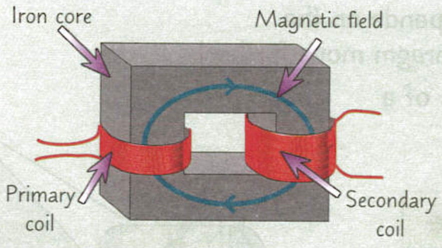


2) You also get an induced p.d. when the magnetic field through an electrical conductor changes (gets bigger or smaller or reverses). This is what happens in a transformer (below).
3) You can increase the size of the induced p.d. by increasing the STRENGTH of the magnetic field, increasing the SPEED of movement/change of field or having MORE TURNS PER UNIT LENGTH on the coil of wire.
4) The induced p.d./current always opposes the change that made it:
   - When a current is induced in a wire, that current produces its own magnetic field (p.87).
   - The magnetic field created by an induced current always acts against the change that made it. Basically, it's trying to return things to the way they were.

Transformers Change the p.d. — but Only for Alternating Current

1) Transformers use induction to change the size of the potential difference of an alternating current.
2) They all have two coils of wire, the primary and the secondary coils, joined with an iron core.
3) When an alternating p.d. is applied across the primary coil, it produces an alternating magnetic field.
4) The iron in the core is a magnetic material (see p.86) that is easily magnetised and demagnetised. Because the coil is producing an alternating magnetic field, the magnetisation in the core also alternates.
5) This changing magnetic field induces a p.d. in the secondary coil.

There's more about transformers on p.91.



STEP-UP TRANSFORMERS step the potential difference up (i.e. increase it). They have more turns on the secondary coil than the primary coil.

STEP-DOWN TRANSFORMERS step the potential difference down (i.e. decrease it). They have more turns on the primary coil than the secondary.

6) Transformers are almost 100% efficient. So you can assume that the input power is equal to the output power. Using $P = I \times V$ (page 78), you can write this as:

$$V_p \times I_p = V_s \times I_s$$

p.d. across primary coil (V)

Current through primary coil (A)

Current through secondary coil (A)

p.d. across secondary coil (V)

$V_p \times I_p$ is the power output at the primary coil. $V_s \times I_s$ is the power input at the secondary coil.

Transformers — NOT robots in disguise...

Make sure you know how transformers work, and then take a stab at using that equation with this question.

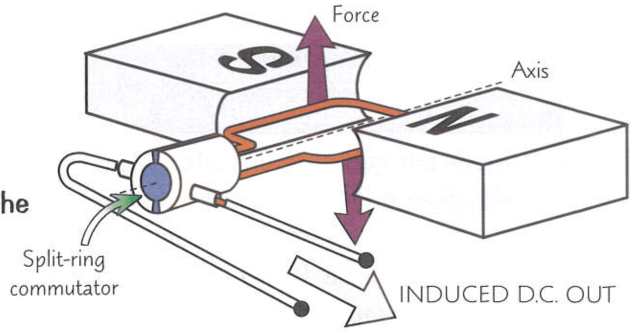
Q1 A transformer has an input potential difference of 1.6 V. The output power is 320 W. Calculate the input current. [2 marks]

Generators, Microphones and Loudspeakers

Generators make use of electromagnetic induction from the previous page to induce a current. Whether this current is alternating or direct depends on exactly how the generator's put together.

Dynamos Generate Direct Current

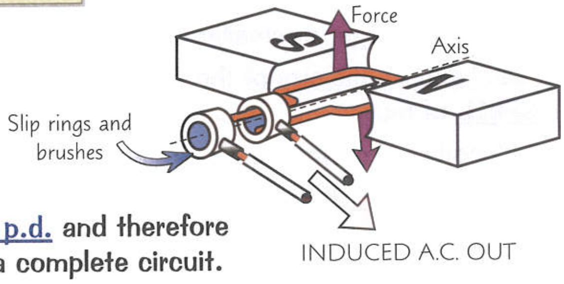
1) Generators apply a force to rotate a coil in a magnetic field (or a magnet in a coil) — their construction is a lot like a motor.
2) As the coil (or magnet) spins, a current is induced in the coil. This current changes direction every half turn.
3) Dynamos are d.c. generators. They have a split-ring commutator (like a d.c. motor, p.88).
4) This swaps the connection every half turn to keep the current flowing in the same direction.



The current induced in an alternator or dynamo will be greater if there are more turns of wire in the coil, the magnetic flux density is increased or if the speed of rotation is increased.

