(M1-5) Magnetic Field of a Toroid Current

Aim of experiment

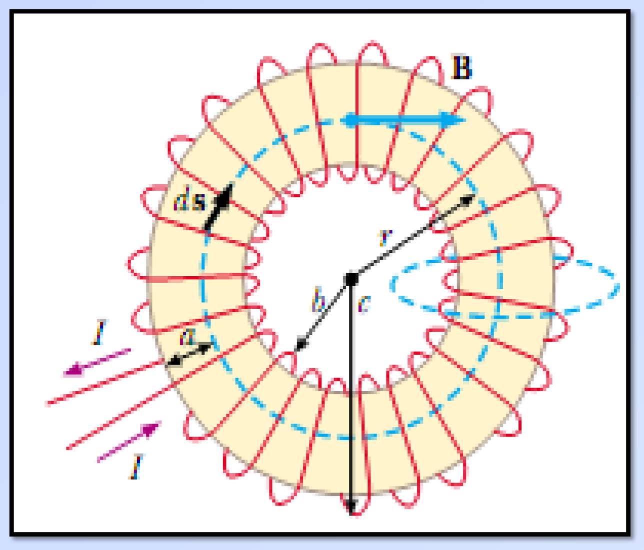
Calculation of the magnetic field in the region occupied by the torus.

Apparatus

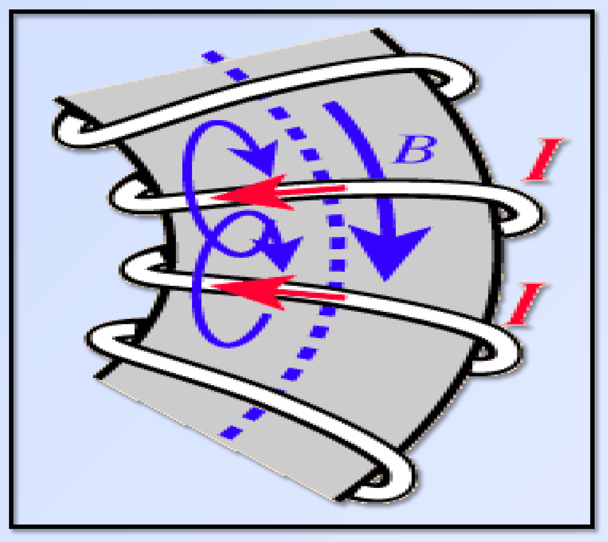
Toroid, a conducting wire wrapped around a ring (a torus) - Oscilloscope- Voltmeter- Ammeter- Function generator – Search Coil

Theory of experiment

A device called a Toroid, *figure 1*(a) is often used to create an almost uniform magnetic field in some enclosed area. The device consists of a conducting wire wrapped around a ring (a torus) made of a nonconducting material. All of the loops of wire which make up a Toroid contribute magnetic field in the same direction inside the Toroid. The sense of the magnetic field is that given by the right hand rule and a more detailed visualization of the field of each loop can be obtained by examining the field of a single current loop *figure 1(b).*



(a)



(b)

Figure 1.(a) A Toroid , **(b)** The resultant field is approximately equals the sum of the fields produced by each loop of the Toroid

For a Toroid having N closely spaced turns of wire, an easy procedure to derive the equation describing the magnetic field due a current passing through a Toroid loop is *Amperes Law*, which states that line integral of $B.ds$ around any closed path equals $\mu_0 I$, where I is the total steady current passing through any surface bounded by the closed path.

For a Toroid of an average radius of r, *figure 1*, apply Ampere's law one can derive the equation of the magnetic field inside the Toroid as;

$$\oint B.ds = Bl = \mu_0 NI$$

$$B = \frac{\mu_o N I}{2\pi r}$$

In case the torus is a magnetic material, the magnetic permeability of space μ_o is replaced by that of the material, μ_m

Sometimes, it is not available to measure the Toroid magnetic field in student laboratory, so one can use a calibrated search coil to measure the induced electromotive voltage, from which one can deduce the magnetic field.

The sinusoidally varying current in the field coil produces a magnetic field that varies sinusoidally with time. The part of the magnetic field that threads through the search coil produces a sinusoidally varying voltage in it. This voltage will be measured on an oscilloscope and will be used to determine the magnetic field.

In this experiment the peak to peak current I_{pp} through the field coil is held constant. For a constant I_{pp} the peak to peak magnetic field B_{pp} is proportional to peak to peak electromotive force, V_{pp}, so that we can write

$$B_{pp} = KV_{pp},$$

where K is a constant.

Procedure

1. Set the search coil of known K, such that its turns surround the Toroid.
2. Connect the terminals of the search coil to an oscilloscope to measure V_{pp}
3. Connect the frequency generator through an ammeter to measure a constant current, I_{pp}.
4. Turn the power on the function generator and set frequency at 20 kHz, for example, and voltage amplitude at 5 V.
5. At different current I_{pp} measure the corresponding V_{pp} and tabulate the results
6. Calculate the measured magnetic field, B_{ppexp} and B_{th}
7. Draw the relation between I_{pp} on x-axis and B_{ppexp} and B_{th} on y-axis, a straight line passing through origin is obtained.
8. Comment on the graph.

Results

$K=$ T/V

	Trial 1		Trial 2		Trial 3		B_{ppav}	
I_{pp}	V_{pp1}	B_{pp1}	V_{pp2}	B_{pp2}	V_{pp3}	B_{pp3}	B_{exp}	B_{th}

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