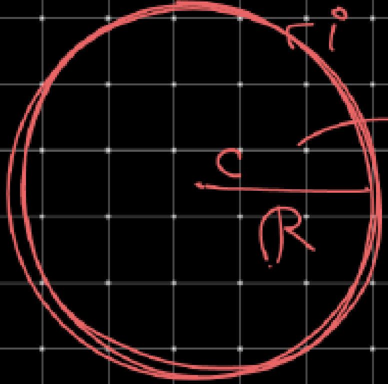
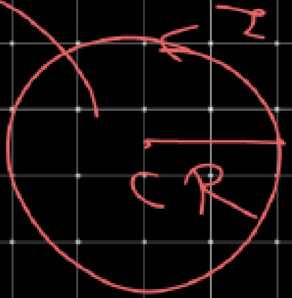
Magnetic field due to Circular Coil at its centre & axial point -

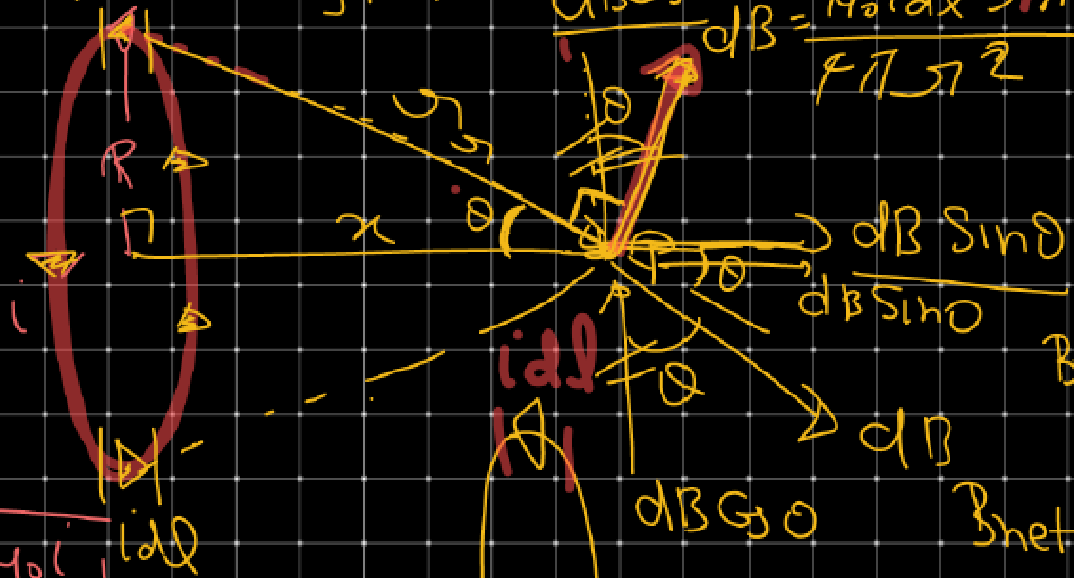
N-turn



$$B_C = \frac{\mu_0 i}{2R} \quad \text{[for single turn)}$$

$$\boxed{B_C = \frac{\mu_0 N i}{2R}}$$





$r=\sqrt{R^2+x^2}$

$$dB = \frac{\mu_0 i\, dl \sin 90}{4\pi r^2}$$

$$dB_{net} = dB\sin\theta$$

$$B_{net} = \frac{\mu_0 i\, dl}{4\pi r^2}\cdot\sin\theta$$

$$B_{net} = \frac{\mu_0 i}{4\pi r^2}\sin\theta\cdot\int dl$$

$$B_{net} = \frac{\mu_0 i}{\cancel{4\pi} r^2}\cdot\frac{R}{r}\times \cancel{2\pi} R$$

