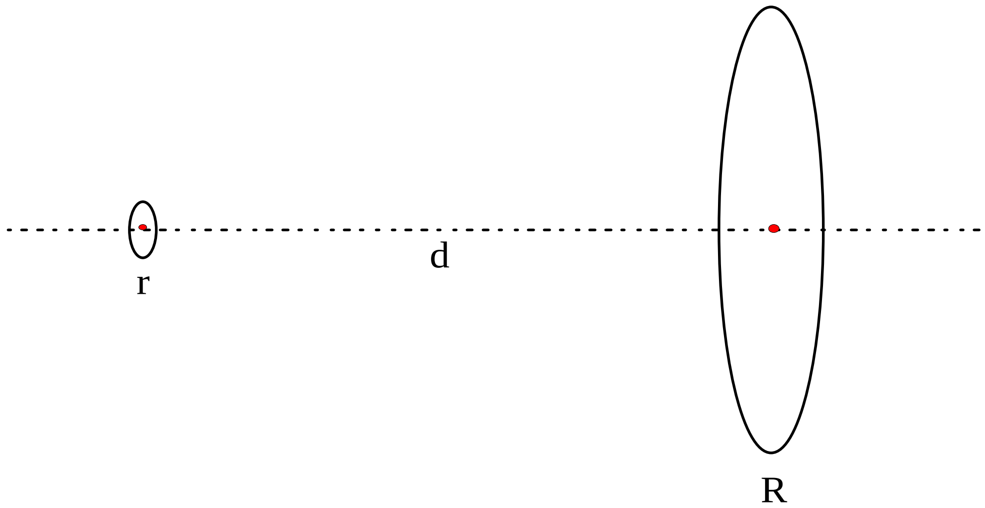
A circular loop of radius 0.3 cm lies parallel to a much bigger circular loop of radius 20 cm. The centre of the small loop is on the axis of the bigger loop. The distance between their centres is 15 cm. If a current of 2.0 A flows through the smaller loop, then the flux linked with bigger loop is:

(1) 9.1 x 10^{-11} weber (2) 6 x 10^{-11} weber (3) 3.3 x 10^{-11} weber (4) 6.6 x 10^{-9} weber

[JEE Main 2013]

Solution



Key Concept: The mutual inductance is the same whether current is passed through one coil or the other.

Let us first pass current I_R through the large coil,

$$\phi_r = M.I_R = B.\pi r^2 = \frac{\mu_0}{4\pi}\frac{2\pi I_R R^2}{(R^2+d^2)^{3/2}}.\pi r^2$$

[Since R >> r, magnetic field at a point on the axis of a coil formula can be used]

$$\therefore M = \frac{\mu_0}{4\pi}\frac{2\pi R^2}{(R^2+d^2)^{3/2}}.\pi r^2$$

Let us now pass current I_r through the small coil,

$$\phi_R = M.I_r = \frac{\mu_0}{4\pi}\frac{2\pi R^2}{(R^2+d^2)^{3/2}}.\pi r^2.I_r$$

[M remains the same]

$$\therefore \phi_R = 10^{-7}\frac{2\pi^2 R^2 r^2}{(R^2+d^2)^{3/2}}.I_r \approx 10^{-7}\times\frac{2\times10\times0.2^2\times0.3^2\times10^{-4}}{(0.2^2+0.15^2)^{3/2}}\times2.0 = \frac{2\times10\times0.2^2\times0.3^2\times10^{-11}\times2.0}{0.25^3}$$

On simplification, correct option = (1).