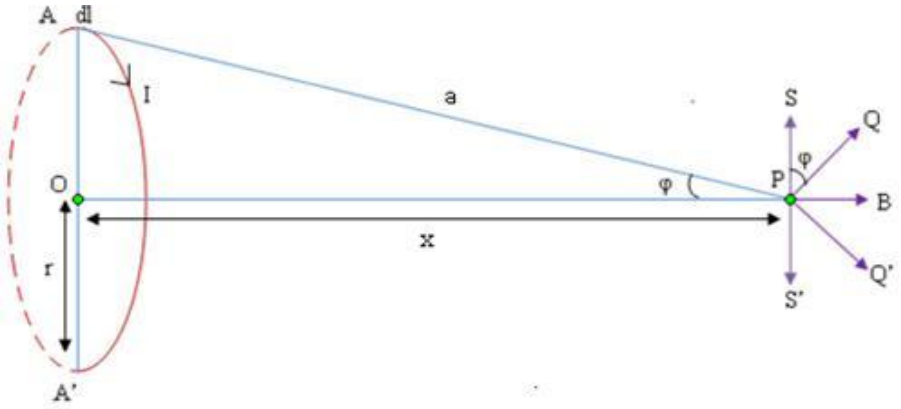
A circular coil of radius 1m having 100 turns carry a current of .2A.Determine the magnetic field along the axis at a distance .2m from the centre

Solution

Consider a circular coil of radius r, carrying a current I. Consider a point P, which is at a distance x from the centre of the coil. We can consider that the loop is made up of a large number of short elements, generating small magnetic fields. So the total field at P will be the sum of the contributions from all these elements. At the centre of the coil, the field will be uniform. As the location of the point increases from the centre of the coil, the field decreases.



By Biot- Savart's law, the field dB due to a small element dl of the circle, centered at A is given by,

$$dB = \frac{\mu_0}{4\pi} I \frac{dl}{(x^2 + r^2)}$$

This can be resolved into two components, one along the axis OP, and other PS, which is perpendicular to OP. PS is exactly cancelled by the perpendicular component PS' of the field due to a current and centered at A'. So, the total magnetic field at a point which is at a distance x away from the axis of a circular coil of radius r is given by,

$$B_X = \frac{\mu_0 I}{2} * \frac{r^2}{(x^2 + r^2)^{\frac{3}{2}}}$$

If there are *n* turns in the coil, then

$$B_X = \frac{\mu_0 nI}{2} * \frac{r^2}{(x^2+r^2)^{\frac{3}{2}}}$$

where μ_0 is the absolute permeability of free space.
So

$$B_X = \frac{4\pi * 10^{-7} * 100 * 0.2}{2} \frac{1^2}{(1^2 + 0.2^2)^{\frac{3}{2}}} = 11.84 * 10^{-6}\text{T} = 11.84\ \mu T$$

Answer: 11.84 μT.