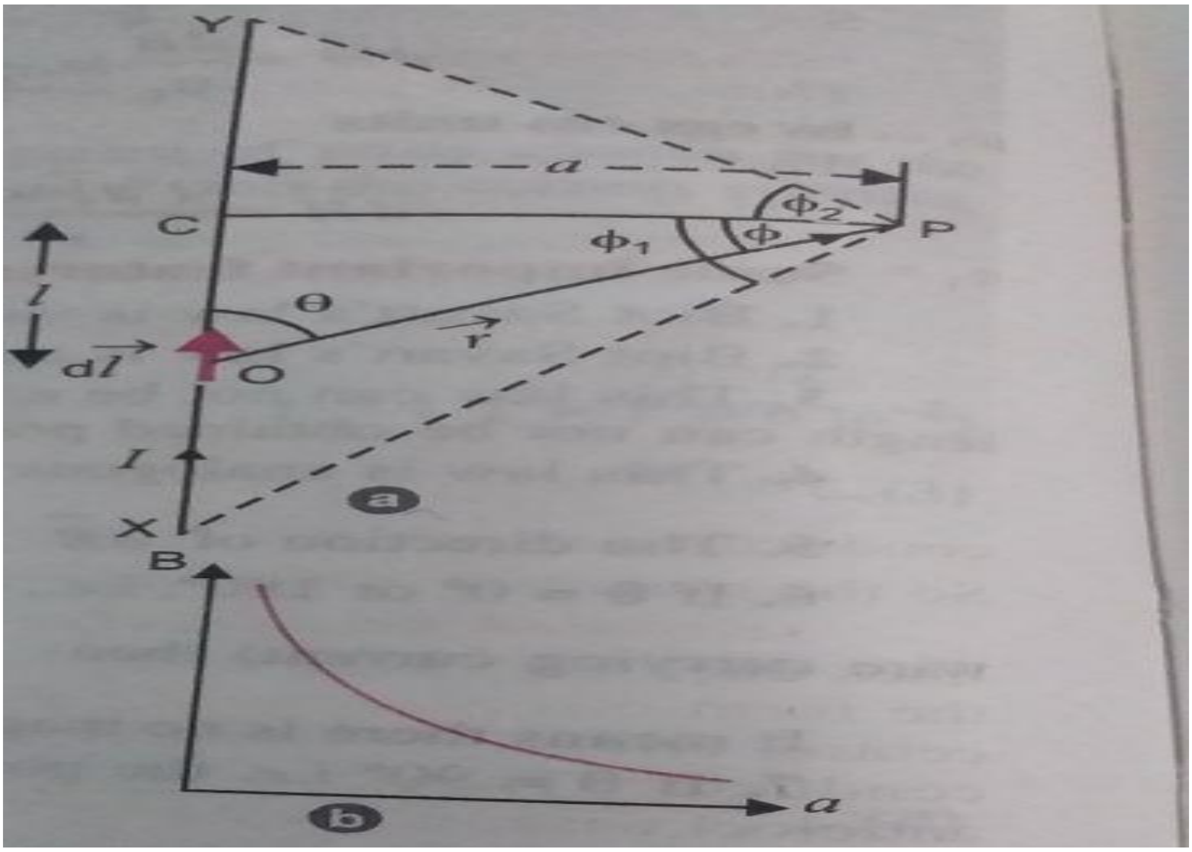
Magnetic field due to a straight wire carrying current



Consider a straight wire conductor XY lying on the plane of the paper carrying a current I .Let P be the perpendicular distance a from the straight wire conductor

In right angle triangle POC

$\Theta + \varphi = 90^0$ or $\Theta = 90^0 - \varphi$

$\sin\Theta = \sin(900 - \varphi) = \cos\varphi$

$\cos\varphi = a/r$

$r = a/\cos\varphi$

$\tan\varphi = l/a$ or $l = a\tan\varphi$

differentiate it

$dl = a\sec^2\varphi d\varphi$

write Biot- savart law

$dB = \mu_0/4\pi \times Idl\sin\Theta / r^2$

putting all these value in B-S law we get

$dB = \mu_0 I(a\ sec^2\varphi d\varphi)\ cos\varphi/\ a^2/cos^2\varphi$

$dB = \mu_0 I\ cos\varphi d\varphi/4\pi a$

integrate within the limit

$\int_{-\varphi 1}^{\varphi 2} cos\ \varphi d\ \varphi$

After integration we get

$B = \mu_0 I\ (sin\varphi_1 - sin\varphi_2)/4\pi a$

Lorentz force: The total force experienced by a charged particle moving in a region where both electric and magnetic fields are present is called Lorentz force

