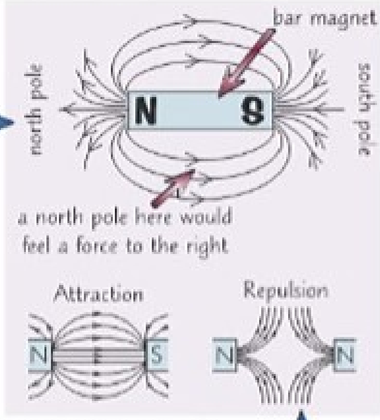
Permanent and Induced Magnets

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

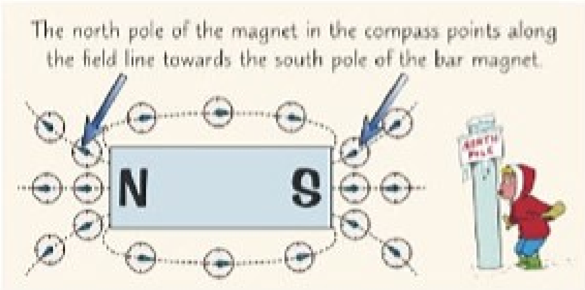
Magnets Produce Magnetic Fields

1) All magnets have two poles — north (or north seeking) and south (or south seeking).
2) All magnets produce a magnetic field — a region where other magnets or magnetic materials (e.g. iron, steel, nickel and cobalt) experience a force. (This is a non-contact force — similar to the force on charges in an electric field, like you saw on page 36.)
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 if it was put at that point in the field.
5) The closer together the lines are, the stronger the magnetic field. The further away from a magnet you get, the weaker the field is.
6) The magnetic field is strongest at the poles of a magnet. This means that the magnetic forces are also strongest at the poles.
7) The force between a magnet and a magnetic material is always attractive, no matter the pole.
8) If two poles of a magnet are put near each other, they will each exert a force on each other. This 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.



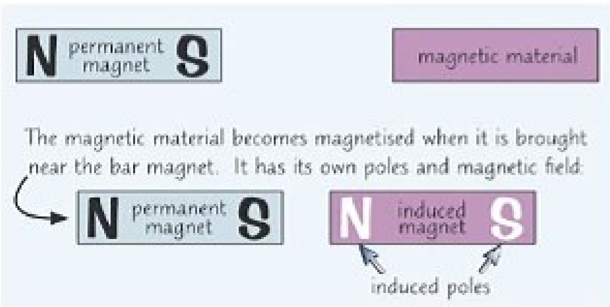
Compasses Show the Directions of Magnetic Fields

1) Inside a compass is a tiny bar magnet. The north pole of this magnet is attracted to the south pole of any other magnet it is near. So the compass points in the direction of the magnetic field it is in.
2) You can move a compass around a magnet and trace its position on some paper to build up a picture of what the magnetic field looks like.
3) When they're not near a magnet, compasses always point north. This is because the Earth generates its own magnetic field, which shows the inside (core) of the Earth must be magnetic.



Magnets Can be Permanent or Induced

1) There are two types of magnet — permanent magnets and induced magnets.
2) Permanent magnets produce their own magnetic field.
3) Induced magnets are magnetic materials that turn into a magnet when they're put into a magnetic field.
4) The force between permanent and induced magnets is always attractive (see magnetic materials above).
5) When you take away the magnetic field, induced magnets quickly lose their magnetism (or most of it) and stop producing a magnetic field.



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. [2 marks]

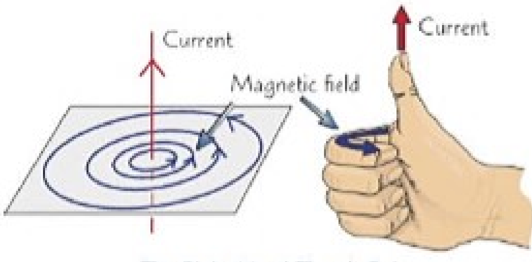
Q2 Give two differences between permanent and induced magnets. [2 marks]

Electromagnetism

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 wire, a magnetic field is created around the wire.
2) The field is made up of concentric circles perpendicular to the wire, with the wire in the centre.
3) You can see this by placing a compass near a wire that is carrying a current. As you move the compass, it will trace the direction of the magnetic field.
4) 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.

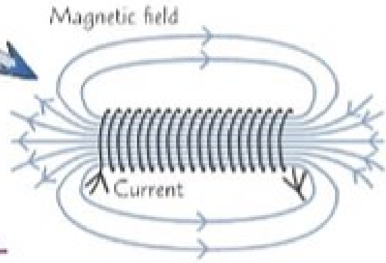


The Right-Hand Thumb Rule
Using your right hand, point your thumb in the direction of current and curl your fingers. The direction of your fingers is the direction of the field.

5) The strength of the magnetic field produced changes with the current and the distance from the wire. The larger the current through the wire, or the closer to the wire you are, the stronger the field is.

