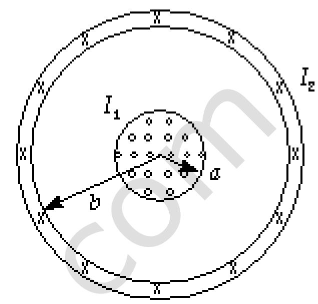
Q- An infinite cylindrical conductor of radius a = 1 cm carries a current I_1 = 0.3 A out of the page. A coaxial, infinite, thin cylindrical conducting shell of radius b = 5 cm carries a current I_2 = 0.12 A, into the page. The current densities in each conductor are uniform.



(a) Calculate the magnitude of the current density in the inner conductor.
The current density in the inner conduction is given by

$$j = \frac{I}{A} = \frac{I}{\pi a^2} = \frac{0.3}{3.14*(0.01)^2} = 954.9 \text{ A/m}^2$$

(b) Calculate the magnitude of the net magnetic field at r = 0.5 cm.

The current is symmetrically distributed about the axis of the conductors and hence the magnetic field B at distance r is given by using Ampere's law

$$\oint \vec{B} \bullet dl = B.2\pi r = \mu_0 I_{in} = \mu_0 * \pi r^2 j_1$$

Gives $B = \frac{\mu_0 * \pi r^2 j_1}{2\pi r} = \frac{1}{2}\mu_0 r j_1 = 0.5*4\pi*10^{-7}*0.005*954.9 = 3.0*10^{-6}$ T

(c) Calculate the magnitude of the net magnetic field at r = 3 cm.

Using the same rule but now the current in the loop is the current in the inner wire we have

$$B = \frac{\mu_0 I_1}{2\pi r} = \frac{4\pi*10^{-7}*0.3}{2\pi*0.03} = 2.0*10^{-6}$$

(d) Calculate the magnitude of the net magnetic field at r = 10 cm.

Using the same rule but now the current in the loop is the current in the inner wire minus the current in the outer wire we have

$$B = \frac{\mu_0 (I_1 - I_2)}{2\pi r} = \frac{4\pi*10^{-7}*(0.3-0.12)}{2\pi*0.1} = 3.6*10^{-7} \text{ T}$$

(e) With I_1 fixed at 0.3 A, what value of I_2 should be chosen to make the net magnetic field in the region $r > b$ equal to zero everywhere?

For the field outside the two conductors to be zero the net current in the loop should be zero and hence the current in the outer wire must be equal to that in the inner wire and its direction opposite.
Hence the value (magnitude) of the current should be 0.3 A.