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EE114 Power Engineering - I
Assignment 03

- **Question 1:** The magnetic circuit shown in Fig. 1 has dimensions $A_e = A_g = 9\ cm^2$, g = 0.050 cm, l_c= 30 cm and N = 500 turns. Assume the value μ_r = 70,000 for core material. (a) Find the reluctances R_e and R_g. For the condition that the magnetic circuit is operating with B_c = 1.0 T, find (b) the flux ϕ and (c) the current i .

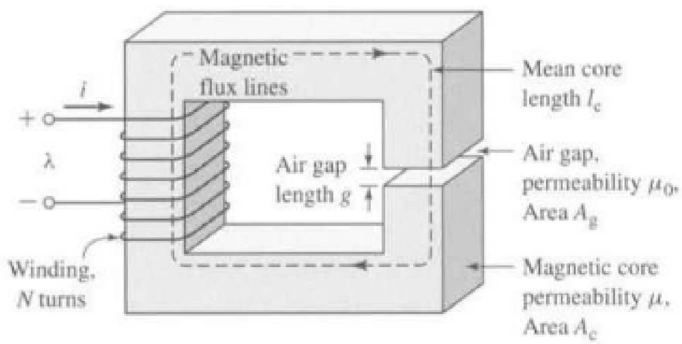

Figure 1

- **Question 2:** Find the flux ϕ and current for Question 1 if (a) The number of turns is doubled to N = 1000 turns while the circuit dimensions remains the same. (b) if the number of turns remains same (N = 500 turns) and the gap is reduced to 0.040 cm.

- **Question 3:** The relative permeability of the core material for the magnetic circuit of Fig. 1 is assumed to be μ_r = 70000 at a flux density of 1.0 T.

  (a) For this value of μ_r, calculate the inductance of the winding. (b) Calculate the inductance under the assumption that the relative permeability is equal to 2900.

  Derive your conclusions from these problems (a) and (b).

- **Question 4:** For the magnetic circuit of Fig. 1. find (a) the inductance L, (b) the magnetic stored energy W for B_c = 1.0 T, and (c) the induced voltage e for a 60 Hz time varying core flux of the form B_c = 1.0 sin (ωt) where $\omega = 2\pi 60$.

- **Question 5:** Assume the core material in Fig. 1 is M-5 electrical steel. (a) Find the current i required to produce B_c = 1.0 T. (H_c = 11 A-turns/m)(b) Find the current i required to produce B_c = 1.6 T. (H_c = 71 A-turns/m) (c) By what factor does the current have to be increased to result in this factor of 1.6 increase in flux density?

- **Question 6:** A magnetic circuit with a single air gap is shown in Fig. 2. The core dimensions are:

  $A_c = 1.8 \text{ x } 10^{-3}\ m^2\ l_c = 0.6\ m\ g = 2.3 \text{ x } 10^{-3}\ m$ N = 83 turns

  Assume that the core is of infinite permeability and neglect the fringing effect. (a) Calculate the reluctance of the core and that of the air gap.

  For a current of $i = 1.5$ A, calculate (b) the total flux ϕ (b) the flux linkage λ (c) coil inductance L.

- **Question 7:** The magnetic circuit of Fig. 3 consists of a core and a moveable plunger of width l_p, each of permeability μ. The core has cross-sectional area A_c and mean length l_c. The overlap area of the two air gaps A_g is a function of the plunger position x and can be assumed to vary as

  $$A_g = A_c\left(1 - \frac{x}{X_0}\right)$$

  You may neglect the fringing effect at the air gap and use approximation consistent with magnetic-circuit analysis.

  (a) Assume infinite permeability, derive an expression for the magnetic flux density in the air gap B_g as a function of the winding current I and as the plunger position is varied (0 $\leq$x$\leq$ 0.8X$_0$). What is the corresponding flux density in the core?

  (b) Repeat part (a) for a finite permeability.