A Solenoid is a Coil of Wire

1) You can increase the strength of the magnetic field that a wire produces by wrapping the wire into a coil called a solenoid.
2) This happens because the field lines around each loop of wire line up with each other.
3) This results in lots of field lines pointing in the same direction that are very close to each other. As you saw on the last page, the closer together field lines are, the stronger the field is.

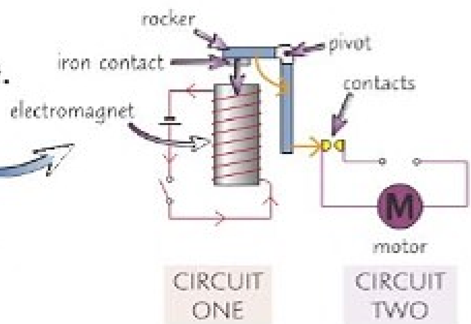


4) The magnetic field inside a solenoid is strong and uniform (it has the same strength and direction at every point in that region).
5) Outside the coil, the magnetic field is just like the one round a bar magnet.
6) You can increase the field strength of the solenoid even more by putting a block of iron in the centre of the coil. This iron core becomes an induced magnet whenever current is flowing.
7) If you stop the current, the magnetic field disappears. A solenoid with an iron core (a magnet whose magnetic field can be turned on and off with an electric current) is called an ELECTROMAGNET.

Electromagnets Have Lots of Uses

Magnets you can switch on and off are really useful. They're usually used because they're so quick to turn on and off or because they can create a varying force (like in loudspeakers, p.95).

1) Electromagnets are used in some cranes to attract and pick up things made from magnetic materials like iron and steel, e.g. in scrap yards. Using an electromagnet means the magnet can be switched on when you want to pick stuff up, then switched off when you want to drop it.
2) Electromagnets can also be used within other circuits to act as switches (e.g. in the electric starters of motors), like this:
   - When the switch in circuit one is closed, it turns on the electromagnet, which attracts the iron contact on the rocker.
   - The rocker pivots and closes the contacts, completing circuit two, and turning on the motor.



Strong, in uniform and a magnetic personality — I'm a catch...

Electromagnets are used in loads of everyday things from alarms to trains, so you'd better learn how they work.

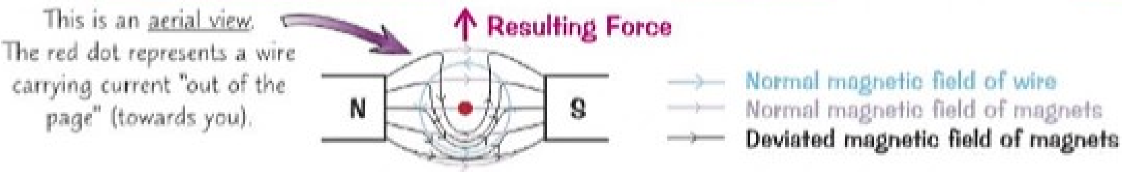
Q1 Draw the magnetic field for: a) a current-carrying wire b) a current-carrying solenoid [4 marks]

The Motor Effect

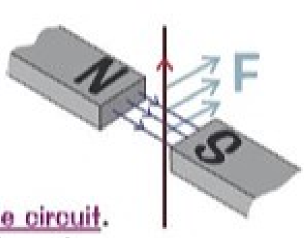
The motor effect can happen when you put a current-carrying wire in a magnetic field. It's really useful in stuff like... well... electric motors. If you want to know exactly what it is, you'll have to keep reading.

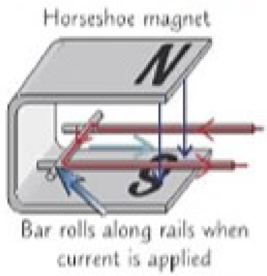
A Current in a Magnetic Field Experiences a Force

When a current-carrying wire (or any other conductor) is put between magnetic poles, the magnetic field around the wire interacts with the magnetic field it has been placed in. This causes the magnet and the conductor to exert a force on each other. This is called the motor effect and can cause the wire to move.

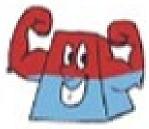


1) To experience the full force, the wire has to be at 90° to the magnetic field. If the wire runs parallel to the magnetic field, it won't experience any force at all. At angles in between, it'll feel some force.
2) The force always acts at right angles to the magnetic field of the magnets and the direction of the current in the wire.
3) A good way of showing the direction of the force is to apply a current to a set of rails inside a horseshoe magnet (shown opposite). A bar is placed on the rails, which completes the circuit. This generates a force that rolls the bar along the rails.





4) The magnitude (strength) of the force increases with the strength of the magnetic field.
5) The force also increases with the amount of current passing through the conductor.

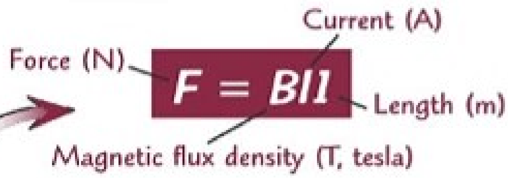


You Can Find the Size of the Force...

