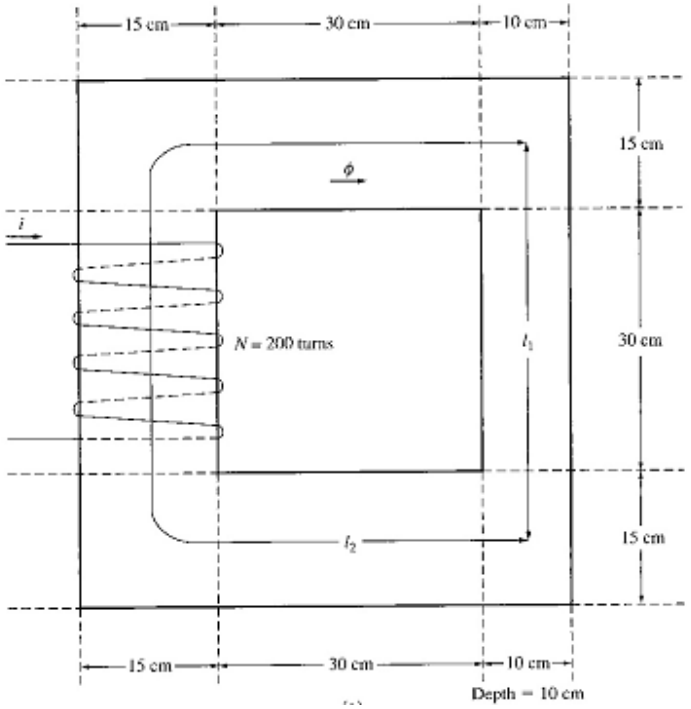
Department of Electrical Engineering

Indian Institute of Technology Madras

Electrical Machines tutorial on Magnetic Circuit

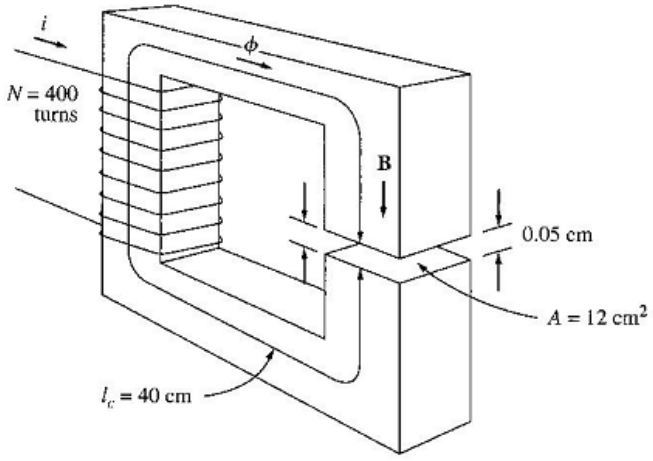
Tutorial Sheet No.1 Date: 30-01-2018

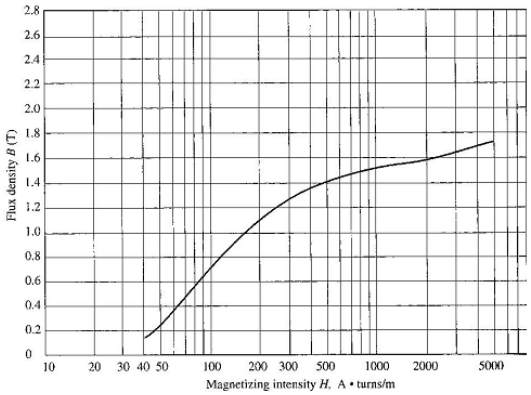
1. A ferromagnetic core is shown. Three sides of this core are of uniform width, while the fourth side is somewhat thinner. The depth of the core (into the page) is 10cm, and the other dimensions are shown in the figure. There is a 200 turn coil wrapped around the left side of the core. Assuming relative permeability of 2500, how much flux will be produced by a 1A input current?