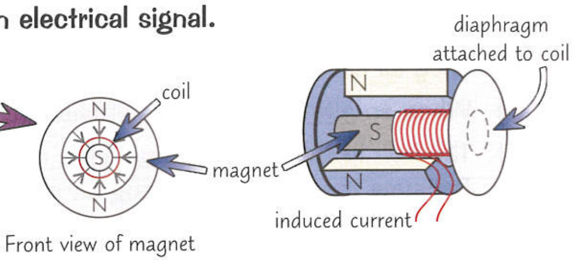
Alternators Generate Alternating Current

1) Alternators work in the same way as dynamos, apart from one important difference.
2) Instead of a split-ring commutator, a.c. generators have slip rings and brushes so the contacts don't swap every half turn.
3) This means an alternator produces an alternating p.d. and therefore an alternating current (a.c.) if the coil is part of a complete circuit.



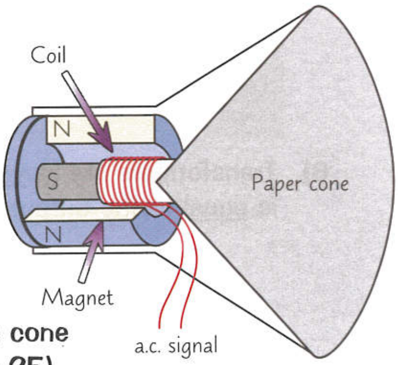
Microphones Generate Current From Sound Waves

1) Microphones use electromagnetic induction to generate an electrical signal.
2) Sound waves hit a flexible diaphragm that is attached to a coil of wire. The coil of wire surrounds one pole of a permanent magnet and is surrounded by the other pole.
3) This means as the diaphragm (and so the coil) moves, a current is generated in the coil.
4) The movement of the coil (and so the generated current) depends on the properties of the sound wave (louder sounds make the diaphragm move further).
5) This is how microphones can convert the pressure variations of a sound wave into variations in current in an electric circuit.



Loudspeakers are like Microphones in Reverse

1) In a loudspeaker, the diaphragm is replaced with a paper cone.
2) The coil is wrapped around one pole of a permanent magnet, so the a.c. signal causes a force on the coil (which moves the cone).
3) When the current is reversed, the force acts in the opposite direction.
4) These movements make the cone vibrate, which makes the air around the cone vibrate and creates the variations in pressure that cause a sound wave (p.35).



If a loudspeaker falls in the forest does it still make a sound...

Generators, microphones and loudspeakers all use electromagnetism — make sure you know how for the exam.

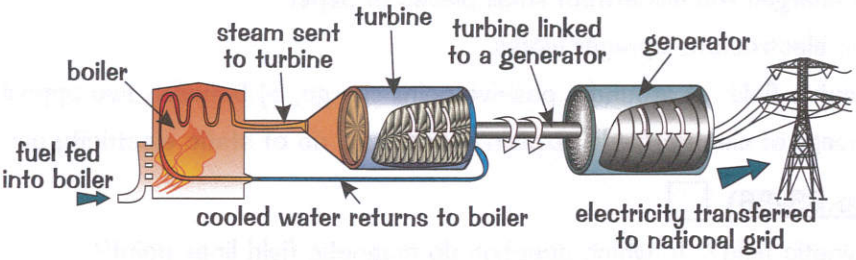
Q1 Explain how a loudspeaker converts electrical signals into sound waves. [4 marks]

Generating and Distributing Electricity

Now it's time for the big leagues — how electricity is generated and distributed on a national scale.

A Power Station uses a Turbine to Turn a Huge Alternator

1) Most of the electricity we use is generated from burning fuels (coal, oil, gas or biomass) in the boilers of big power stations.
2) The burning fuel is used to heat water and convert it to steam, which turns a turbine.



3) The turbine is connected to a powerful magnet (usually an electromagnet, see p.88) inside a generator — a huge cylinder wound with coils of copper wire.
4) As the turbine spins, the magnet spins with it, inducing a large p.d. and alternating current in the coils.
5) The coils are joined together in parallel (see p.75) to produce a single output from the generator.
6) A similar set-up is used for most other types of electricity generation as well. In hydroelectric, tidal and wind power (see p.29) the turbine is turned directly, without needing to turn water into steam first.
7) The only type of power generation that doesn't use a turbine and generator system is solar (p.29).