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.92).
2) The size of the current through the conductor.
3) The length of the conductor that's in the magnetic field.

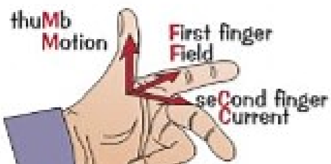
When the current is at 90° to the magnetic field it is in, the force acting on it can be found using the equation on the right.



... and Which Way it's Acting

You can find the direction of the force with Fleming's left-hand rule.

1) Using your left hand, point your First finger in the direction of the Field.
2) Point your seCond finger in the direction of the Current.
3) Your thuMb will then point in the direction of the force (Motion).

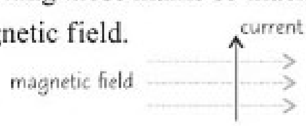


Fleming's left-hand rule shows that if either the current or the magnetic field is reversed, then the direction of the force will also be reversed. This can be used for all sorts of things — like motors on the next page.

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

Use the left-hand rule in the exam. You might look a bit silly, but it makes getting those marks so much easier.

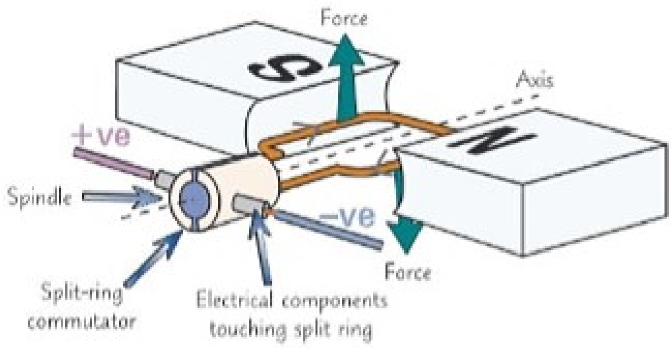
Q1 A 20 cm section of wire with a current of 8 A is at 90° to a 0.1 T magnetic field.
- a) Find the direction of the force acting on the wire. [1 mark]
- b) Calculate the size of the force. [3 marks]



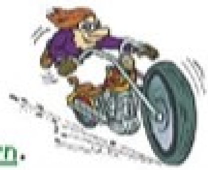
Electric Motors and Loudspeakers

If you've ever broken a pair of headphones, you'll have seen the tiny crinkly paper cone inside them. I'm sure you've never sat and wondered how they work, but that's all about to change my friend...

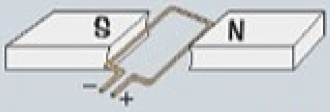
A Current-Carrying Coil of Wire Rotates in a Magnetic Field



1) The diagram on the right shows a basic dc 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.94).
3) Because the coil is on a spindle and the forces act one up and one down, it 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 dc 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?



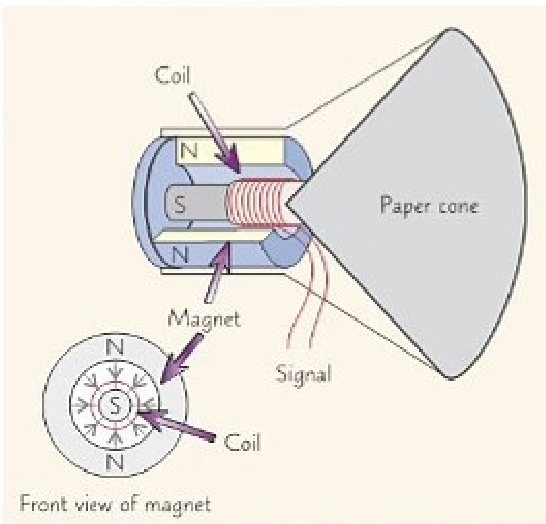
1) Draw in current arrows (from positive to negative, p.24).
2) Use Fleming's left-hand rule on one branch (here, I've picked the right-hand branch).
3) Point your first finger in the direction of the magnetic field (remember, this is north to south).
4) Point your second finger in the direction of the current.
5) Draw in the direction of motion (the direction your thumb is pointing in).

The coil is turning anticlockwise.

Loudspeakers Work Because of the Motor Effect

Loudspeakers and headphones (which are just tiny loudspeakers) both use electromagnets:

1) An alternating current (ac) is sent through a coil of wire attached to the base of a paper cone.
2) The coil surrounds one pole of a permanent magnet, and is surrounded by the other pole, so the current causes a force on the coil (which causes the cone to move).
3) When the current reverses, the force acts in the opposite direction, which causes the cone to move in the opposite direction too.
4) So variations in the current make the cone vibrate, which makes the air around the cone vibrate and creates the variations in pressure that cause a sound wave (p.88).
5) The frequency of the sound wave is the same as the frequency of the ac, so by controlling the frequency of the ac you can alter the sound wave produced.