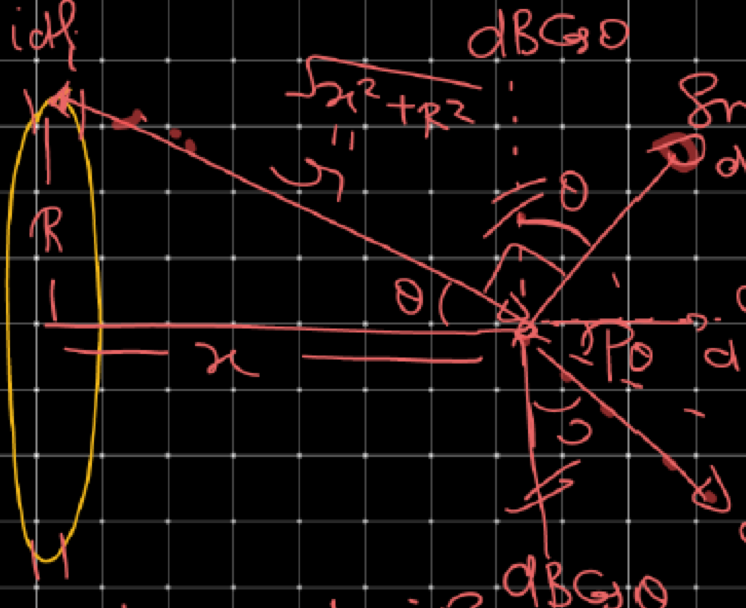
$$B = \frac{\mu_0 i R^2}{2 r^3}$$

$$B = \frac{\mu_0 i R^2}{2\left(\sqrt{x^2+R^2}\right)^3}$$

$$\boxed{B = \frac{\mu_0 i R^2}{2(x^2+R^2)^{3/2}}}$$

$$\boxed{B_c = \frac{\mu_0 i}{2R}}$$

Magnetic field at point P due to small $id\vec{l}$.



$dB = \frac{\mu_0 i dl}{4\pi r^2} \sin 90$

$dB_{net} = dB \sin\theta$

$\int dB_{net} = \int \frac{\mu_0 i dl}{4\pi r^2} \sin\theta$

$B_{net} = \frac{\mu_0 i}{4\pi r^2} \frac{R}{r} \int dl$

$B_{net} = \frac{\mu_0 i R}{\cancel{4}\cancel{\pi} r^3} \times \cancel{2}\cancel{\pi} R$

$= \frac{\mu_0 i R^2}{2 r^3}$

$B_{net} = \frac{\mu_0 i R^2}{2(R^2+x^2)^{3/2}}$

$B_{net} = \frac{\mu_0 i R^2}{2(R^2+x^2)^{3/2}}$

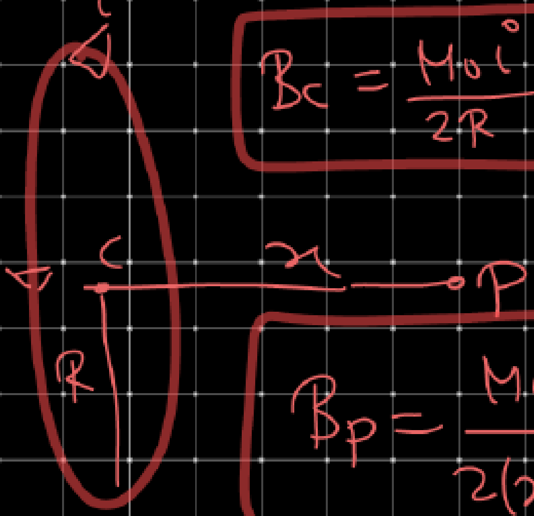
$$B = \frac{\mu_0 i R^2}{2 r^3}$$

$$B = \frac{\mu_0 i R^2}{2\left[(R^2+x^2)^{1/2}\right]^3}$$

$$\boxed{B = \frac{\mu_0 i R^2}{2\left[R^2+x^2\right]^{3/2}}}$$

$$\boxed{r = \sqrt{R^2+x^2}}$$

$$r = (R^2+x^2)^{1/2}$$



$$\boxed{B_c = \frac{\mu_0 i}{2R}}$$

maximum at centre

$$\boxed{B_p = \frac{\mu_0 i R^2}{2(x^2+R^2)^{3/2}}}$$

$$(1+x)^n$$

$$1+nx$$

$$x << 1$$

$$(1-x)^n = 1-nx$$

If $x << 1$

$$\Rightarrow \boxed{B_c = \frac{\mu_0 i}{2R}}$$

$$B_{axial} = \frac{\mu_0 i R^2}{2(x^2+R^2)^{3/2}} = \frac{\mu_0 i R^2}{2\left[R^2+x^2\right]^{3/2}}$$

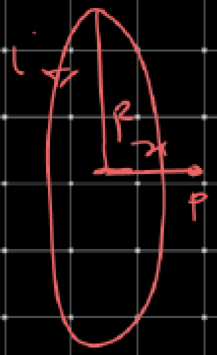
$$B_{axial} = \frac{\mu_0 i R^2}{2\left[R^2\left(1+\frac{x^2}{R^2}\right)\right]^{3/2}} = \frac{\mu_0 i R^2}{2\left[R^2\left(1+\frac{x^2}{R^2}\right)\right]^{3/2}} = \frac{\mu_0 i R^2}{2R^{\frac{2\times 3}{2}}\left(1+\frac{x^2}{R^2}\right)^{3/2}}$$

$$B_{axial} = \frac{\mu_0 i \cancel{R^2}}{2R^3\left(1+\frac{x^2}{R^2}\right)^{3/2}} = \boxed{\frac{\mu_0 i}{2R}\left(1+\frac{x^2}{R^2}\right)^{-3/2}} = \frac{\mu_0 i}{2R}\left(1+\frac{x^2}{R^2}\right)^{-3/2}$$