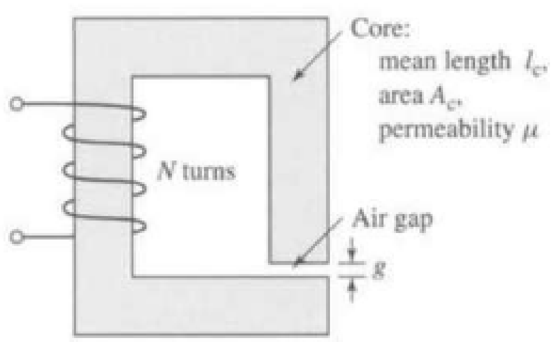

Figure 2

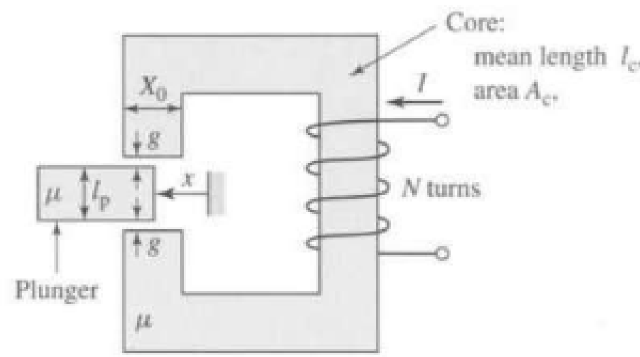

Figure 3

- **Question 8:** The magnetic circuit of Fig 4. consists of rings of magnetic material in a stack of height h. The rings have inner radius R_i and outer radius R_o. Assume that the iron is of infinite permeability and neglect the effects of magnetic leakage and fringing. For:

  $R_i = 3.4\ cm$

  $R_o = 4.0\ cm$

  $h = 2\ cm$

  $g = 0.2\ cm$

  Calculate:

(a) the mean core length and the cross sectional area.

(b) Reluctance of the core and air gap.

if N = 65 turns, calculate:

(c) the inductance.

(d) current i required to operate at an air-gap flux density of $B_g = 1.35$T.

(e) Corresponding flux linkage of the coil.

- **Question 9:** A square voltage wave having a fundamental frequency of 60 Hz and equal positive and negative half cycles of amplitude E is applied to a 1000-turn winding surrounding a closed iron core of 1.25 x $10^{-3}m^2$ cross section. (a) Sketch the voltage, winding flux linkage and the core flux as a function of time. (b) Find the maximum permissible value of E if the maximum flux density is not to exceed 1.15 T.

- **Question 10:** The inductor of Fig. 5 has following dimensions.

  $A_c = 1.0cm^2$

  $l_c = 15cm$

  $g = 0.8mm$

  N = 480 turns

  Neglect fringing effect and leakage flux.

  (a) Calculate inductance. ($\mu_r = 1000$)

  (b) This inductor is connected to 60 Hz voltage source. Calculate the RMS inductor voltage corresponding to peak core flux density of 1.5 T. Calculate the RMS current and the peak stored energy.

- **Question 11:** Consider the magnetic circuit of Fig. 6. This structure, known as a pot-core, is typically made in two halves. The N -tum coil is wound on a cylindrical bobbin and can be easily inserted over the central post of the core as the two halves are assembled. Because the air gap is internal to the core, provided the core is not driven excessively into saturation, relatively little magnetic flux will "leak" from the core, making this a particularly attractive

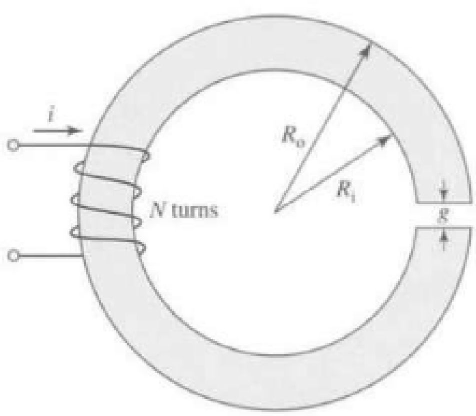

Figure 4

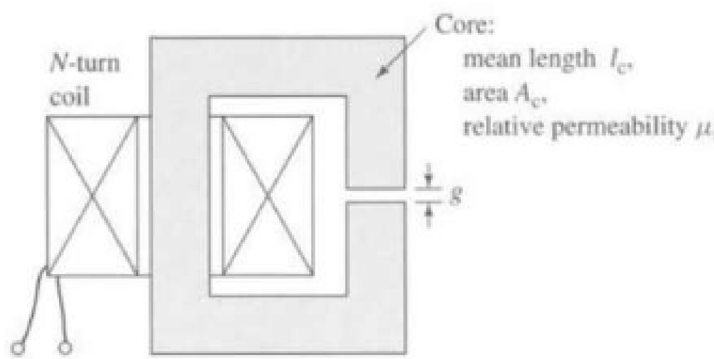

Figure 5

configuration for a wide variety of applications, both for inductors such as that of Fig. 5 and transformers.

Assume the core permeability to be $\mu = 2500\mu_0$ and N = 200 turns. The following dimensions are specified:

$R_1 = 1.5cm$

$R_2 = 4cm$

$l = 2.5cm$

$h = 0.75cm$

$g = 0.5mm$

(a) Find the value of R_3 such that the flux density in the outer wall of the core is equal to that within the central cylinder.

(b) Assume flux density in the radial section of the core remains uniform. (i) write an expression for the coil inductance. (ii) evaluate for the given dimensions.

(c) The core is to be operated at peak flux density of 0.8 T at frequency of 60 Hz. Find (i) RMS value of the voltage induced in the winding, (ii) RMS coil current, (iii) The peak stored energy.

