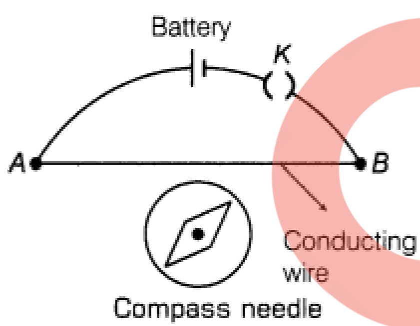
12^{th} Standard Physics

Moving Charges and Magnetism

1. The space in the surroundings of a magnet or a current-carrying conductor in which its magnetic influence can be experienced is called magnetic field. Its SI unit is Tesla (T).

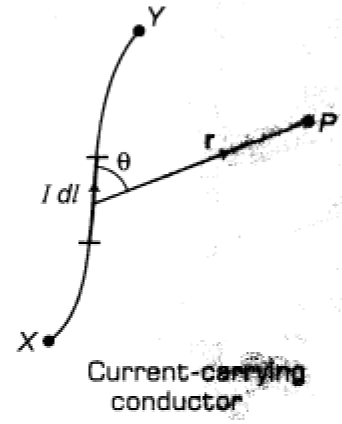
2. Oersted experimentally demonstrated that the current-carrying conductor produces magnetic field around it.



When key K is closed, then deflection occurs in the compass needle and vice-versa,

3. Biot-Savart's Law According to this law, the magnetic field due to small; current-carrying element dl at any nearby point P is given by

$$d\mathbf{B} = \frac{\mu_0}{4\pi} \cdot \frac{Id\mathbf{l}\,\hat{\mathbf{r}}}{|\mathbf{r}|^2} \quad \text{or} \quad dB = \frac{\mu_0}{4\pi} \cdot \frac{Idl \sin\theta}{r^2}$$



and direction is given by Ampere's swimming rule or right hand thumb rule.

where, $\frac{\mu_0}{4\pi} = 10^{-7}$ T-m/A

and μ_0 = permeability of free space and r = distance of point P from current-carrying element.

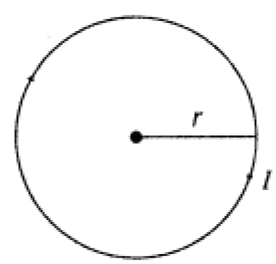
4. The relationship between μ_0, ε_0 and c is

$$\frac{1}{\mu_0 \varepsilon_0} = c^2$$

where, c is velocity of light, ε_0 is permittivity of free space and μ0 is magnetic permeability.

5. Magnetic field at the centre of a circular current-carrying conductor/coil.

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

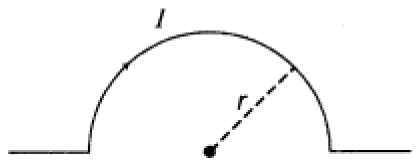


where, r is the radius of a circular loop.

For N turns of coil, $B = \frac{\mu_0 NI}{2r}$

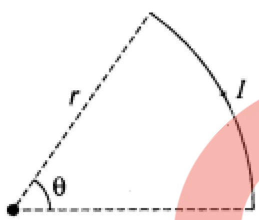
6. Magnetic field at the centre of semi-circular current-carrying conductor.

$$B = \frac{\mu_0 I}{4r}$$



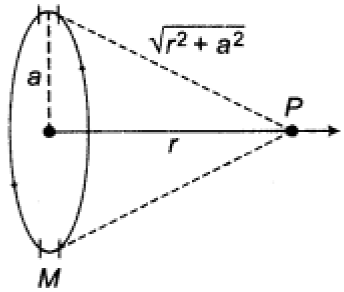
7. Magnetic field at the centre of an arc of circular current-carrying conductor which subtends an angle 0 at the centre.

$$B = \frac{\mu_0}{4\pi} \cdot \frac{I\theta}{r}$$

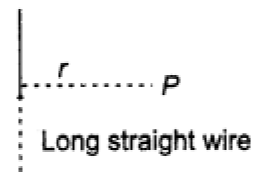


8. Magnetic field at any point lies on the axis of circular current-carrying conductor

$$B = \frac{\mu_0 I a^2}{2(r^2 + a^2)^{3/2}}$$



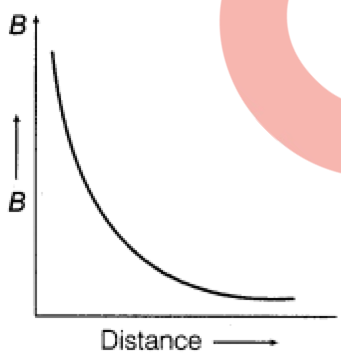
9. Magnetic field due to straight current-carrying conductor at any point P at a distance r from the wire is given by



$$B = \frac{\mu_0}{4\pi} \cdot \frac{2I}{r}$$

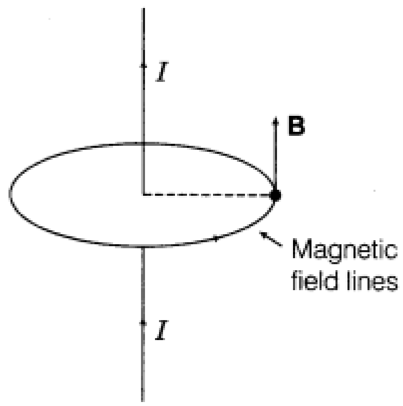
$$\Rightarrow \quad B \propto \frac{1}{r}$$

10. The following figure shows the graphical representation of variation of B with distance from straight conductor.



11. Ampere's Circuital Law The line integral of the magnetic field B around any closed loop is equal to μ_0 times the total current I threading through the loop, i.e.

$$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I$$



Magnitude of magnetic field of a straight wire using Ampere's law

$$B = \frac{\mu_0 I}{2\pi r}$$

12. Maxwell introduced the concept of displacement current.

Displacement current, $I_D = \varepsilon_0 \frac{d\phi_E}{dt}$

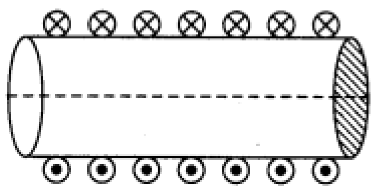
Displacement current flows in the space due to a variation in electric field.

$\Rightarrow$ $$\oint \mathbf{B} \cdot d\boldsymbol{l} = \mu_0 (I_C + I_D)$$

13. Magnetic Field due to a Straight Solenoid

(i) At any point inside the solenoid,
$B = \mu_0 nI$
where, n = number of turns per unit length.

(ii) At the ends of the solenoid,
$B = 1/2\ \mu_0 nI$



14. Magnetic Field due to Toroidal Solenoid
(i) Inside the toroidal solenoid,

$B = \mu_0 nI$, here, $n = N/2\pi r$,N= total number of turns
(ii) In the open space, interior or exterior of toroidal solenoid,
$B = 0$