MAGNETIC FIELDS DUE TO ELECTRIC CURRENT

LEGEND

$\vec{B} \rightarrow Magnetic\ Field$

$\vec{v} \rightarrow Velocity$

$\vec{E} \rightarrow Electric\ field$

$q \rightarrow$ *Charge*

$t \rightarrow TIme\ interval$

$I \rightarrow Current$

$F \rightarrow Force$

$n \rightarrow Frequency$

$\vec{F}_m \rightarrow Magnetic\ force$

$r \rightarrow Radius$

$K.E. \rightarrow Kinetic\ enegy$

$n \rightarrow Frequency$

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1. Electric force in charge q:

$$\vec{F}_e = q\vec{E}$$

2. Magnetize force on charge q:

$$\vec{F}_m = q(\vec{c} \times \vec{B})$$

3. Lorentz force law:

$$\vec{F} = q[\vec{E}(\vec{v} \times \vec{B})]$$

4. Relation for magnetic force

$$\vec{F} = q|\vec{v} \times \vec{B}|\hat{n} = \sin\theta\,\hat{n}$$

5. Cyclotron formula:

$$mv = p = qBR$$

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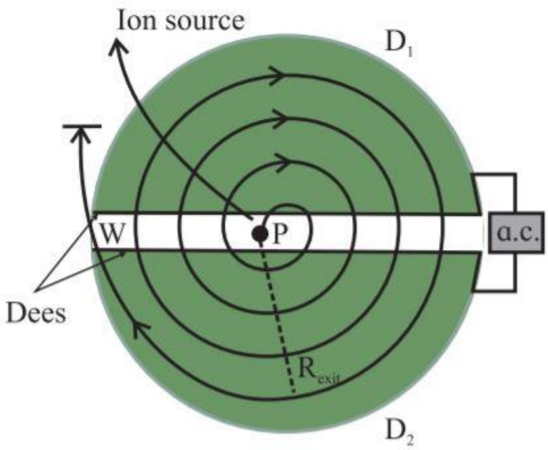

6. Cyclotron formula (Cyclotron frequency) is:

$$f_e = \frac{1}{T} = \frac{qB}{2\pi m}$$

7. Velocity of particle in cyclotron:

$$v = \frac{qBR_{exit}}{m}$$

8. Kinetic energy of the ions / protons will be:

$$K.E. = \frac{1}{2}mv^2 = \frac{q^2B^2R_{exit}^2}{2m}$$

9. Magnetize force on straight wire carrying current:

$$F_m = I\vec{L} \times \vec{B}$$

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10. Magnetize force by $\vec{\mathbf{B}}$ is uniform over the whole wire:

$$\vec{F}_m = I\left[\int \vec{d}l\right] \times \vec{B}$$

11. Magnetize force for arbitrarily shaped wire:

$$\vec{F}_m = I\left[\int \vec{d}l\right] \times \vec{B}$$

12. Torque on the current loop:

i. $= Il_1l_2\,B\sin\theta$

ii. a. For n turns

$\tau' = N\tau = NLl_1l_2\,B\sin\theta$

b. $\tau' = (NIA)\,B\sin\theta$

iii. $\tau = K\phi$

where K is torsional constant and ϕ is angular deflection in coil

iv. $\vec{\tau} = \vec{m} \times \vec{B}$

13. Deflection in M.C.G.:

$$\phi = \left(\frac{NAB}{K}\right) I$$

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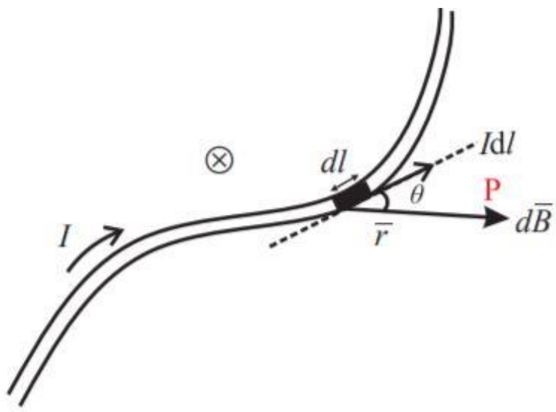
14. Magnetic potential energy of a magnetic dipole $\vec{\mathbf{m}}$ in a magnetic field $\vec{\mathbf{B}}$:

$$\vec{U} . -\vec{m}.\vec{B} = -mB\cos\theta$$

15. Biot savart law:

$$dB = \frac{\mu_0}{4\pi} \times \frac{Idl\sin\theta}{r^2}$$



16. Biot savart law in vector form:

$$\overrightarrow{dB} = \frac{\mu_0}{4\pi}\frac{Id\vec{l} \times \vec{r}}{r^3}$$

17. Magnetic Field due to infinite straight current carrying wire:

$$B = \frac{\mu_0 I}{2\pi} R \times \frac{1}{R^2} = \frac{\mu_0 I}{2\pi R}$$

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18. Magnetic Field due to semi-infinite straight current carrying wire:

$$B_{semi} = \frac{B}{2} = \frac{\mu_0 I}{2\pi R} \times \frac{1}{2} = \frac{\mu_0 I}{4\pi R}$$

19. Force per unit length of the wire will be:

$$\frac{F}{L} = \frac{\mu_0}{2r} \times \frac{I_1 I_2}{d}$$

20. Magnetic Field at the centre of the circle:

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

21. Magnetic Field at the centre of the loop:

$$B_0 = \frac{\mu_0 I}{2R}$$

$$\text{for a coil of N turns, } B = \frac{\mu_0 NI}{2R}$$

22. Magnetic Field due to circular current loop at large distances in terms of magnetic moment (m):

$$B_Z = \frac{\mu_0}{2r} \frac{m}{Z^3}$$

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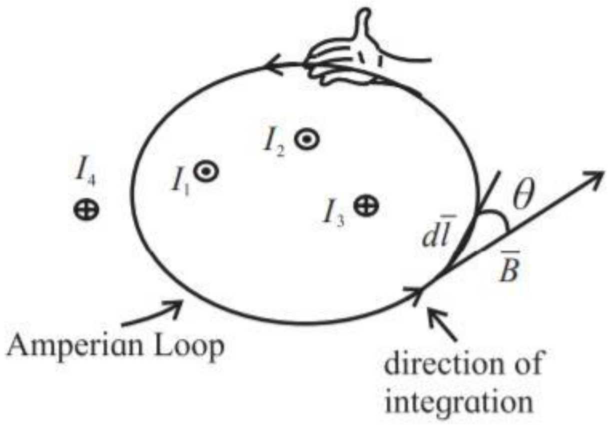
23. Ampere's law:

$$\oint \vec{B}.\vec{ds} = \mu_0 I$$



24. Magnetic Field at a distance r from straight current conducting wire:

$$\int \vec{B}.\vec{dl} = \mu_0 I$$

25. i. Magnetic induction at the centre of circular coil:

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

ii. For n turns in the coil:

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

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26. Magnetic induction due to long solenoid:

i. At a point inside a solenoid,

$$B = \mu_0 ni$$

ii. At a point near the end of solenoid,

$$B_{end} = \frac{1}{2}\mu_0 ni$$

Where, $n = \frac{N}{l}$ = turns per unit length of a solenoid

27. Magnetic induction at a point along this axis of a toroid:

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

Where, i is current flowing in each turn.