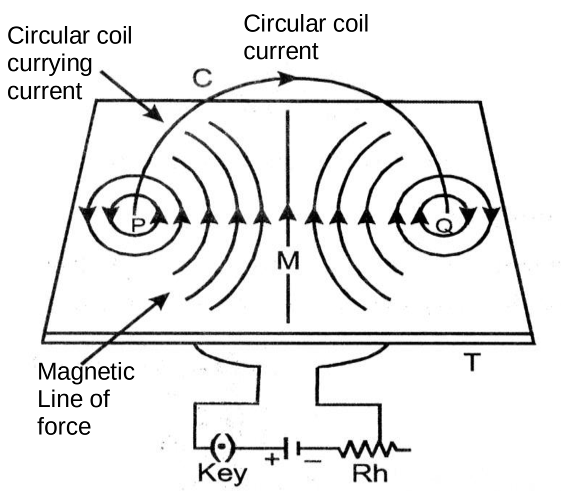
MAGNETIC EFFECT OF ELECTRIC CURRENT
Clock Face Rule for Determining Polarity of a Circular Wire Carrying Current

Magnetic Field due to Circular Coil Carrying Current:

A piece of wire bent in the form of a ring (or coil) is passed through a horizontal cardboard C at two points P and Q at the opposite ends of a diameter of the ring and then some iron fillings are scattered on the cardboard. The ends of the coil are connected to a battery through a rheostat and a key.
When a strong electric current is passed through the coil by closing the key and the cardboard is gently tapped, we find that the iron filing arranges themselves in a definite pattern representing the magnetic lines of force due to the current carrying coil.



Direction of magnetic field is found by applying the right-hand thumb rule to each section of the coil and we find that the concentric lines of force pass through the coil in the same direction. Further more that:

(i) The magnetic lines of force are nearly circular near the wire.

(ii) Within the space enclosed by the wire, the lines of force are in the same direction.

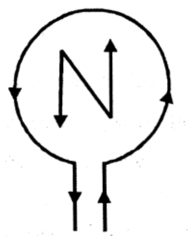
(iii) Near the center of the coil, the lines of force are nearly parallel and the magnetic field may be assumed to be practically uniform for a small space around the center.

(iv) At the center, the lines of force are along its axis and at right angle to the plane of the coil.

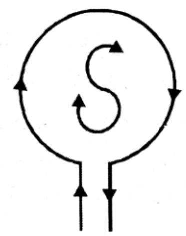
(v) The magnetic field strength is increased if the number of turns in the coil is increased or the strength of current in the coil is increased.

Since the magnetic lines of force through the coil point in the same direction, hence one face of the coil acts as a large area of north polarity because it is sending out magnetic lines of force and the other face acts as a large area of south polarity as magnetic lines of force are entering it. thus, the coil has a magnetic field similar to a magnetised iron disc of same radius as that of the coil.

The polarity of the faces of the coil depends on the direction of current and is determined by the clock rule. Looking at the face of the coil, if the current around the face is in an anticlockwise direction, the face has north polarity, while if the current at that face is in the clockwise direction, the face has south polarity. This can e tested by using a compass needle.



Anticlockwise Current
(a)



Clockwise Current
(b)

The magnitude of magnetic field **B** produced by a current-carrying circular wire at its center is :

(i) directly proportional to the current **I** passing through the circular wire
(ii) inversely proportional to the radius **r** of the circular wire.

$$\text{i.e. } B \propto I \qquad \text{and } B \propto \frac{1}{r}$$

$$\text{Magnetic field, } B = \frac{\mu_0 I}{2r}$$

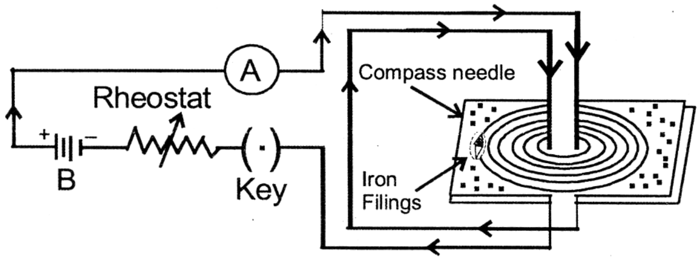
Formula which we have given above is applicable when there is only one turn of a circular wire. If we have circular coil having **N** turns of wire, then the magnetic field will become **N** times. Thus, the magnetic field at the center of a circular coil of **N** turns having radius **r** and carrying current **I** is given by

$$B = \frac{N \times \mu_0 \times I}{2r}$$

Magnetic field produced by a circular coil carrying current is directly proportional to both, number of turn (**N**) and current (**I**), but inversely proportional to its radius (**r**). Thus, the strength of magnetic field produced by a current carrying circular coil can be increased by
(i) increasing the number of turns of wire in the coil
(ii) increasing the current following through the coil
(iii) decreasing the radius of the coil.

Magnetic Field due to a Straight Current Carrying Wire:
When a current is passed through a conducting wire, a magnetic field is produced around it. The direction of magnetic field due to a straight current carrying wire can be mapped by means of a small compass needle or by iron fillings.
Take a sheet of smooth cardboard with a hole at the centre. Place it horizontally and pass a wire vertically through the hole, Sprinkle some iron fillings on the cardboard and pass an electric current through the wire. Gently tap the cardboard. We find that the iron filling arrange themselves in concentric circles around the wire as shown in figure.

If a small compass needle is kept anywhere on the board near the wire, the direction in which the north pole of the needle points gives the direction of the magnetic the magnetic field (i.e., magnetic lines of force) at that point.



Card board

The magnetic lines of force form concentric circles near the wire, with their plane perpendicular to the straight conductor and with their centers lying on its axis. if the direction of current in the wire is reversed, the direction of lines of force is also reversed.
On increasing the strength of current in the wire, the lines of force become denser and iron fillings are arranged in circles unto a larger distance from the wire, showing that the magnetic field strength has increased.