CAIE Physics A-level

20 - Magnetic Fields

Flashcards

Define magnetic field.

Define magnetic field.

A region of space in which moving charged particles are subject to a magnetic force.

This force is caused by the interaction of two magnetic fields (there is a field around the moving charged particles which interacts with the existing magnetic field they are passing through).

Are magnetic fields produced by moving charges, permanent magnets or both?

Are magnetic fields produced by moving charges, permanent magnets or both?

Both moving charges and permanent magnets produce a magnetic field. These fields can interact with one another.

What are magnetic field lines?

What are magnetic field lines?

Field lines point from North to South.

They display the direction of the force on a North pole, if it were moved incrementally around the vicinity of the magnetic field.

How can you map field lines around a magnet?

How can you map field lines around a magnet?

You can place iron filings on a piece of paper and then put the magnet on the paper and the filings will align with the field.

You can also use a plotting compass and place it in various positions around the magnet. Mark the direction of the needle at each point and connect them.

How do you represent the strength of a magnetic field on a diagram?

How do you represent the strength of a magnetic field on a diagram?

It is represented by how close together the field lines are – the closer they are, the stronger the field. (It is the **density** of field lines per unit area, which is why **magnetic flux density** and **magnetic field strength** can be used interchangeably)

What is magnetic flux density?

What is magnetic flux density?

Magnetic flux density (Magnetic flux per unit area) is equal to the force per unit current, per unit length of a current-carrying conductor, that is placed in a magnetic field, perpendicular to the direction of field lines.

What is the unit of magnetic flux density?

What is the unit of magnetic flux density?

Tesla (T)

$$1\ T = 1\ N\ m^{-1}\ A^{-1}$$

When a magnetic field is perpendicular to a current-carrying wire, does the wire feel a force?

When a magnetic field is perpendicular to a current-carrying wire, does the wire feel a force?

Yes, the magnitude of the force is = BIL

L = length of the wire

B = Magnetic flux density

I = Current in the wire

Give the formula relating magnetic force, flux density, current, length and angle between the field and the conductor.

Give the formula relating magnetic force, flux density, current, length and angle between the field and the conductor.

$$F = BIL\sin\theta$$

F = Magnetic force (N)

B = Magnetic flux density (T)

I = Current in the conductor (A)

L = Length of conductor in the field (m)

θ = Angle between the field lines and the conductor (º or rad)

Fleming's left hand rule for motors represents what properties on which fingers?

Fleming's left hand rule for motors represents what properties on what fingers?

Thumb - **T**hrust/Force

First finger - **F**ield (Magnetic)

Se**c**ond finger - **C**urrent

Does a charged particle, moving through a field, feel a force when it is traveling along the field lines or perpendicular to them?

Does a charged particle moving through a field feel a force when it is traveling along the field lines or perpendicular to them?

When moving perpendicular to them.

What is the equation for the force felt by a moving charge in a magnetic field?

What is the equation for the force felt by a moving charge in a magnetic field?

$$F = BQv\sin\theta$$

Where 'Q' is the magnitude of the charge, 'v' is its velocity and 'θ' is the angle between the field lines and the direction of travel of the moving charge.

What is the Hall effect?