- **Question 12:** The magnetic circuit of Fig. 7 has two windings and two air gaps. The core can be assumed to be infinite permeability.
  (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 zero current in winding 1 and a current I_2 in winding 2.
  (c) Repeat part (a), assuming the current in winding 1 to be I_1 and the current in winding 2 to be I_2.
  (d) Find the self-inductances of windings 1 and 2 and the mutual inductance between the windings.

- **Question 13:** The symmetric magnetic circuit of Fig. 8. has three windings. Windings A and B each have N turns and are wound on the two bottom legs of the core. The core dimensions are indicated in the figure.
  (a) Find the self-inductances of each of the windings.

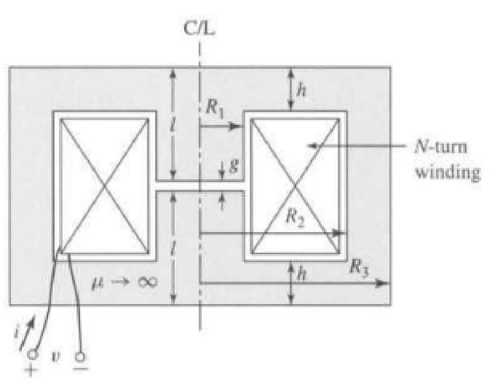

Figure 6

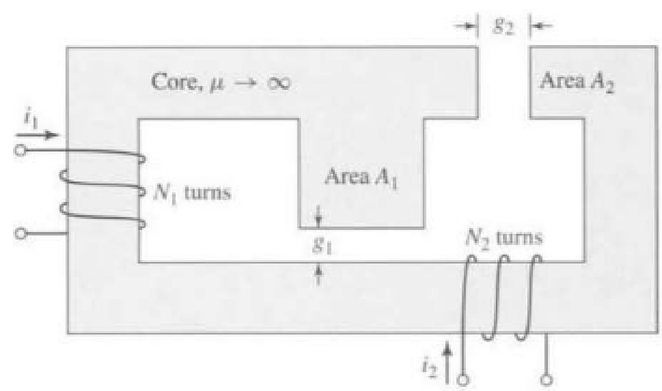

Figure 7

(b) Find the mutual inductances between the three pairs of windings.
(c) Find the voltage induced in winding 1 by time-varying currents $i_a(t)$ and $i_b(t)$ in windings A and B. Show that this voltage can be used to measure the imbalance between two sinusoidal currents of the same frequency.

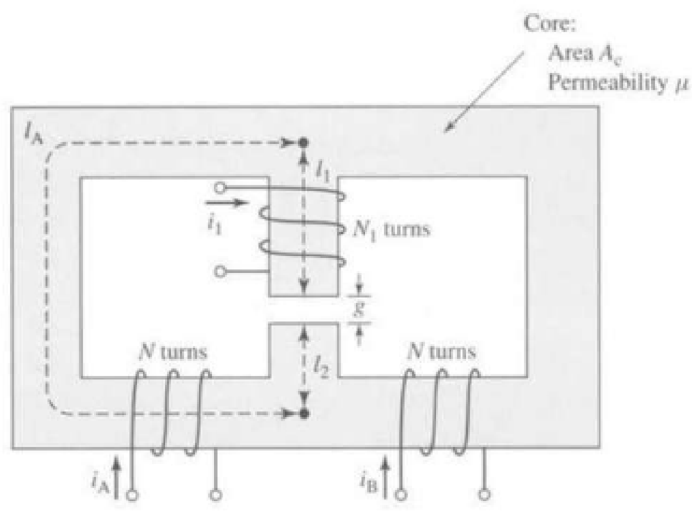

Figure 8

- **Question 14:** Solve for I_1, I_2 and V_o in Fig.9.

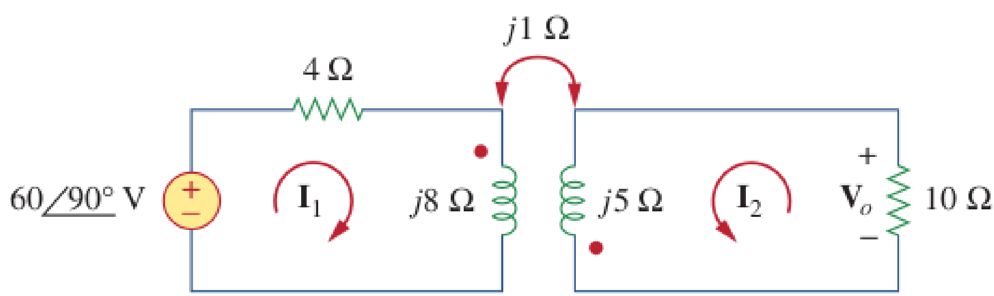

Figure 9