Tutorial Sheet – No 2

(Magnetic Circuits)

(In all questions assume the permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ Hm^{-1})

1 An iron toroidal core has a mean diameter 20cm, a cross-sectional area of 10cm^2 and a relative permeability of 1000. If the current in a coil wound on the core to establish a flux density of 0.28T is 2.8A, calculate the number of turns on the coil and the self inductance.

(50 turns; 5mH)

2 An iron ring has a mean diameter of 10cm and a cross-sectional area of 10cm^2. A coil having 250 turns is wound round it. Calculate the self-inductance of the coil if the relative permeability of the iron is 1000.

(0.25H)

3 An iron cored inductor is to be designed to give a required inductance, L, of 2H. The magnetic circuit of the inductor has a mean iron path of length 200mm and area 10^{3}mm^2, made from a material of relative permeability 4000, and an airgap of length 1mm cut through one side of the core.
Calculate:
- (a) the reluctance of the total magnetic circuit
- (b) the number of turns, N, required to give the desired inductance
  (Use may be made of the relationship for inductance, $L = \dfrac{N\phi}{I}$ Henry)
- (c) the current through the inductor and the peak core flux density when the coil is excited from a 50Hz, 500V rms voltage source and the coil resistance is negligible
- (d) the core flux density for case (c) if the coil had a finite resistance of 500Ω.

(8.4 x10^5 H^{-1}; 1296 turns; 0.79A; 1.73T; 1.36T)

4 A magnetic circuit consists of a steel ring with a mean diameter of 35cm and cross sectional area 2.4cm^2, and a parallel-sided airgap of length 1.2cm and area 12cm^2, created by short pole-pieces of negligible reluctance. The iron has a relative permeability of 700 and the ring is wound with a 300 turn coil. If an airgap flux density of 0.25T is required calculate the corresponding flux density in the steel, and the coil current required to produce the desired airgap flux density.

(1.25T; 13.1A)

5 The attractive force between the faces of an electromagnet is given by:

$$Force = \frac{B^2 A}{2\mu_0} \text{ Newtons}$$

where A is the area of one face.
An electromagnet is formed from an iron path of length 500mm and cross section 200mm^2 with an airgap of length 1mm and face area 200mm^2. The iron has a relative permeability of 300 and the 100 turn excitation coil carries a direct current of 2A.
Calculate:
- (a) the reluctance of the total magnetic circuit
- (b) the flux density in the airgap
- (c) the force between the faces of the magnet
- (d) what rms 1kHz ac voltage applied to the coil would produce the same peak force. How would the force vary with time in the latter case?

(1.06 x 10^7 H^{-1}; 94.3mT; 0.7N; 8.4V)
(The force will pulsate between zero and its peak value at twice supply frequency)

6 The output of a power amplifier is connected to its load by a matching transformer. The amplifier can produce an output of $200V_{rms}$ amplitude over the frequency range 20Hz to 1kHz. If the 200 turn primary winding of the transformer has negligible resistance, calculate the necessary cross-sectional area of the transformer core so that its flux density does not exceed 1.5T. What range of peak flux densities would occur in the core over the frequency range?

(75 cm^2; 1.5T to 0.03T)

7 A universal motor, so called because it can operate on ac or dc, has a magnetic circuit reluctance of $4 \times 10^5 H^{-1}$. The stator winding has 500 turns and a resistance of 50Ω. If the motor field-winding produces the required peak flux when connected to a $240V_{rms}$ 50 Hz ac supply, what value of dc voltage applied to the same winding would give the same peak flux level?

(83.8V dc)

8 A plunger solenoid has the dimensions given in figure 1 below. If the coil has 1000 turns and a d.c. resistance of 120Ω, calculate the ratio of the powers dissipated in the coil when the plunger if fully in and fully out. The supply is 240Vrms, 50Hz and the relative permeability of core and plunger is 500.

(21.8:1)

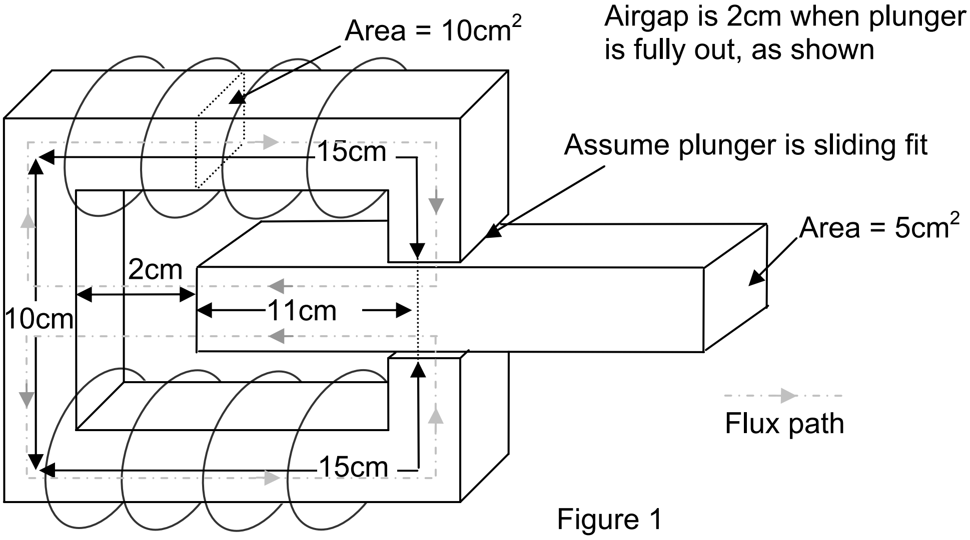

Figure 1