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

Motors and speakers are both really common examples, so make sure you learn them well for the exam.

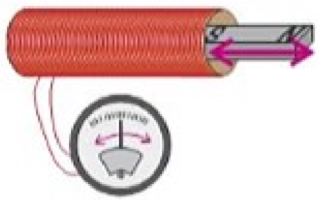
Q1 Explain how a loudspeaker converts electrical signals into sound waves. [4 marks]

The Generator Effect

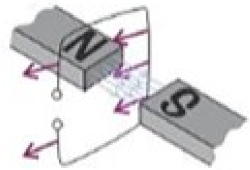
Electricity is generated using the generator effect (which is also known as electromagnetic induction). Sounds terrifying, but read this page carefully and it hopefully shouldn't be too complicated.

Cutting Field Lines Induces a Potential Difference

The Generator Effect: The induction of a potential difference (and current if there's a complete circuit) in a wire which is moving relative to a magnetic field, or experiencing a change in magnetic field.



1) The generator effect creates a potential difference in a conductor, and a current if the conductor is part of a complete circuit.
2) You can do this by moving a magnet in a coil of wire OR moving a conductor (wire) in a magnetic field ("cutting" magnetic field lines).
3) Shifting the magnet from side to side creates a little "blip" of current if the conductor is part of a complete circuit.
4) If you move the magnet (or conductor) in the opposite direction, then the potential difference/current will be reversed. Likewise if the polarity of the magnet is reversed, then the potential difference/current will be reversed too.
5) If you keep the magnet (or the coil) moving backwards and forwards, you produce a potential difference that keeps swapping direction — an alternating current.



You can create the same effect by turning a magnet end to end in a coil, or turning a coil inside a magnetic field. This is how generators work to produce ac or direct current (dc) — see next page.

1) As you turn the magnet, the magnetic field through the coil changes. This change in the magnetic field induces a potential difference, which can make a current flow in the wire.
2) When you've turned the magnet through half a turn, the direction of the magnetic field through the coil reverses. When this happens, the potential difference reverses, so the current flows in the opposite direction around the coil of wire.
3) If you keep turning the magnet in the same direction — always clockwise, say — then the potential difference will keep on reversing every half turn and you'll get an alternating current.

Induced Current Opposes the Change that Made It

1) So, a change in magnetic field can induce a current in a wire. But, as you saw on page 93, when a current flows through a wire, a magnetic field is created around the wire. (Yep, that's a second magnetic field — different to the one whose field lines were being cut in the first place.)
2) The magnetic field created by an induced current always acts against the change that made it (whether that's the movement of a wire or a change in the field it's in). Basically, it's trying to return things to the way they were.
3) This means that the induced current always opposes the change that made it.

You Can Change the Size of the Induced Potential Difference

If you want to change the size of the induced pd, you have to change the rate that the magnetic field is changing. Induced potential difference (and so induced current) can be increased by either:

1) Increasing the speed of the movement — cutting more magnetic field lines in a given time.
2) Increasing the strength of the magnetic field (so there are more field lines that can be cut).

Generators work when the coil or the field is moving...

Electricity is super useful in our daily lives, which means the generator effect is really important too. Learn it.

Q1 State the generator effect. [1 mark]

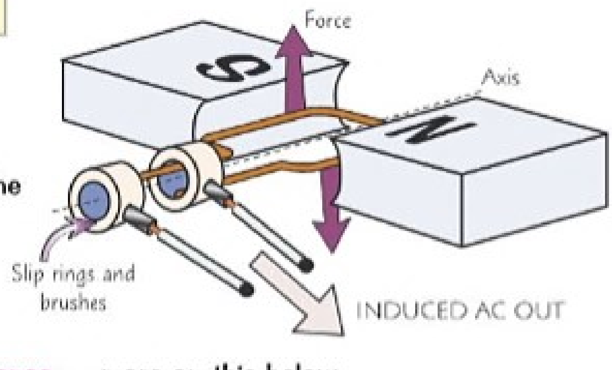
Q2 Give two ways to increase the induced current in a generator. [2 marks]

Generators and Microphones

Generators make use of the generator effect from the previous page to induce a current. Whether this current is alternating or direct all depends on two similar sounding methods of connection. Don't get them mixed up.

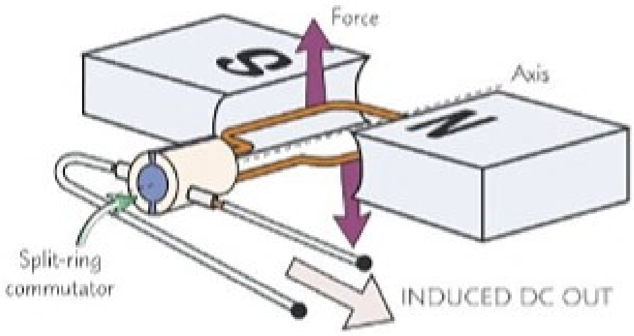
Alternators Generate Alternating Current

1) Generators rotate a coil in a magnetic field (or a magnet in a coil).
2) Their construction is pretty much like a motor.
3) As the coil (or magnet) spins, a current is induced in the coil. This current changes direction every half turn.
4) Instead of a split-ring commutator, ac generators have slip rings and brushes so the contacts don't swap every half turn.
5) This means they produce an alternating potential difference — more on this below.



