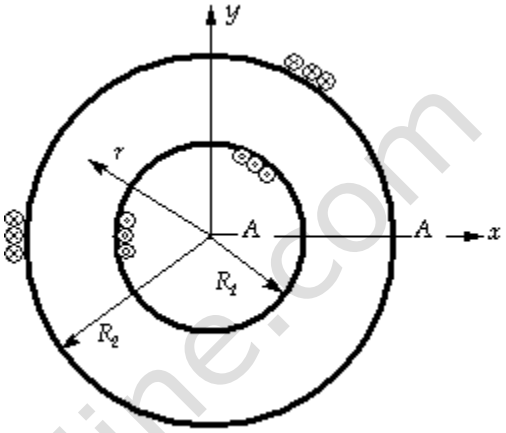
Q- A circular torus has inner radius R_1 = 30 cm, outer radius R_2 = 50 cm, and N = 710 turns wound uniformly around it. The current in the windings is I = 3 A.
(a) Calculate the magnitude of the magnetic field *B* inside the torus, in the symmetrical plane parallel to the inner and outer diameter, at the following distances from the axis of symmetry: r_1 = 35 cm and r_2 = 40 cm.



The magnetic flux lines inside a toroid are circular and symmetrical to the axis of the toroid and hence we can apply Ampere's law for this. The current in the winding wires in the inner part of the toroid are in the same direction and hence added up. Thus, the current through every loop through the gap of a toroid is I*N where I is the current and N is the number of turns of the winding.

At a distance r from the axis of toroid inside it if the field strength is B then $\int \vec{B} \bullet d\vec{l}$ for that loop will be B.2πr and hence according to Ampere's law we have

$$B.2\pi r = \mu_0 * I_{in} = \mu_0 * (N * I)$$

Therefore, the field inside the toroid is given by

$$B = \frac{\mu_0 (N * I)}{2\pi r}$$

Hence, field at a distance r_1 = 35 cm = 0.35 m will be

$$B(r_1, 0) = \frac{\mu_0 (N * I)}{2\pi r_1} = \frac{2 * 10^{-7} (710 * 3.0)}{0.35} = 1.22 * 10^{-3}\,\text{T}$$

And field at a distance r_2 = 40 cm = 0.40 m will be

$$B(r_2, 0) = \frac{\mu_0 (N * I)}{2\pi r_2} = \frac{2 * 10^{-7} (710 * 3.0)}{0.40} = 1.065 * 10^{-3}\,\text{T}$$

As the current inside the loop is out of the screen according to right hand rule the field lines inside the toroid will be anticlockwise.

(b) Calculate the magnitude of the magnetic field *B,* outside the torus, in the symmetrical plane along the inner and outer diameter, at the following distances from the axis of symmetry: r_3 = 0 and r_4 = 60 cm.

As for any loop or radius is greater than 50 cm the total current due to inner windings and due to outer windings are equal and opposite, the net current through the loop is zero and hence the field will be zero at distance r_3 and r_4.