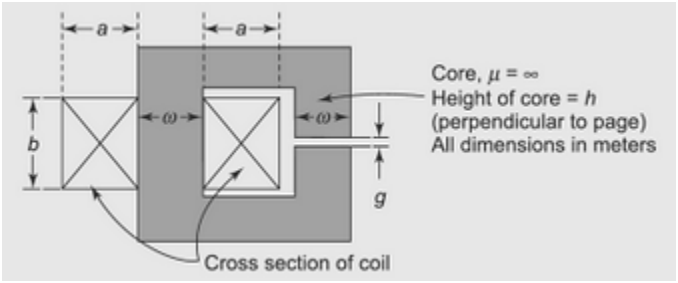
2. A toroidal ring has a circular cross section of 3cm in diameter and a mean circumference of 80cm. The ring is uniformly wound with a coil of 600 turns.
   (a) Estimate the current in the coil required to produce a flux of 0.5mWb in the ring, when
      i. The entire core region is replaced by air
      ii. A core made of solid cast steel of relative permeability 3000 is used.
   (b) If a saw cut creates a 2mm air gap in the ring, find approximately the air gap flux produced by the current obtained in (a - ii). (Neglect magnetic leakage and fringing)
   (c) Find the current required in the above case to produce the same flux in the air gap as in (a - ii).

3. A square magnetic core has a mean path length of 40 cm and a cross sectional area of 12 cm^2. There is a small gap of 0.05cm in the structure of the otherwise whole core as shown in below figure. A 400 turn coil of wire is wrapped around one leg of the core. Use the BH curve shown below and neglect magnetic leakage and fringing. Find:
   a) How much current is required to produce 1.68 mWb of flux in the air gap?
   b) What is the core's relative permeability at that current level?
   c) What is its reluctance?



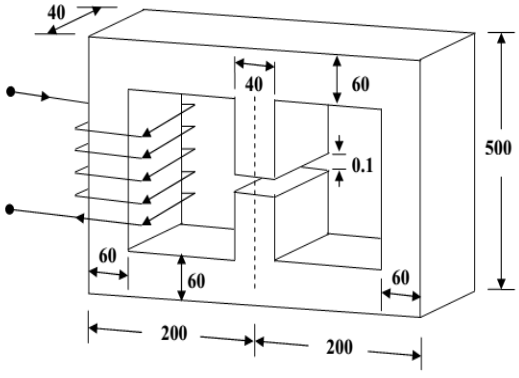


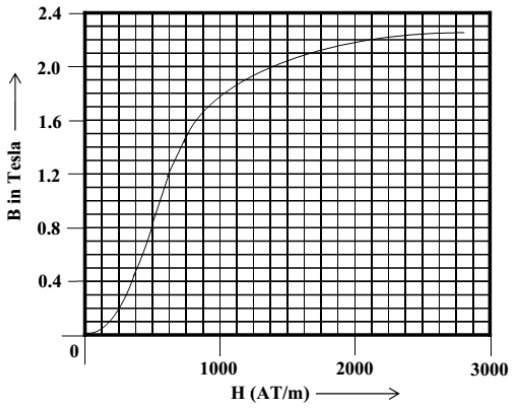
4. An inductor is wound on a high permeability laminated iron core of rectangular cross section. Assume that the permeability of iron is infinite. Neglect magnetic leakage and fringing effect in the air gap g. The winding is done by an insulated copper wire whose resistivity is 1.73×10^{-6} Ωcm. Assume that a fraction, f_w=0.7 of winding space is only available for copper, where the remaining space is occupied by insulation.



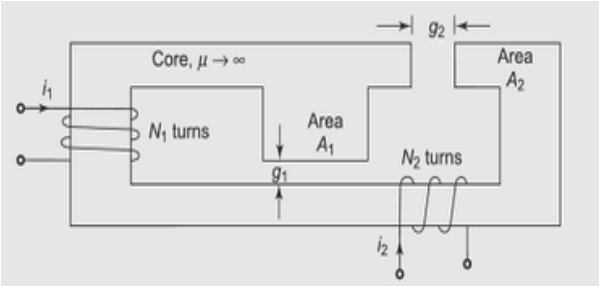
As shown in above figure, the dimensions are: a=h=w=1.5 cm, b=2cm, g=0.3cm. The coil is to be operated with a constant applied voltage of 40 V, and the air-gap flux density is 1.2 T. Find the power dissipated in the coil, coil current, number of turns and coil resistance.