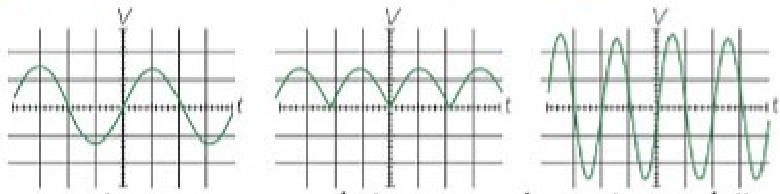
Dynamos Generate Direct Current

1) Dynamos work in the same way as alternators, apart from one important difference.
2) They have a split-ring commutator instead of slip rings.
3) This swaps the connection every half turn to keep the current flowing in the same direction (similar to the motion of a dc motor, p.95).



You Can Use an Oscilloscope To See the Generated pd

1) Oscilloscopes show how the potential difference generated in the coil changes over time.
2) For ac this is a line that goes up and down, crossing the horizontal axis.
3) For dc the line isn't straight like you might expect, but it stays above the axis (pd is always positive) so it's still direct current.

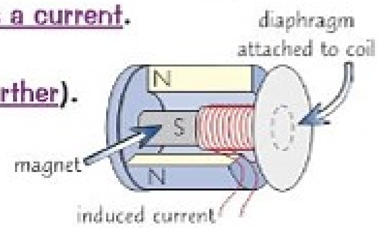


ac trace dc trace Increasing revolutions

4) The height of the line at a given point is the generated potential difference at that time.
5) Increasing the frequency of revolutions increases the overall pd, but it also creates more peaks too.

Microphones Generate Current From Sound Waves

1) Microphones are basically loudspeakers in reverse.
2) Sound waves hit a flexible diaphragm that is attached to a coil of wire, wrapped around a magnet.
3) This causes the coil of wire to move in the magnetic field, which generates a current.
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.



ac from Alternators, dc from Dynamos — easy peasy...

Remember, microphones act like a loudspeaker in reverse. If you're not sure about speakers, go back to page 95.

Q1 a) Draw a potential difference-time graph for a direct current generated by a dynamo. [2 marks]
b) Explain how the dynamo generates this current. [3 marks]

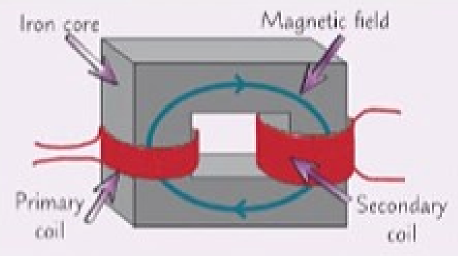
Transformers

Transformers only work with an alternating current. Try it with a battery (dc) and you'll be there for days.

Transformers Change the pd — but Only for Alternating Current

1) Transformers change the size of the potential difference of an alternating current.
2) They all have two coils of wire, the primary and the secondary, joined with an iron core.
3) When an alternating pd is applied across the primary coil, the iron core magnetises and demagnetises quickly. This changing magnetic field induces an alternating pd in the secondary coil (p.96).
4) If the second coil is part of a complete circuit, this causes a current to be induced.
5) The ratio between the primary and secondary potential differences is the same as the ratio between the number of turns on the primary and secondary coils.

Iron is used because it's easily magnetised.



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.

The Transformer Equation — Use it Either Way Up

1) As long as you know the input pd and the number of turns on each coil, you can calculate the output pd from a transformer using the transformer equation:

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

Input potential difference (V) — V_p; Output potential difference (V) — V_s; Number of turns on primary coil — n_p; Number of turns on secondary coil — n_s

So for a step-up transformer, $V_s > V_p$ and for a step-down transformer, $V_s < V_p$.

2) This equation can be used either way up, so $\frac{V_s}{V_p} = \frac{n_s}{n_p}$ works just as well.
   There's less rearranging to do if you put whatever you're trying to find (the unknown) on the top.
3) Transformers are almost 100% efficient. If you assume that they are, then the input power is equal to the output power. Using $P = VI$ from page 33, you can write this as:

$$V_s I_s = V_p I_p$$

Pd across secondary coil (V) — V_s; Current through secondary coil (A) — I_s; Pd across primary coil (V) — V_p; Current through primary coil (A) — I_p

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

4) You need to be able to relate both of these equations to power transmission in the national grid, to explain why and how the national grid transmits at very high pds.
5) You've already seen on page 34 that a low current means that less energy is wasted heating the wires and the surroundings, making the national grid an efficient way of transmitting power. The equation in the blue box shows why, for a given power, a high pd is needed for a low current.
6) The equation in the orange box above can be used to work out the number of turns needed to increase the pd (and decrease the current) to the right levels.

