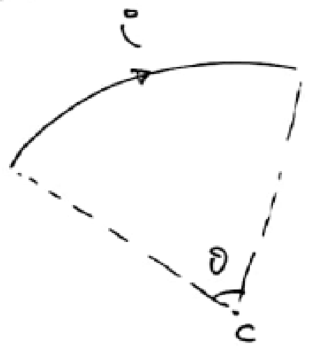
⇒ Magnetic field due to current carrying wire.

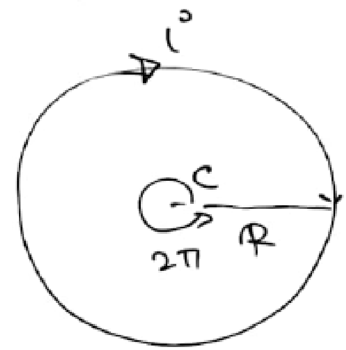
due to Circular arc :-



θ in radian

$\otimes$

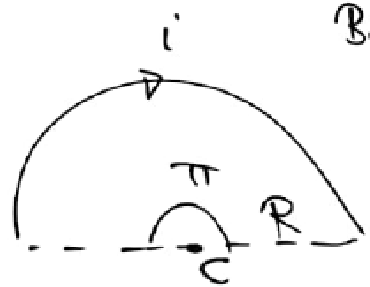
$$B_c = \frac{\mu_0 i}{4\pi R}(\theta)$$



$\theta = 2\pi$

$$B_c = \frac{\mu_0 i}{4\pi R}(2\pi) = \frac{\mu_0 i}{2R} \otimes$$

$\otimes$



$$B_c = \frac{\mu_0 i}{4\pi R}(\pi) = \frac{\mu_0 i}{4R} \otimes$$

⇒ Magnetic field due to current carrying wire.

(#) due to Circular arc :-

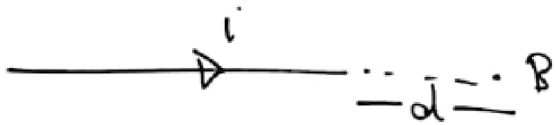
$$B_c = \frac{\mu_0 i}{4\pi R}(\theta)$$

$60 \rightarrow 60 \times \frac{\pi}{180} = \frac{\pi}{3}$

$$\vec{B}_c = \frac{\mu_0 i}{4\pi R}\left(\frac{\pi}{3}\right) = \frac{\mu_0 i}{12R}$$

$$\vec{B}_c = \frac{\mu_0 i}{12R}\odot = \frac{\mu_0 i}{12R}(+\hat{k})$$

(#)

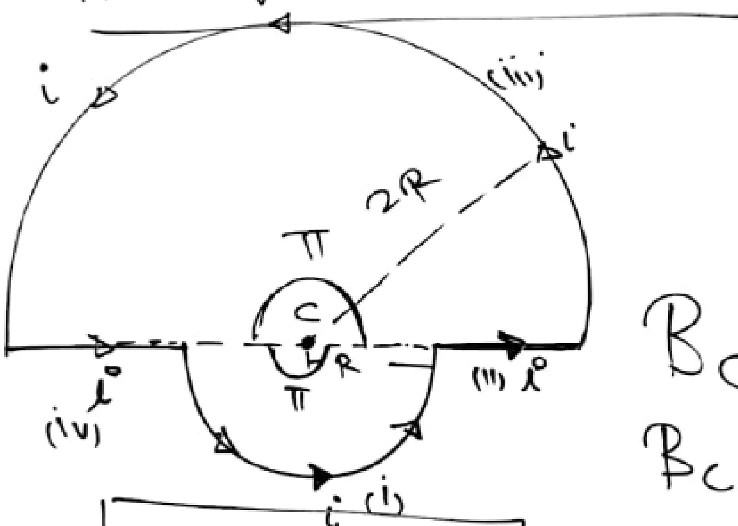


$B = 0$

⇒ Magnetic field due to current carrying wire.