5. In the magnetic circuit detailed in Figure with all dimensions in mm, calculate the required current to be passed in the coil having 200 turns in order to establish a flux of 1.28 mWb in the air gap. Neglect fringing effect and leakage flux. The B-H curve of the material is given below. Permeability of air may be taken as, $\mu_0 = 4\pi \times 10^{-7}$ H/m





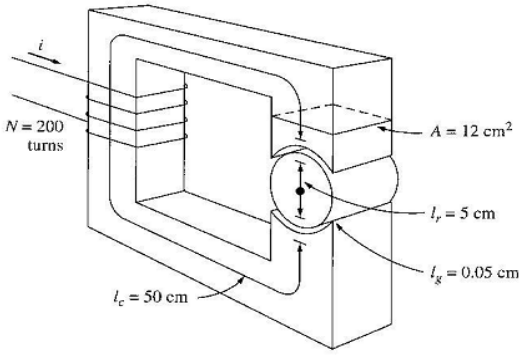
6. The magnetic circuit shown in below figure has two windings and two air gaps. The core can be assumed to be of infinite permeability. The core dimensions are indicated in the figure.



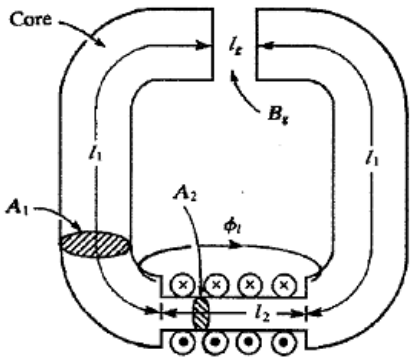
a) Assuming coil 1 to be carrying a current I_1 and the current in coil 2 to be zero, calculate
   I. The magnetic flux density in each of the air gaps
   II. The flux linkage of winding 1, and
   III. The flux linkage of winding 2.

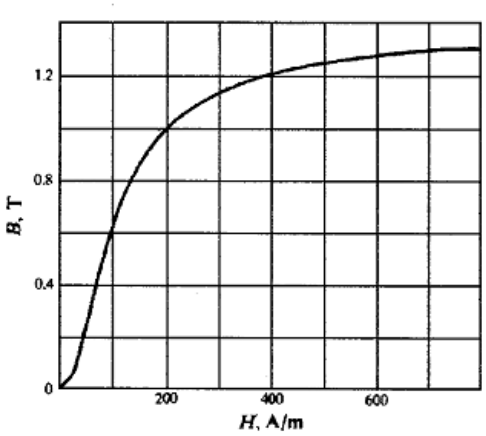
b) Repeat part (a), assuming the current in winding 1 to be I_1 and winding 2 to be I_2

7. Figure shows a simplified rotor and stator for a dc motor. The mean path length of the stator is 50cm, and its cross sectional area is $12cm^2$. The mean path length of the rotor is 5 cm, and its cross sectional Area also may be assumed to be $12cm^2$. Each air gap between the rotor and the stator is 0.05cm wide, and the cross sectional area of each air gap (including fringing) is $14cm^2$. The iron of the core has a relative permeability of 2000, and there are 200 turns of wire on the core. If the current in the wire is adjusted to be 1A, what will the resulting flux density in the air gaps be?



8. Figure below shows a composite magnetic circuit of varying cross sectional area. The iron portion has the BH characteristics as shown. Given N=400 turns, $l_1=4l_2=40cm$, $A_1=2A_2=10cm^2$, l_g = 2mm, leakage flux, $\phi_1=0.01mWb$. Calculate current required to establish an air gap flux density of 0.6T.


Core
l_g
B_g
l_1
l_1
A_1
A_2
ϕ_l
l_2


1.2
0.8
0.4
0
200
400
600
B, T
H, A/m

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