Transformers in the National Grid Produce a High p.d. and a Low Current

1) Once the electricity has been generated, it goes into the national grid — a network of wires and transformers that connects UK power stations to consumers (anyone who uses electricity).
2) The national grid has to transfer loads of energy each second, which means it transmits electricity at a high power (as power = energy transferred ÷ time taken, $P = E \div t$, p.78).
3) Electrical power = current × potential difference ($P = IV$, p.78), so to transmit the huge amounts of power needed, you either need a high potential difference or a high current.
4) But a high current makes wires heat up, so loads of energy is wasted to thermal stores. The power lost due to resistive heating is found using electrical power = current² × resistance ($P = I^2R$, p.78).
5) So to reduce these losses and make the national grid more efficient, high-voltage, low-resistance cables, and transformers are used. You saw on page 89 that transformers are (almost) 100% efficient, so the input power is equal to the output power. For a given power, as you increase the potential difference across a coil, you decrease the current through it ($V_p \times I_p = V_s \times I_s$).
6) Step-up transformers at power stations boost the p.d. up really high (400 000 V) and keep the current low. Step-down transformers then bring it back down to safe, usable levels at the consumers' end.
7) The ratio between the potential differences in the primary and secondary coils of a transformer is the same as the ratio between the number of turns on the coils.
8) So as long as you know the input p.d. and the number of turns on each coil, you can calculate the output p.d. from a transformer using the transformer equation:

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

Input p.d. (V)

Output p.d. (V)

Number of turns on primary coil

Number of turns on secondary coil

9) It works either way up, so $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ works just as well.

I once had a dream about transforming into a hamster...

Make sure you can remember the stuff about transformers from page 89 too, then have a go at this question:

Q1 A transformer has 16 turns on its primary coil, 4 turns on its secondary coil and an output potential difference of 20 V. Calculate the potential difference across the primary coil. [2 marks]

Revision Questions for Section 6

Congratulations! You've battled to the end of Section 6 — now see how much you've learnt.

- Try these questions and tick off each one when you get it right.
- When you've done all the questions under a heading and are completely happy, tick it off.

Static Electricity and Electric Fields (p.82-84) ☐

1) How does the rubbing together of materials cause static electricity to build up? ☐
2) Explain why a charged rod will attract small pieces of paper. ☐
3) Explain how an electrostatic sprayer works. ☐
4) Sketch the electric field: a) around a positive point charge, b) between two oppositely-charged plates. ☐
5) Using the concept of electric fields, explain how a build up of static electricity can cause a spark. ☐

Magnetism (p.85-86) ☐

6) What is a magnetic field? In which direction do magnetic field lines point? ☐
7) Sketch the field lines around a bar magnet. ☐
8) Explain the behaviour of a plotting compass that is far away from a magnet. ☐
9) Give three examples of magnetic materials. ☐
10) What is the difference between a permanent magnet and an induced magnet? ☐

Electromagnetism and the Motor Effect (p.87-88) ☐

11) Describe the magnetic field around a current-carrying wire. ☐
12) Explain why a current-carrying conductor in a magnetic field experiences a force. ☐
13) State the equation for calculating the size of this force. ☐
14) What is Fleming's left-hand rule? ☐
15) Name two ways you could decrease the force on a current-carrying wire in a magnetic field. ☐
16) Explain how a basic d.c. motor works. ☐
17) Explain the shape and strength of the magnetic field inside and outside a solenoid. ☐

Electromagnetic Induction and Transformers (p.89-91) ☐

18) Describe how you can induce a current in a coil of wire. ☐
19) Give two ways you could reverse the direction of an induced current. ☐
20) Give one way that you can increase the size of an induced current. ☐
21) True or false? Induced currents create magnetic fields that oppose the change that made them. ☐
22) What kind of current are transformers used with? ☐
23) Why do transformers have a core of iron? ☐
24) True or false? Step-down transformers have more coils on their primary coil than on their secondary. ☐
25) A transformer has an input p.d. of 100 V and an output p.d. of 20 V. What kind of transformer is it? ☐
26) Write down the equation that relates the input and output currents and p.d.s of transformers.
What does this equation assume? ☐
27) What kind of current do dynamos produce? ☐
28) Explain how microphones translate sound waves into electrical signals. ☐
29) Describe how a fossil fuel power station generates electricity. ☐
30) Explain how transformers are used to improve efficiency when transmitting electricity. ☐