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

Make sure you know how transformers work and then take a stab at using those equations with this question.

Q1 a) 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. [3 marks]

b) Calculate the input current needed to produce an output power of 320 W. [3 marks]

Revision Questions for Topic 7

Whew, the end of Topic 7 — time to put yourself to the test and see how much you can remember.

- 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 with it, tick it off.

Magnetism and Basic Electromagnetism (p.92-93)

1) What is a magnetic field?
2) Give three magnetic materials.
3) In what direction do magnetic field lines point?
4) Describe how you could use a compass to show the direction of a bar magnet's magnetic field lines.
5) Describe the behaviour of a compass that is far away from a magnet.
6) True or false? The force between a magnet and a magnetic material is always repulsive.
7) What happens to an induced magnet when it is moved far away from a permanent magnet?
8) Describe the magnetic field around a current-carrying wire.
9) Why does adding more turns to a solenoid increase the strength of its magnetic field?
10) Describe an electromagnet and give one example of where it could be used.

The Motor Effect (p.94-95)

11) Explain why a current-carrying conductor in a magnetic field experiences a force.
12) State the equation for calculating the size of this force.
13) Name three ways you could increase the force on a current-carrying wire in a magnetic field.
14) What is Fleming's left-hand rule?
15) Explain how a basic dc motor works.
16) Draw the magnetic field for the magnet inside a loudspeaker.

The Generator Effect (p.96-97)

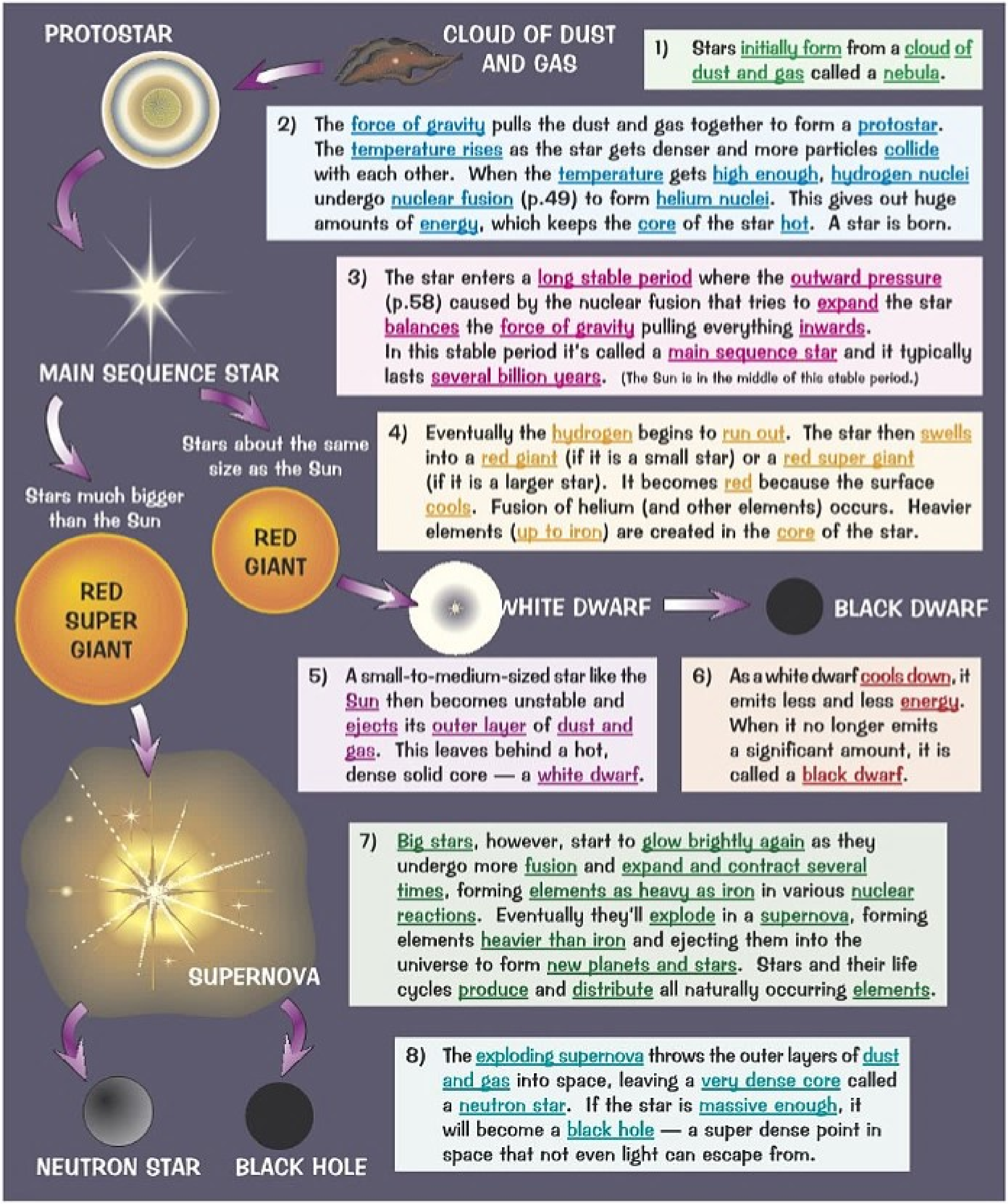
17) Describe how you can induce a current.
18) Give two ways you could reverse the direction of an induced current.
19) True or false? Induced currents create magnetic fields that oppose the change that made them.
20) Give two ways that you can increase the size of an induced potential difference.
21) Which type of generator uses slip rings and brushes?
22) What kind of current do dynamos produce?
23) Draw a graph of potential difference against time for an ac supply.
24) Explain how microphones translate sound waves into electrical signals.

