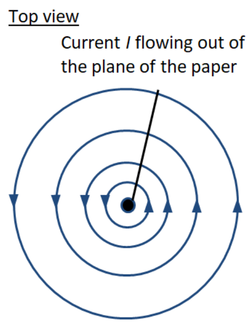
16 Electromagnetism

Magnetic fields due to currents

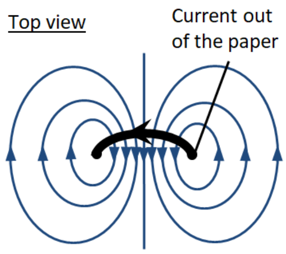
A current flowing through a wire creates a magnetic field around it.

Straight wire:



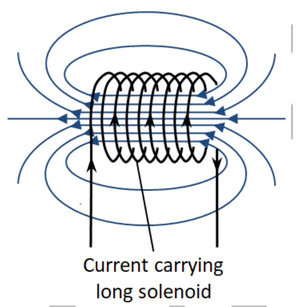
Magnetic field (B-field) is given by $B = \frac{\mu_0 I}{2\pi d}$ (given).

Flat circular coil:



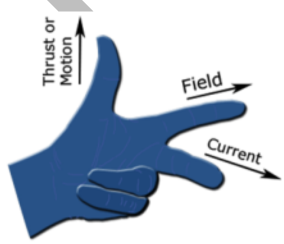
B-field at centre of coil is given by $B = \frac{\mu_0 NI}{2r}$ (given).

Solenoid:



B-field in solenoid is given by $B = \mu_0 nI$ (given). A soft iron core can be used to concentrate flux density in the solenoid.

Force on current-carrying conductor



A **magnetic field** is a region of space where a moving charge experiences a magnetic force $F = BIL\sin\theta$. Direction is found using **Fleming's Left Hand Rule** (FLHR).

Force on current-carrying conductor

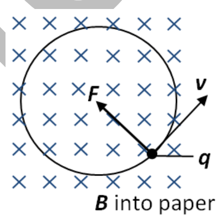
Magnetic flux density *B* is defined as the magnetic force acting per unit current per unit length of a straight current-carrying conductor places perpendicular to the field.

The SI unit of magnetic flux density *B* is Tesla (T). A current balance can be used to measure the flux density of a magnetic field.

Force between current-carrying conductors

When the currents in two straight parallel conductors X and Y are in the same direction, the flux density at Y due to X is perpendicular to Y. From FLHR, the direction of force *F* on Y is towards X. By N3L, the force on X is pointing towards Y. Hence, there is a force of attraction pulling the conductors towards each other.

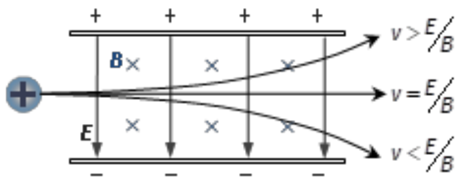
Force on a moving charge



When a charged particle *q* moves in magnetic field *B* with velocity *v*, it experiences force $F = Bqv\sin\theta$, whose direction is found using FLHR.

Note: Key formulae for circular motion will come in useful, i.e. $F_C = F_B$. There is also no WD on the particles.
If *v* is at an angle to *B* between 0° and 90°, the path of the particle will become helical.

Deflection of charged particles by uniform fields



If an electric field and magnetic field are placed at right angles to each other and in the correct direction, the forces generated will cancel each other out, i.e. $F_B = F_E \rightarrow Bqv = qE$