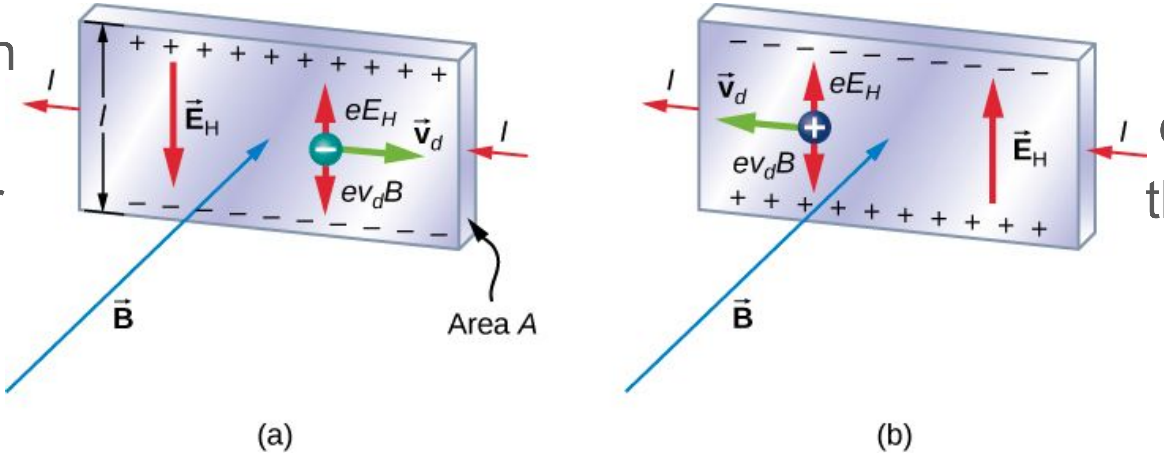
What is the Hall effect?

The Hall effect is the production of a potential difference (hall voltage) across an electrical conductor induced while it remains in a magnetic field. This potential difference is perpendicular to both the direction of the field and to the direction of conventional current.

Draw a diagram that conveys the Hall effect?

Draw a diagram that conveys the Hall effect?

Accumulation of electrons on the bottom of the conductor leading to a downward acting pd



Accumulation of electrons on the top of the conductor leading to a upward acting pd

Give an equation for the Hall voltage?

Give an equation for the Hall voltage?

$$V_H = BI/(ntq)$$

Where ‘n’ is the number of electrons, ‘q’ is the charge on an electron and ‘t’ is the thickness of the plate.

What is a Hall probe?

What is a Hall probe?

A Hall probe is a device, made up of a copper film of known thickness with a voltmeter across it. When placed in an unknown magnetic field, it ascertains the Hall voltage across the film so that the strength of the field (magnetic flux density) may be calculated.

Describe the motion of an uncharged particle as it moves through a uniform magnetic field acting perpendicular to its initial velocity.

Describe the motion of an uncharged particle as it moves through a uniform magnetic field acting perpendicular to its initial velocity.

The particle will continue to pass through the field. Its velocity and direction of travel will be unaffected by the magnetic field.

Describe the motion of a charged particle as it moves through a uniform magnetic field acting perpendicular to its initial velocity.

Describe the motion of a charged particle as it moves through a uniform magnetic field acting perpendicular to its initial velocity.

In the direction of its initial travel, the particle will continue with a constant speed. However, on the perpendicular plane, parallel to the magnetic field lines, positively/negatively charged particles will be accelerated towards the North/South poles respectively. This acceleration changes the direction vector, such that a projectile motion results.

How is a velocity selector oriented?

How is a velocity selector oriented?

A velocity selector is comprised of a uniform magnetic and a uniform electric field oriented perpendicularly to one another and an input current oriented perpendicularly to both of these field.

How are velocity selectors used to ascertain the incident velocity of charge carriers?

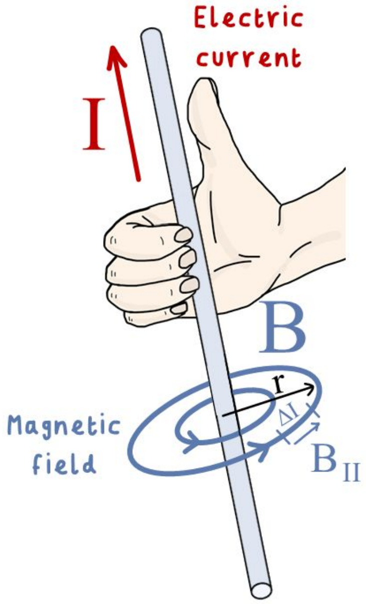
How are velocity selectors used to ascertain the incident velocity of charge carriers?