$$B_{axial} = B_{centre}\left[1+\frac{x^2}{R^2}\right]^{-3/2}$$

$$B_{axial} = \frac{\mu_0 i}{2R}\left(1+\frac{x^2}{R^2}\right)^{-3/2}$$

$$= B_c\left(1+\frac{x^2}{R^2}\right)^{-3/2}$$



$x << R$

$$\boxed{\frac{x^2}{R^2} << 1}$$

If $x << R$

$$B_{axial} = B_c\left[1+\frac{x^2}{R^2}\right]^{-3/2}$$

$$\boxed{B_{axial} = B_c\left(1-\frac{3}{2}\frac{x^2}{R^2}\right)}$$

$$\boxed{B_{axial} = B_c\left(1-\frac{3}{2}\frac{x^2}{R^2}\right) \quad x << R}$$

near the centre & its axial position.

$$B_{axial} = B_{centre}\left[1 - \frac{3}{2}\frac{x^2}{R^2}\right]$$

$$\boxed{x << R}$$

$$B_A = B_C - B_C \times \frac{3}{2}\frac{x^2}{R^2}$$

$$B_A - B_C = -B_C \frac{3}{2}\frac{x^2}{R^2}$$

$$\boxed{\frac{B_{axial} - B_{centre}}{B_{centre}} = -\frac{3}{2}\frac{x^2}{R^2}}$$

fractional change.

$$\boxed{B_{axial} = B_C\left[1 - \frac{3}{2}\frac{x^2}{R^2}\right] \quad x << R} \rightarrow \text{Imp.}$$

LD

$$B_{axial} = \frac{\mu_0 i R^2}{2(x^2+R^2)^{3/2}}$$

$$= \frac{\mu_0 i R^2}{2\left[x^2\left(1+\frac{R^2}{x^2}\right)\right]^{3/2}}$$

$$= \frac{\mu_0 i R^2}{2(x^2)^{3/2}\left(1+\frac{R^2}{x^2}\right)^{3/2}}$$

$\Rightarrow$

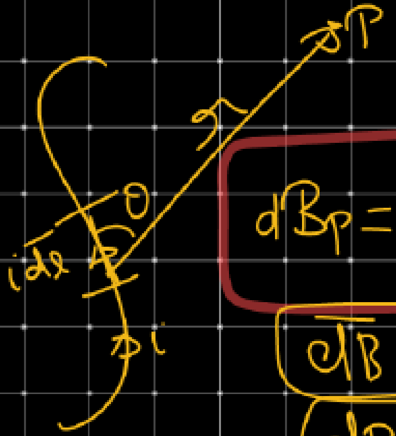
M

$$B_{axial} = \frac{\mu_0 i R^2}{2x^3\left(1+\frac{R^2}{x^2}\right)^{3/2}}$$

$$R << x$$

$$\frac{R^2}{x^2} \simeq 0$$

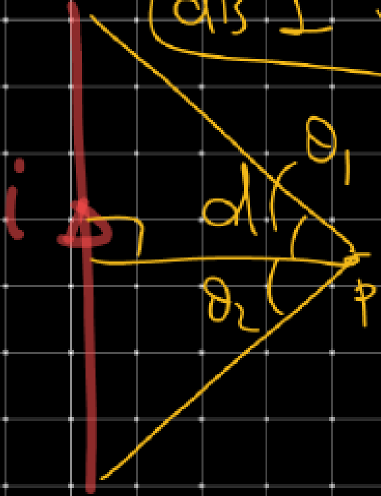
$$B_{axial} = \frac{\mu_0 i R^2}{2x^3} \quad [x >> R]$$



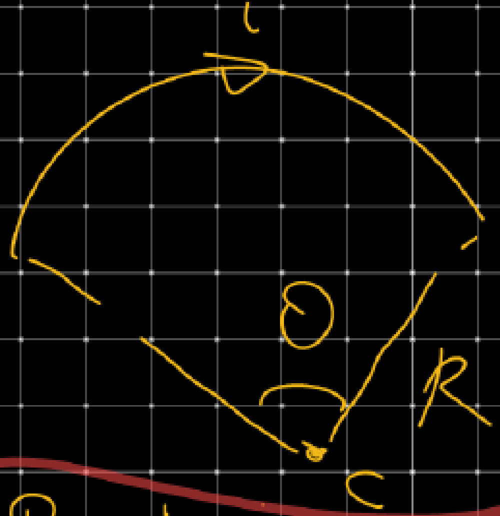
$$\boxed{dB_P = \frac{\mu_0}{4\pi}\frac{i\,dl\sin\theta}{r^2}}$$

$\vec{dB} \perp \vec{r}$

$\vec{dB} \perp i\vec{dl}$



$$B_P = \frac{\mu_0 i}{4\pi d}(\sin\theta_1 + \sin\theta_2)$$



$$B_C = \frac{\mu_0 i}{4\pi R}(\theta \text{ in radian})$$