Find magnetic field at Centre:-

$B_{wire(ii)}$ & $B_{wire(iv)} = 0$



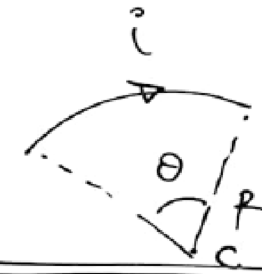
$\vec{B}_C = \frac{3\mu_0 i}{8R}(\hat{k})$

$$B_C = B_1 + B_3$$

$$B_C = \frac{\mu_0 i}{4\pi(R)}(\pi)\odot + \frac{\mu_0 i}{4\pi(2R)}[\pi]\odot$$

$$= \left(\frac{\mu_0 i}{4R} + \frac{\mu_0 i}{8R}\right)\odot$$

$$B_C = \frac{3\mu_0 i}{8R}$$

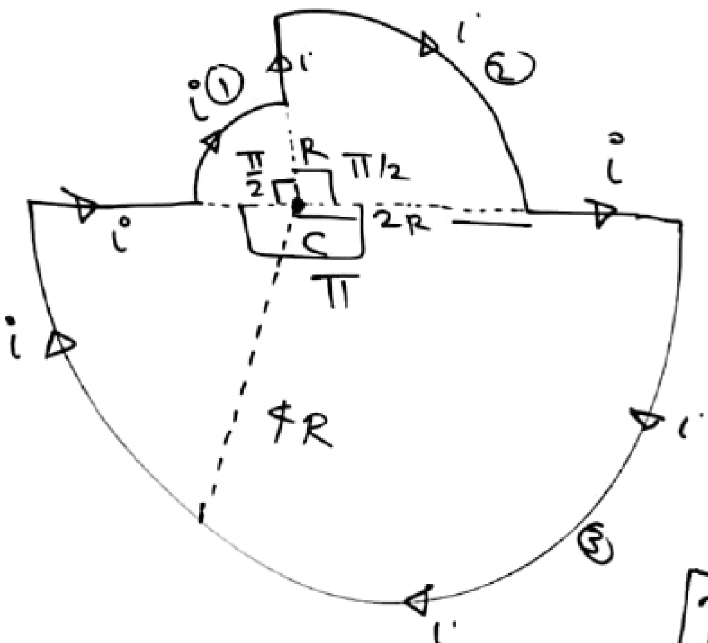


$B_C = \frac{\mu_0 i}{4\pi(R)}(\theta)$

⇒ Magnetic field due to current carrying wire.

Find magnetic field at Centre:

find magnetic field at Centre (C)



$$\bar{B}_C = \bar{B}_1 + \bar{B}_2 + \bar{B}_3$$

$$= \frac{\mu_0 i}{4\pi(R)}\left(\frac{\pi}{2}\right) + \frac{\mu_0 i\left(\frac{\pi}{2}\right)}{4\pi(2R)} + \frac{\mu_0 i}{4\pi(4R)}(\pi)$$

$$= \frac{\mu_0 i}{8R} + \frac{\mu_0 i}{8R \times 2} + \frac{\mu_0 i}{16R}$$

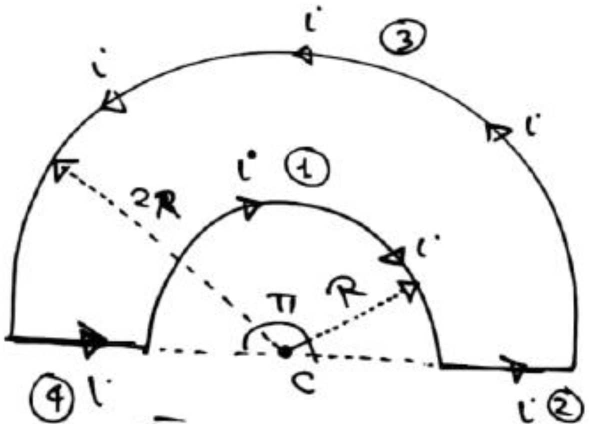
$$= \frac{\mu_0 i}{8R} + \frac{\mu_0 i}{16R} + \frac{\mu_0 i}{16R}$$

$$= \frac{2\mu_0 i + \mu_0 i + \mu_0 i}{16R} = \frac{4\mu_0 i}{16R} = \frac{\mu_0 i}{4R}$$

$$B_C = \frac{\mu_0 i}{4R} \otimes$$

⇒ Magnetic field due to current carrying wire.

