Assignment-3

The determination of field, B inside a torroid having air as a medium for the path of the magnetic field as provided in 'Concepts of Physics' by H. C. Verma is provided below:

lue to a Current 243

35.8 TOROID

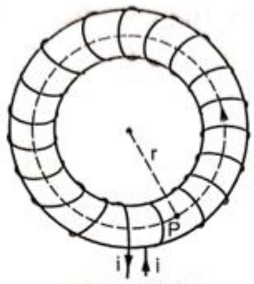

Figure 35.16

If a solenoid is bent in a circular shape and the ends are joined, we get a toroid. Alternatively, one can start with a nonconducting ring and wind a conducting wire closely on it. The magnetic field in such a toroid can be obtained by using Ampere's law.

Suppose, we have to find the field at a point P inside the toroid. Let the distance of P from the centre be r. Draw a circle through the point P and concentric with the toroid. By symmetry, the field will have equal magnitude at all points of this circle. Also, the field is everywhere tangential to the circle. Thus,

$$\oint \vec{B} \cdot \vec{dl} = \int B\, dl = B \int dl = 2\pi r B.$$

If the total number of turns is N, the current crossing the area bounded by the circle is Ni where i is the current in the toroid. Using Ampere's law on this circle,

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 Ni$$

or, $$2\pi r B = \mu_0 Ni$$

or, $$B = \frac{\mu_0 Ni}{2\pi r}. \quad \ldots (35.12)$$

Based on the aforementioned formulation answer the following questions:

Q1) Consider the effective length of the magnetic path through the toroid, L($2\pi r$) is 3π cm. The medium inside the toroid is air. The number of turns of the coil is 100, and it is carrying a dc current of 10 A. Find H (in Henry/meter) and B (in Weber/sqmeter or Tesla) inside the toroid, The permeability of free space is $4\pi \times 10^{-7} Henry/meter$. Assume that the flux is confined within the toroid.

Q2) Consider the effective length of the magnetic path through the toroid, L($2\pi r$) is 3π cm. The medium inside the toroid is a magnetic material having relative permeability of 2000. The number of turns of the coil is 10, and it is carrying a dc current of 10 A. Find H (in Henry/meter) and B (in Weber/sqmeter or Tesla) inside the toroid, The permeability of free space is $4\pi \times 10^{-7} Henry/meter$. Assume that the flux is confined within the toroid.

Q3) Consider the effective length of the magnetic path through the toroid, L($2\pi r$) is 3π cm. The number of turns of the coil is 10. A constant flux density, B of 0.1 Weber/m^2 (or Tesla) is required to be established inside the toroid. Determine the dc current that needs to flow through the coil if the medium inside the toroid is a magnetic material having relative permeability of i) 2000, ii) 200000, iii) tends to infinity. The permeability of free space is $4\pi \times 10^{-7} Henry/meter$. Assume that the flux is confined within the toroid.

Q4) Consider the toroid with an airgap having a length of 3π mm as shown in Figure 1. The rest of the medium inside the toroid is a magnetic material with a very high relative permeability (let's take an ideal case of infinity!), and is having an effective magnetic path length of 10π cm, and a cross sectional area of 10 cm^2. The number of turns of the coil is 100, and is carrying a current of 10 A. Assume that the flux remains confined in the airgap within the cross-section as demarcated by that of the magnetic material. Determine flux, $\emptyset$, B and H in i) the magnetic material and ii) in the airgap. [Note: flux lines are closed lines, and hence flux in the magnetic material and in the air gap has to be the same.]

Q5) Consider the toroid with an airgap having a length of 3π mm as shown in Figure 1. The rest of the medium inside the toroid is a magnetic material with a relative permeability of 2000, and is having an effective magnetic path length of 10π cm, and a cross sectional area of 10 cm^2. The number of turns of the coil is 100, and is carrying a current of 10 A. Assume that the flux remains confined in the airgap within the cross-section as demarcated by that of the magnetic material. Determine flux, $\emptyset$, B and H in i) the magnetic material and ii) in the airgap. [Note: flux lines are closed lines, and hence flux in the magnetic material and in the air gap has to be the same.]

Q6) Consider the toroid with two airgaps having a length of 3π mm each as shown in the Figure 2. The rest of the medium inside the toroid is a magnetic material with a very high relative permeability (let's take an ideal case of infinity!), and is having an effective magnetic path length of 3π cm, and a cross sectional area of 10 cm^2. The number of turns of the coil is 100, and is carrying a current of 10 A. Assume that the flux remains confined in the airgaps within the cross-section as demarcated by that of the magnetic material. Determine flux, $\emptyset$, B and H in i) the magnetic material and ii) in the airgap. [Note: flux lines are closed lines, and hence flux in the magnetic material and in the air gap has to be the same.]