Transformers (p.98)

25) What kind of current are transformers used with?
26) Why do transformers have a core of iron?
27) True or false? Step-down transformers have more coils on their primary coil than on their secondary.
28) A transformer has an input pd of 100 V and an output pd of 20 V. What kind of transformer is it?
29) State the transformer equation.
30) Write down the equation that relates the input and output currents and pds of transformers. What does this equation assume?
31) Explain how transformers are used to improve efficiency when transmitting electricity.

The Life Cycle of Stars

Stars go through many traumatic stages in their lives — just like teenagers.



1) Stars initially form from a cloud of dust and gas called a nebula.

2) The force of gravity pulls the dust and gas together to form a protostar. The temperature rises as the star gets denser and more particles collide with each other. When the temperature gets high enough, hydrogen nuclei undergo nuclear fusion (p.49) to form helium nuclei. This gives out huge amounts of energy, which keeps the core of the star hot. A star is born.

3) The star enters a long stable period where the outward pressure (p.58) caused by the nuclear fusion that tries to expand the star balances the force of gravity pulling everything inwards.
In this stable period it's called a main sequence star and it typically lasts several billion years. (The Sun is in the middle of this stable period.)

4) Eventually the hydrogen begins to run out. The star then swells into a red giant (if it is a small star) or a red super giant (if it is a larger star). It becomes red because the surface cools. Fusion of helium (and other elements) occurs. Heavier elements (up to iron) are created in the core of the star.

5) A small-to-medium-sized star like the Sun then becomes unstable and ejects its outer layer of dust and gas. This leaves behind a hot, dense solid core — a white dwarf.

6) As a white dwarf cools down, it emits less and less energy. When it no longer emits a significant amount, it is called a black dwarf.

7) Big stars, however, start to glow brightly again as they undergo more fusion and expand and contract several times, forming elements as heavy as iron in various nuclear reactions. Eventually they'll explode in a supernova, forming elements heavier than iron and ejecting them into the universe to form new planets and stars. Stars and their life cycles produce and distribute all naturally occurring elements.

8) The exploding supernova throws the outer layers of dust and gas into space, leaving a very dense core called a neutron star. If the star is massive enough, it will become a black hole — a super dense point in space that not even light can escape from.

It's the beginning of the world as we know it...

Pretty neat, seeing how stars like our Sun — which all of us rely on — were made all those years ago.

Q1 Describe the life cycle of a star much larger than our Sun, from its main sequence onwards. [4 marks]

The Solar System and Orbits

The Sun is the centre of our solar system. It's orbited by eight planets, along with a bunch of other objects.

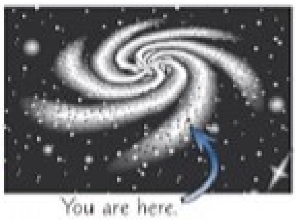
Our Solar System has One Star — The Sun

The planets are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune.

The solar system is all the stuff that orbits our Sun. This includes things like:

1) Planets — these are large objects that orbit a star. There are eight in our solar system. They have to be large enough to have "cleared their neighbourhoods". This means that their gravity is strong enough to have pulled in any nearby objects apart from their natural satellites.
2) Dwarf planets, like our pal Pluto. These are planet-like objects that orbit stars, but don't meet all of the rules for being a planet.
3) Moons — these orbit planets. They're a type of natural satellite (i.e. they're not man-made).
4) Artificial satellites are satellites that humans have built. They generally orbit the Earth.

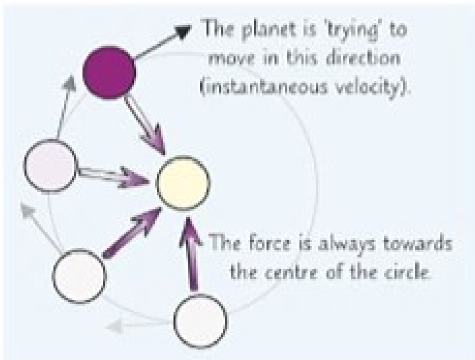
Our solar system is a tiny part of the Milky Way galaxy. This is a massive collection of billions of stars that are all held together by gravity.