If the forces produced by the electric and magnetic fields is equal, and the direction of current is perpendicular to them both, $F = Bqv = qE$. Therefore $Bv = E$, so $v = E/B$ i.e. the velocity of charged particles equals to magnitude of the electric field over the magnitude of the magnetic field.

Sketch the magnetic field produced by a straight current-carrying wire.

Sketch the magnetic field produced by a straight current-carrying wire.

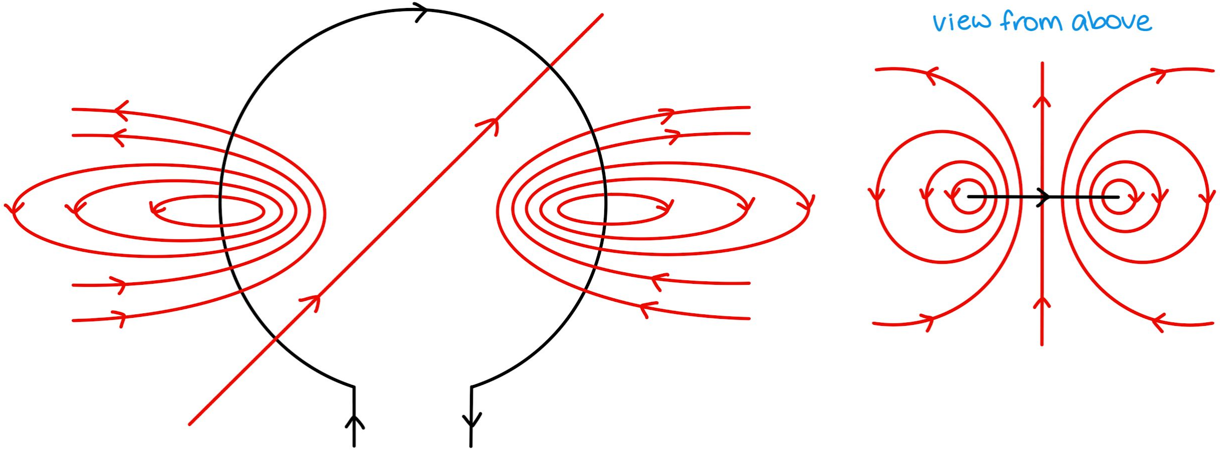
The right hand grip rule (shown on the right) indicates the direction of the magnetic field produced by a current carrying wire.



Sketch the magnetic field produced by a flat circular coil.

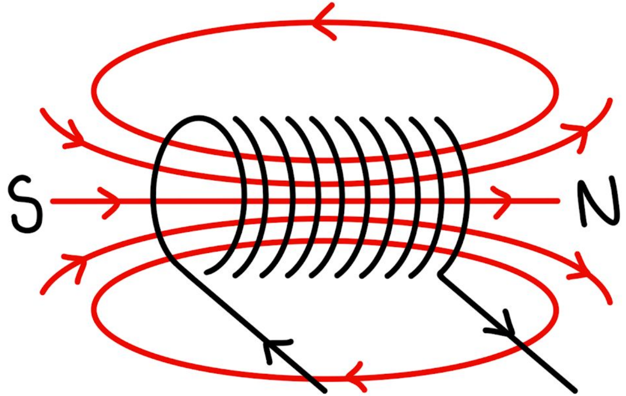
Sketch the magnetic field produced by a flat circular coil.