Q7) Consider the 2 pole salient pole synchronous machine shown in Figure 3 having uniform air gap length of 0.5π mm. The number of turns of the field winding on the salient pole is 1000. In order to create a flux density of 1.2 T in the airgap over the pole faces of the machine what should be the dc current, I that needs to flow through the field winding. Assume that the field is radial in the airgap, and the relatively permeability of the rotor and stator iron is infinite, and the stator conductors a and $a^{/}$ are not carrying any current.

Q8) Consider the star current three phase system shown in Figure 4 wherein

$$e_a = E_m \sin \omega t,\ e_b = E_m \sin(\omega t - 120^0),\ e_c = E_m \sin(\omega t + 120^0)$$

Derive an expression for e_{ac} from the first principle (i.e without involving phasors/vectors etc.)

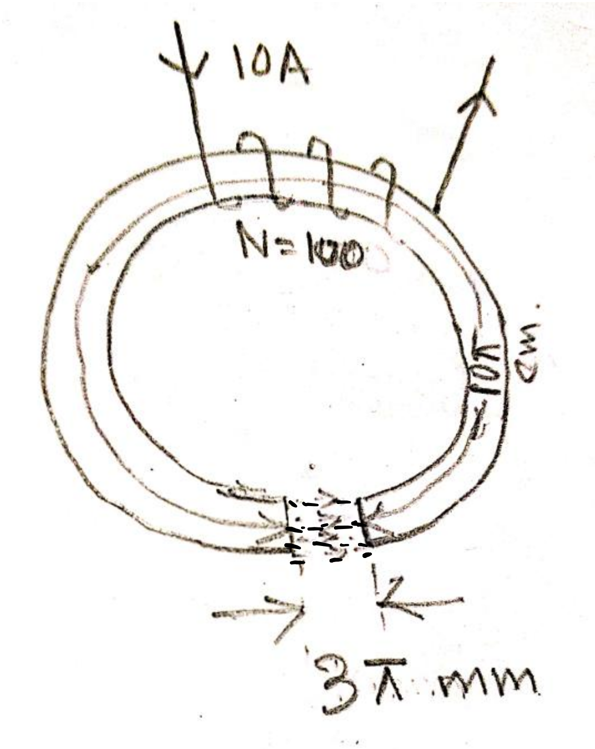

Figure-1

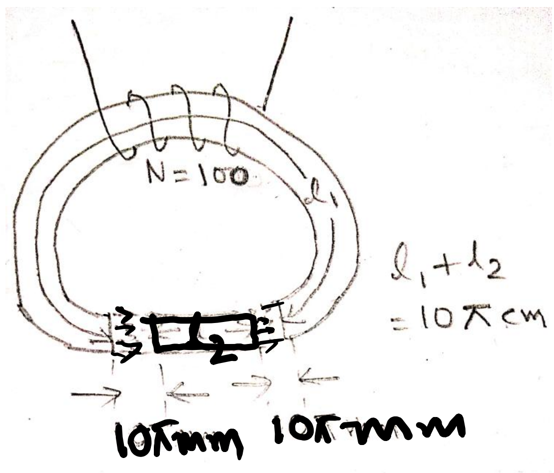

Figure-2

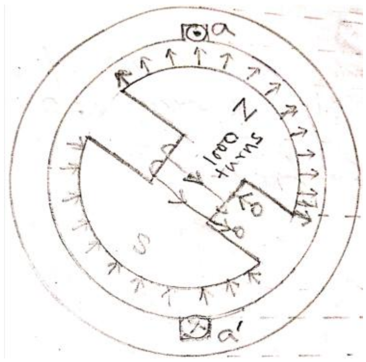

Figure 3

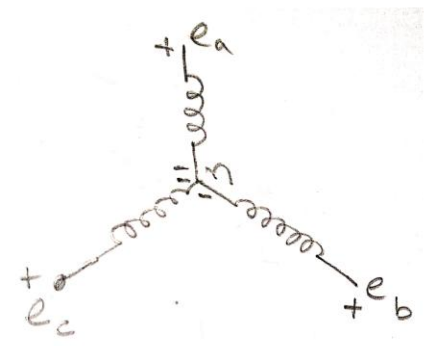

Figure 4