Find magnetic field at Centre:-



Magnetic field due to wire ② & ④ is zero.

— magnetic field due to wire ①

$$\bar{B}_1 = \frac{\mu_0 i}{4\pi(R)}(\pi) = \frac{\mu_0 i}{4R} \otimes \Rightarrow \frac{\mu_0 i}{4R}(-\hat{k})$$

$$\bar{B}_1 = -\frac{\mu_0 i}{4R}\hat{k}$$

→ Magnetic field due to wire ③

$$\bar{B}_3 = \frac{\mu_0 i}{4\pi(2R)}(\pi) = \frac{\mu_0 i}{8R}(+k)$$

$$\bar{B}_3 = \frac{\mu_0 i}{8R}(+k)$$

$$\bar{B}_{net} = \bar{B}_1 + \bar{B}_3$$

$$= \frac{\mu_0 i}{4R}(-k) + \frac{\mu_0 i}{8R}(+k)$$

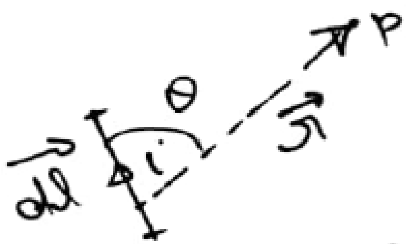
$$-\frac{\mu_0 i}{4R}k + \frac{\mu_0 i}{8R}k$$

$$\bar{B} = \frac{\mu_0 i}{8R}(-k) \Rightarrow B = \frac{\mu_0 i}{8R}\text{ [inward]}$$

⟹ Magnetic field due to current carrying wire.

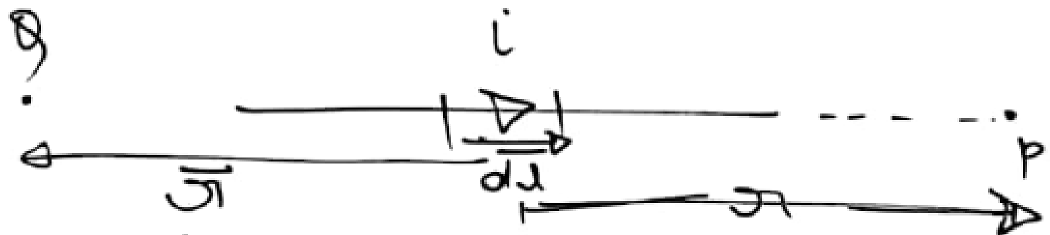
$\sin 0° = 0$

$\sin 180° = 0$



$$dB = \frac{\mu_0 i \, dl \sin\theta}{r^2}$$

θ → angle b/w $i\vec{dl}$ & $\vec{r}$



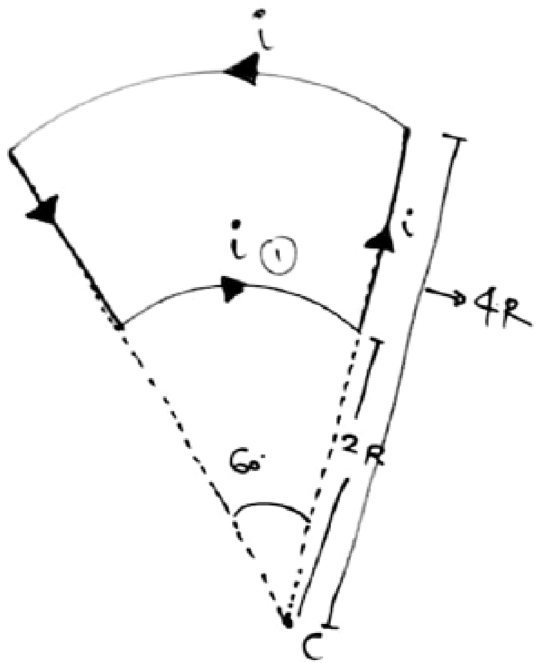
⇓

θ = 180°

θ = 0

B = 0

⇒ Magnetic field due to current carrying wire.