Now the electric force

$F_e = qE$

And the magnetic force

$F_m = q(v \times B)$

Now $F = F_e + F_m$

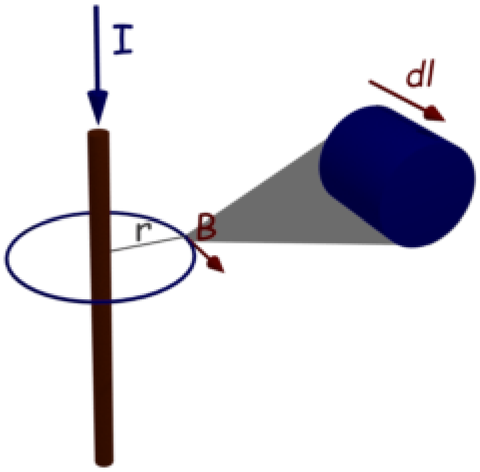
$F = q\ (V \times B\ )$

Ampere circuital law : The line integral of magnetic field induction B around a closed path in vacuum is equal to μ_0 times the total current I threading the closed path.

It is mathematically expressed as

$\int B.dl = \mu_o I$

Here μ_o = permeability of free space = $4\ \pi \times 10^{-15}\ N/\ A^2$ and $\int B.dl$ = line integral of B around a closed path.



Consider a regular coil, carrying some current I. Let us assume a small element dl on the loop.

$\int B\, dl = \int B\, dl \cos\theta$

Here, θ is the small angle with the magnetic field. The magnetic field will be around the conductor so we can assume,

$\theta = 0°$

We know that, due to a long current-carrying wire, the magnitude of the magnetic field at point P at a perpendicular distance ‘r’ from the conductor is given by,

$B = \mu_0 i/2\pi r \quad \times \int dl$

The magnetic field doesn’t vary at a distance r due to symmetry. The integral of an element will form the whole circle of the circumference *(2πr):*

$\int dl = 2\pi r$

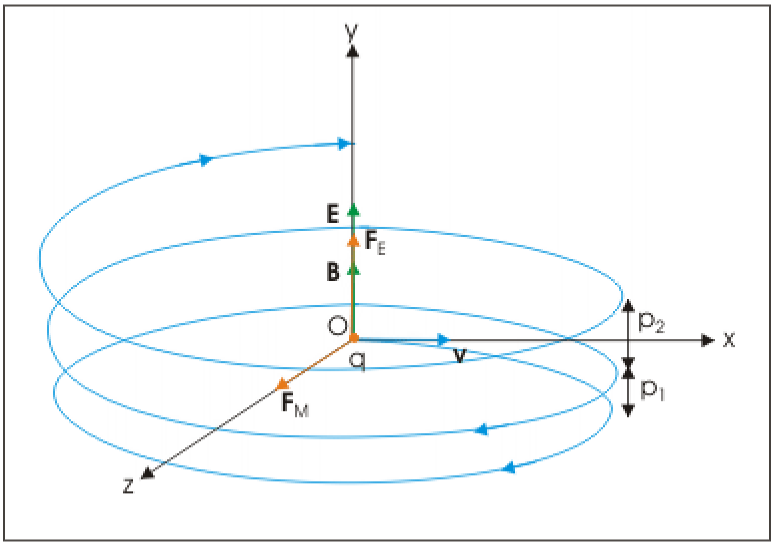
Put the value of *B* and ∫ *dl* in the equation, we get:

$\int B.dl = B\int dl = \mu_0 i/2\pi r \quad \times 2\pi\, r = \mu_o i$

therefore,

$\int B.dl = \mu_o i$

Motion of charge particle inside magnetic field :



$$Bqv = \frac{mv^2}{r}$$

$$Where\ 'm'\ is\ the\ mass\ of\ the\ charged\ particle$$ and

r be the radius of the circular path of the charged particle in magnetic field

$$Bq = \frac{mv}{r}$$

$$Bq = \frac{m\omega r}{r}$$

$$Bq = m\omega$$

$$Bq = m\frac{2\pi}{T}$$

$$T = \frac{m2\pi}{Bq}$$

Also,

$$f = \frac{Bq}{m2\pi}$$

The distance moved along the magnetic field in one rotation is called pitch of the helical path

Pitch = V_H x T = VcosΘ x 2πm/Bq = 2πmvcosΘ/qB