7.11 Magnetic flux density

Around any magnetised object there is a region of space where we can detect a magnetic field. We can do this by placing a compass at any point and noting what direction it points. The compass consists of a small, magnetised bar which contains a north and south pole. The magnetic field exerts a torque (turning force) on the compass causing it to align along a magnetic field line.

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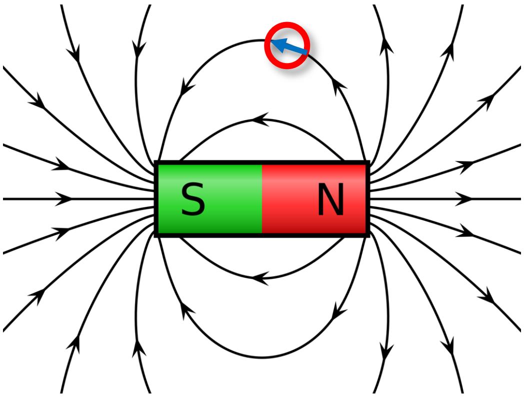
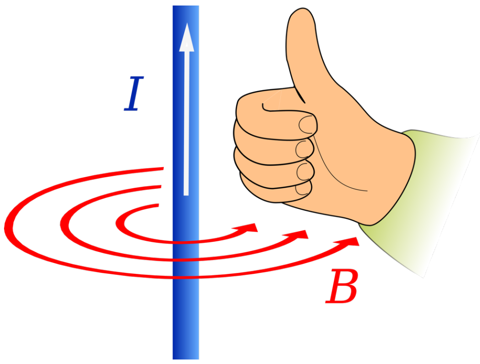


In this diagram, left, you can see that a plotting compass is pointing along the direction of the magnetic field line. Magnetic field lines go from a north (N) magnetic pole to a south (S) magnetic pole. Magnetic field lines are known as <u>lines of magnetic flux</u>.

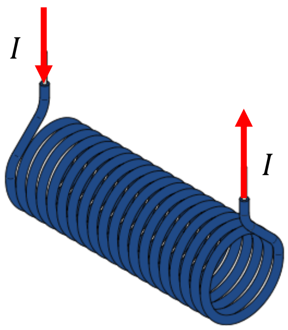
(1)✐Where would the magnetic flux be the most concentrated? How can you tell from the diagram?

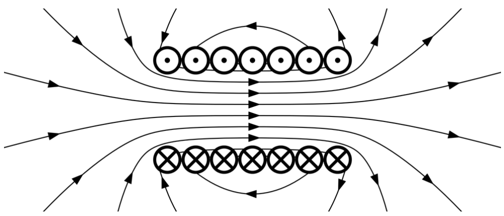
When we pass an electric current through a conducting wire a magnetic field is produced in the space around the wire.

The magnetic flux lines wrap around the wire in a circle. You can determine the direction they point by using the right-hand thumb rule. The thumb points in the direction that the current (I) flows, and the fingers wrap around in the direction of the lines of magnetic flux.



If we wrap the wire into a coil (called a solenoid) we can produce a magnetic field similar to that of a bar magnet.





In the diagram, above, the dots show current flowing upwards (out of the page) and the crosses show current flowing downwards.

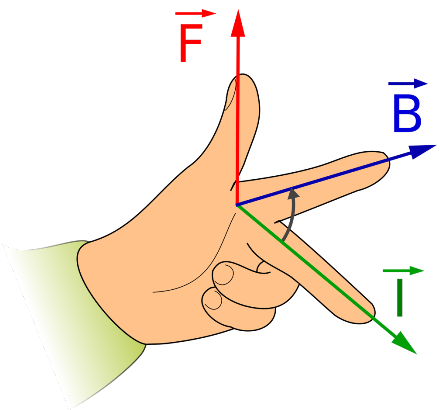
(2)✐ How would you describe the magnetic field down the middle of the solenoid?

The strength of the magnetic field is known as the magnetic flux density (B).

(3)✐ How could you increase the magnetic flux density in the middle of the solenoid?

The motor effect

When a current-carrying wire is placed in a magnetic field it experiences a force. This is known as the 'motor effect'. The direction of the force on the wire can be determined using Fleming's left-hand rule.



If you point your first finger along the field direction (N to S) and your second finger in the direction that the current is flowing in the wire, your thumb will show the direction of the force on the wire.

This force arises from the interaction of the magnetic field and the magnetic field produced by the current flowing in the wire.

The strength of the magnetic field (magnetic flux density B) can be determined from the force produced.

The force F on a length l of wire carrying a current I is given by:

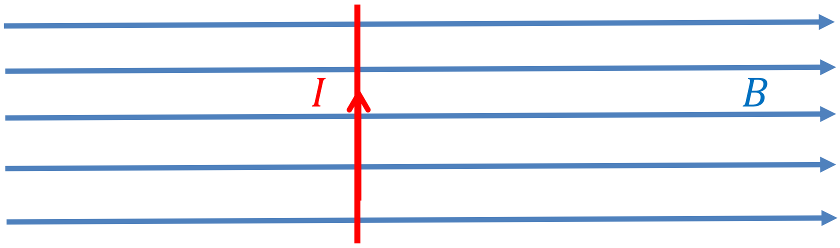
$$F = BIl$$

(4)✐ Rearrange this equation to make the magnetic flux density (B) the subject.

(5)✐ From this equation, what are the units for magnetic flux density?

The magnetic flux density is given its own unit called the *tesla* (T).

(6)✐*A 3cm length of wire carrying a current of 2A is placed at right angles to a uniform magnetic field. It experiences a force of 0.3N. What is the magnetic flux density?*

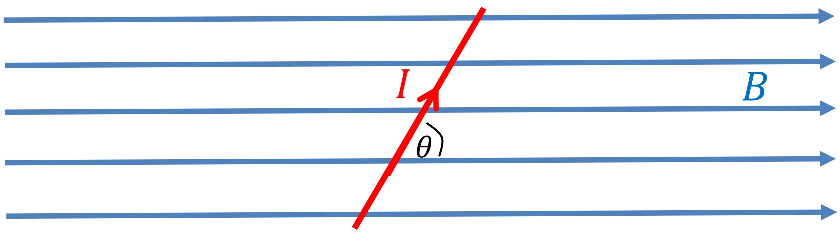


(7)✐*Using Fleming's left-hand rule, what direction would the force act in the diagram above?*

If the current-carrying wire is not at right angles to the magnetic flux lines, then the force will be less. The force on the wire is therefore modified:

$$F = BIl \sin\theta$$

where θ is the angle between the current direction and the magnetic flux lines.



(8)✐*What would the force be if the angle θ is zero?*