Gravity Provides the Force That Creates Orbits

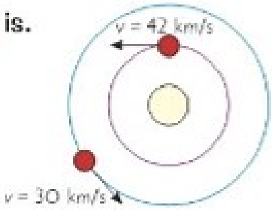
A satellite is an object that orbits a second, more massive object.

1) The planets move around the Sun in almost circular orbits (the same goes for the Moon orbiting the Earth).
2) If an object is travelling in a circle it is constantly changing direction, which means it is constantly accelerating. (Just like a car going around a roundabout, pages 60-61.)
3) This also means it is constantly changing velocity (but NOT changing speed).
4) For an object to accelerate, there must be a force acting on it (p.64). This force is directed towards the centre of the circle.
5) This force would cause the object to just fall towards whatever it was orbiting, but as the object is already moving, it just causes it to change its direction.
6) The object keeps accelerating towards what it's orbiting but the instantaneous velocity (which is at a right angle to the acceleration) keeps it travelling in a circle.
7) The force that makes this happen is provided by the gravitational force (gravity) between the planet and the Sun (or between the planet and its satellites).



The Size of the Orbit Depends on the Object's Speed

1) The closer you get to a star or planet, the stronger the gravitational force is.
2) The stronger the force, the faster the orbiting object needs to travel to remain in orbit (to not crash into the object that it's orbiting).
3) For an object in a stable orbit, if the speed of the object changes, the size (radius) of its orbit must do so too. Faster moving objects will move in a stable orbit with a smaller radius than slower moving ones.



Revision's hard work — you've got to plan et...

Make sure you know what orbits what and how to tell a moon from a planet. Then have a go at these questions.

Q1 Give one difference between natural and artificial satellites. [1 mark]

Q2 If the distance between the Moon and the Earth was smaller, how would the orbital speed of the Moon compare to its current orbital speed? Explain your answer. [4 marks]

Red-shift and the Big Bang

'How it all began' is a tricky question that we just can't answer. Our best guess at the minute is the Big Bang.

The Universe Seems to Be Expanding

As big as the universe already is, it looks like it's getting even bigger.
All its galaxies seem to be moving away from each other. There's good evidence for this...

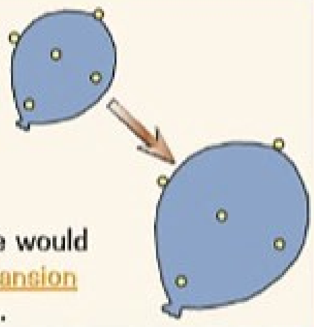
1) When we look at light from most distant galaxies, we find that the wavelength has increased.
2) The wavelengths are all longer than they should be — they're shifted towards the red end of the spectrum. This is called red-shift.
3) This suggests the source of the light is moving away from us. Measurements of the red-shift indicate that these distant galaxies are moving away from us (receding) very quickly — and it's the same result whichever direction you look in.
4) More distant galaxies have greater red-shifts than nearer ones. This means that more distant galaxies are moving away faster than nearer ones.
5) The inescapable conclusion appears to be that the whole universe (space itself) is expanding.

You can think of the light wave 'stretching out' as the source moves away from us.

Imagine a balloon covered with pompoms.
As you blow into the balloon, it stretches.
The pompoms move further away from each other.

The balloon represents the universe and each pompom is a galaxy. As time goes on, space stretches and expands, moving the galaxies away from each other.

This is a simple model (balloons only stretch so far, and there would be galaxies 'inside' the balloon too) but it shows how the expansion of space makes it look like galaxies are moving away from us.



This Evidence Suggests the Universe Started with a Bang

So all the galaxies are moving away from each other at great speed — suggesting something must have got them going. That 'something' was probably a big explosion — the Big Bang. Here's the theory...

1) Initially, all the matter in the universe occupied a very small space. This tiny space was very dense (p.38) and so was very hot.
2) Then it 'exploded' — space started expanding, and the expansion is still going on.

New Evidence Might Change Our Theories

1) Something important to remember is that the Big Bang theory is the best guess we have so far. Whenever scientists discover new evidence, they have to either make a new theory or change a current one to explain what they've observed.
2) There is still lots we don't know about the universe. Observations of supernovae from 1998 to the present day appear to show that distant galaxies are moving away from us faster and faster (the speed at which they're receding is increasing).
3) Currently scientists think the universe is mostly made up of dark matter and dark energy. Dark matter is the name given to an unknown substance which holds galaxies together, but does not emit any electromagnetic radiation. Dark energy is thought to be responsible for the accelerated expansion of the universe. But no-one really knows what these things are, so there are lots of different theories about it. These theories get tested over time and are either accepted or rejected.

And it all started with the Big Bang...

Or at least, that's what we currently think is most likely. Remember that theories change depending on evidence.

Q1 How does observed light from distant galaxies suggest that the universe is expanding? [3 marks]