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Q obtain the expression for the Self Inductance of a long Solenoid and an endless toroid ?

Ans **Self Inductance of a Long Solenoid:-**

Let a long air cored Solenoid having a length 'l' meter, total nos of closely wounded turns N and area of Gross-section 'A' mt^2. The nos of turns per unit length $= \frac{N}{l}$

Let current 'i' flows throug it. Then the magnetic field inside the solenoid,

$$B = \mu_0 \left(\frac{N}{l}\right) i$$

Here μ_0 be the permeability constant. The magnetic flux through each turn is

$$\Phi_B = BA = \mu_0 \left(\frac{N}{l}\right) iA$$

Total magnetic flux through the solenoid

$$N\Phi_B = N \times \mu_0 \left(\frac{N}{l}\right) iA = \frac{\mu_0 N^2 iA}{l}$$

The Self inductance of a solenoid is

$$L = \frac{N\Phi_B}{i} = \frac{\mu_0 N^2 A}{l} \text{ Henery}$$

Self Inductance of a Toroid :→

Let a toroid of mean radius r, total number of turns be 'N' carrying current I.

The magnetic field induction at a point within its core is

$$B = \frac{\mu_0}{2\pi} \left(\frac{NI}{r}\right)$$

The magnetic flux through each turn is given by

$$\phi_B = BA = \frac{\mu_0}{2\pi}\left(\frac{NI}{r}\right)A$$

Here A = cross section area of each turn

The number of flux linked through the toroid is given by

$$= N\phi_B$$

$$= N \times \frac{\mu_0}{2\pi}\left(\frac{NI}{r}\right)A$$

$$= \frac{\mu_0}{2\pi}\frac{N^2 IA}{r}$$

By definition of self inductance of a toroid is given as

$$L = \frac{N\phi_B}{I}$$

$$L = \frac{\mu_0}{2\pi}\frac{N^2 A}{r} \quad \text{Henry}$$