Find magnetic field at centre.

$\theta = \frac{\pi}{3}$

$60 \times \left(\frac{\pi}{180}\right)$

$\Rightarrow \frac{\pi}{3}$ $\quad \pi^c = 180°$

$$\vec{B}_1 = \frac{\mu_0 i}{4\pi(2R)}\left(\frac{\pi}{3}\right) = \frac{\mu_0 i}{24R}(-\hat{k})$$

$$\vec{B}_2 = \frac{\mu_0 i}{4\pi(4R)}\left(\frac{\pi}{3}\right) = \frac{\mu_0 i}{48R}(+\hat{k})$$

$$\vec{B}_{net} = \vec{B}_1 + \vec{B}_2$$

$$= -\frac{\mu_0 i}{24R}k + \frac{\mu_0 i}{48R}(k)$$

$$= \left(\frac{-2\mu_0 i + \mu_0 i}{48R}\right)k = -\frac{\mu_0 i}{48R}k = \frac{\mu_0 i}{48R}(-k)$$

$$\boxed{\vec{B}_{net} = \frac{\mu_0 i}{48R}\text{(inward)}}$$

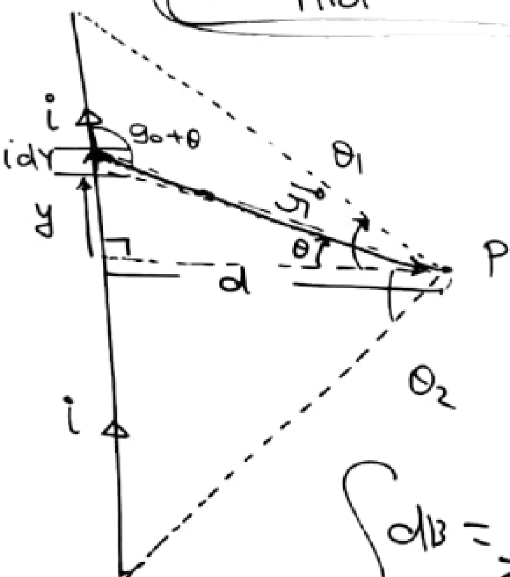
⇒ Magnetic field due to current carrying wire.

Find magnetic field at centre.

⇒ Magnetic field due to straight wire :- [finite wire]

$$B = \frac{\mu_0 i}{4\pi d}[\sin\theta_1 + \sin\theta_2]$$

dB → due to small current carrying element. $(i\,dY)$



$$dB = \frac{\mu_0\, i\, dY \sin(90+\theta)}{4\pi\, r^2}$$

$$dB = \frac{\mu_0\, i\, dY \cos\theta}{4\pi\, r^2}$$

$$\left[\begin{aligned} \tan\theta &= \frac{Y}{d} \\ Y &= d\tan\theta \\ dY &= d\sec^2\theta\, d\theta \\ \cos\theta &= \frac{d}{r} \end{aligned}\right]$$

$$r = d\sec\theta$$

$$r = \frac{d}{\cos\theta}$$

$$dB = \frac{\mu_0 i [d\sec^2\theta\, d\theta]\cos\theta}{4\pi (d\sec\theta)^2}$$

$$dB = \frac{\mu_0 i\, d\sec^2\theta \cos\theta\, d\theta}{4\pi\, d^2\sec^2\theta} = \frac{\mu_0 i}{d}\cos\theta\, d\theta$$

$$\int dB = \frac{\mu_0 i}{4\pi d}\int_{-\theta_2}^{\theta_1}\cos\theta\, d\theta$$

$$B = \frac{\mu_0 i}{4\pi d}[\sin\theta]_{-\theta_2}^{\theta_1}$$

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