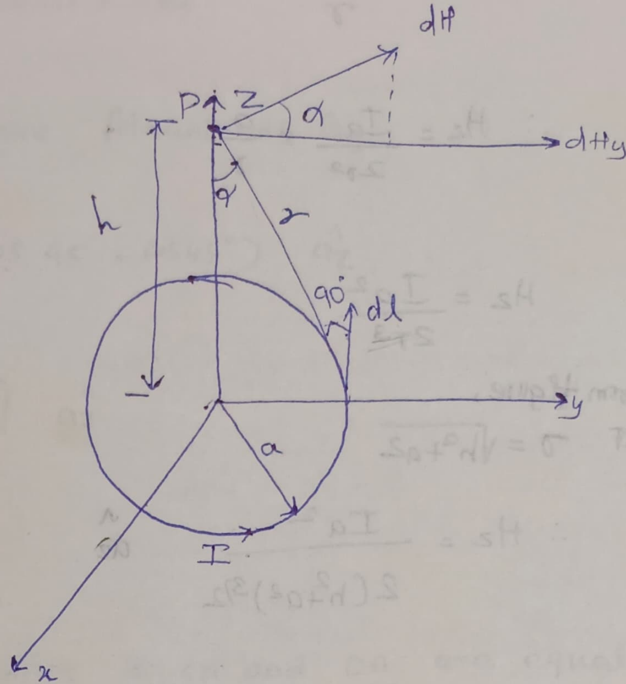
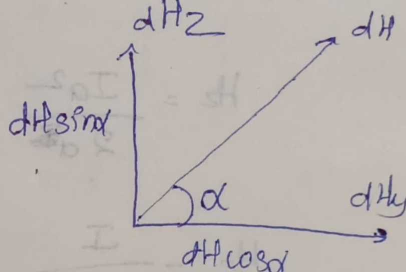
2. Magnetic field intensity due to ~~any~~ circular loop:



Consider a circular wire of radius 'a'.

The direction of dl at any point is the tangent to the circular wire at that point.



Magnetic field intensity at a point 'P'

$$dH = \frac{I\,dl \sin 90^\circ}{4\pi r^2}\,\hat{a}_z$$

dH_y component vanishes.

dH_z component only exists.

$$dH_z = dH \sin\alpha$$

$$dH_z = \frac{I\,dl}{4\pi r^2} \sin\alpha$$

Magnetic field intensity due to entire circular loop

$$H_z = \int \frac{I\,dl}{4\pi r^2} \sin\alpha \qquad \int dl = 2\pi a$$

circumference

$$H_z = \frac{I}{4\pi r^2} \sin\alpha\,(2\pi a)$$

$$H_z = \frac{Ia}{2r^2} \sin\alpha$$

$$\sin\alpha = \frac{a}{r}$$

$$\therefore H_z = \frac{Ia}{2r^2} \times \frac{a}{r}$$

$$H_z = \frac{Ia^2}{2r^3}$$

from figure,

WKT $r = \sqrt{h^2+a^2}$

$$\therefore H_z = \frac{Ia^2}{2(h^2+a^2)^{3/2}} \hat{a}_z$$

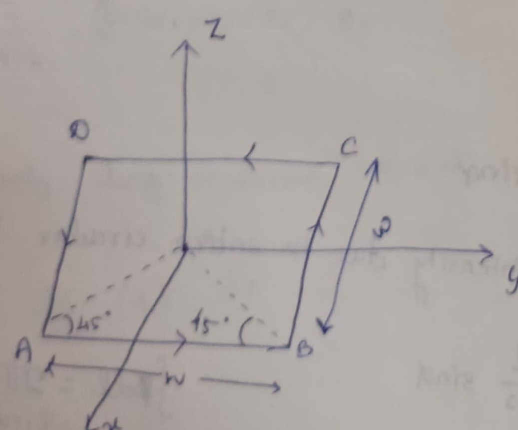
If point P is at the center of the loop, $h=0$

$$H_z = \frac{Ia^2}{2a^3}$$

$$H_z = \frac{I}{2a}$$

$$\therefore H = \frac{I}{2a} \hat{a}_z$$

Magnetic flux density at the centre of square loop.



The field intensity at a distance 'h' from any current carrying conductor of finite length

$$H = \frac{I}{4\pi h} (\cos\alpha_1 + \cos\alpha_2)\, \hat{a}_z$$

H_{AB} due to the current filament AB is,

$$H_{AB} = \frac{I}{4\pi \frac{w}{2}} (\cos 45^\circ + \cos 45^\circ)\, \hat{a}_z$$

$$= \frac{I}{2\pi w} \left(\frac{2}{\sqrt{2}}\right) \hat{a}_z$$

$$H_{AB} = \frac{I}{\sqrt{2}\pi w} \hat{a}_z$$

Field intensities due to sides BC, CD and DA are equal

$$H_{AB} = H_{BC} = H_{CD} = H_{DA}$$

$$\therefore H = 4 H_{AB}$$

$$= 4 \frac{I}{\sqrt{2}\pi w} \hat{a}_z$$

$$H = \frac{2\sqrt{2}\, I}{\pi w} \hat{a}_z$$

magnetic flux density

$$B = \mu_0 H$$

$$B = \frac{2\sqrt{2}\, \mu_0 I}{\pi w} \hat{a}_z$$