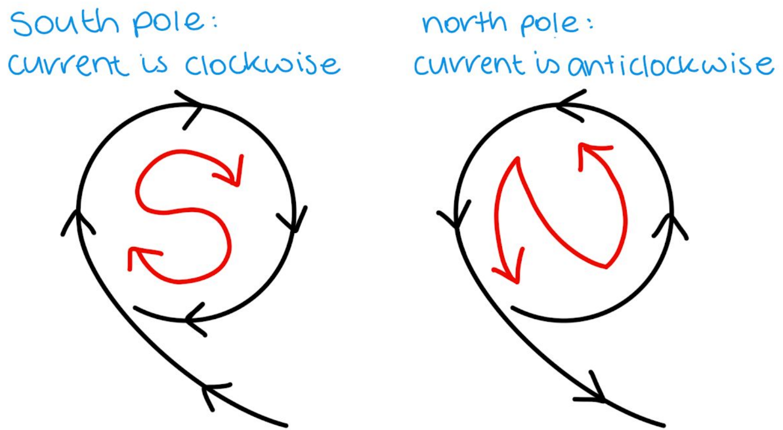
The right hand grip rule applied in 3D.



Sketch the magnetic field produced by a long solenoid.

Sketch the magnetic field produced by a straight current-carrying wire.





How might you strengthen the magnetic field produced by a solenoid?

How might you strengthen the magnetic field produced by a solenoid?

Adding a central ferrous iron core within the solenoid strengthens the magnetic field produced. This happens because the core itself becomes magnetised, amplifying the field produced by the solenoid.

Define magnetic flux.

Define magnetic flux.

The magnetic flux in area is the product of the magnetic flux density and the cross sectional area perpendicular to the flux orientation.

Give an equation for magnetic flux.

Give an equation for magnetic flux.

$$\Phi = BA$$

Where Φ is the magnetic flux, B is the flux density and A is the area of measurement.

What is the magnetic flux linkage?

What is the magnetic flux linkage?

The magnetic flux linkage (λ) of a coil of wire is the number of wire turns (N) multiplied by the magnetic flux (Φ) produced by a single loop.

$$\lambda = N\Phi$$

How could you demonstrate that a change in magnetic flux can induce an emf in a circuit?

How could you demonstrate that a change in magnetic flux can induce an emf in a circuit?

Pass a bar magnet through a solenoid back and forth. An emf should be introduced.

In which direction is the induced emf?

PMT
•resources•tuition•courses

In which direction is the induced emf?

The induced emf is such that the solenoid produces an electromagnet that opposes the motion of the bar magnet i.e. if the North pole of the bar magnet is moved towards the solenoid, the current in the solenoid will move such that the solenoid's North pole faces the bar magnet, repelling it. If the bar magnet is moved away from the solenoid, the current in the solenoid will move such that the solenoid's South pole faces the bar magnet, attracting it.

What happens if you stop moving the bar magnet in and out of the solenoid?

What happens if you stop moving the bar magnet in and out of the solenoid?

A potential difference ceases to exist in the solenoid.

What factors affect the magnitude of the induced emf (if a bar magnet is passed back and forth through one end of a solenoid)?

PMT
•resources•tuition•courses

What factors affect the magnitude of the induced emf (if a bar magnet is passed back and forth through one end of a solenoid)?

The emf induced depends on the rate of change of magnetic flux linkage, therefore it is affected by:

1. The speed with which the bar magnet is moved
2. The number of turns of the solenoid
3. The cross-sectional area of the solenoid

Whereby increasing each of these factors increases the induced emf in a directly proportional manner.

State Faraday's law.

State Faraday's law.

Faraday's law states that the emf induced in a conductor is proportional to the rate of change of magnetic flux linkage.

State Lenz's law.

State Lenz’s law.

Lenz’s law dictates that the direction of the emf induced in a conductor is such that it will oppose the magnetic field that produces it.

Combine Faraday’s and Lenz’s law to give one equation that defines the emf induced in a circuit due to changes in the magnetic flux linkage.

Combine Faraday's and Lenz's law to give one equation that defines the emf induced in a circuit due to changes in the magnetic flux linkage.

$$\varepsilon = -\frac{(\Delta N\phi)}{\Delta t}$$

- ε: induced emf (V)
- $\Delta N\phi$: change of flux linkage (Wb)
- Δt: change in time (s)
- negative because emf acts in the opposite direction to the change that caused it → Lenz's Law