1. The magnetic circuit shown in Fig. Q1 has dimensions $A_c = A_g = 9 \, \text{cm}^2$, $g = 0.050 \, \text{cm}$, $l_c = 30 \, \text{cm}$, and $N = 500$ turns. Assume the value of the relative permeability, $\mu_r = 70,000$ for core material. (a) Find the reluctances $R_c$ and $R_g$. For the condition that the magnetic circuit is operating with $B_c = 1.0 \, \text{T}$, find (b) the flux and (c) the current $i$.

[Ans. (a) $R_c = 3785 \, \text{AT/Wb}$, $R_g = 442321.3 \, \text{AT/Wb}$ (b) $9 \times 10^{-4} \, \text{Wb}$ (c) 0.8 A]

![Fig. Q1](image)

2. The magnetic circuit of Fig. Q2 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. Assuming coil 1 to be carrying a current $i_1$ and the current in coil 2 to be zero, calculate (a) the magnetic flux density in each of the air gaps. (b) Repeat part (a), assuming zero current in winding 1 and a current $i_2$ in winding 2.

[Ans. (a) $\mu_0 N_1 i_1 g_1$, $\mu_0 N_1 i_1 g_2$ (b) 0, $\mu_0 N_2 i_2 g_2$]

![Fig. Q2](image)

3. A coil of 200 turns is wound uniformly over a wooden ring having a mean circumference of 600 mm and a uniform cross sectional area of 500 mm$^2$. If the current through the coil is 4 A, calculate: (a) the magnetic field strength, (b) the flux density, and (c) the total flux

[Ans.: 1333 A/m, 1675×10$^{-6}$ T, 0.8375 μWb] (Permeability of wood is same as air)

4. A steel ring having a mean circumference of 750 mm and a cross sectional area of 500 mm$^2$ is wound with a magnetic coil 120 turns. Using the following data, calculate the current required to set up a magnetic flux of 630 μWb in the ring.

<table>
<thead>
<tr>
<th>Flux density (T)</th>
<th>0.9</th>
<th>1.1</th>
<th>1.2</th>
<th>1.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic field strength (AT/m)</td>
<td>260</td>
<td>450</td>
<td>600</td>
<td>820</td>
</tr>
</tbody>
</table>

[Ans. 4.575 A]
5. A 680 turns coil is wound on the central limb of the cast steel frame as shown in Fig. Q4 (a). A total flux of 1.6 mWb is required in the gap, find what current is required. Assume that the gap density is uniform and that all lines pass straight across the gap. Dimensions are in cms.

[Ans. 1.95 A]

6. The mean diameter of a steel ring is 50 cm and a flux density of 1.0 Wb/m² is produced by a field intensity of 40 AT/cm. If the area of cross section of the ring is 20 cm² and if a 500 turn coil is wound around the ring; (a). Find the inductance of the coil in Henry; (b). When an air gap of 1.0 cm is cut in the ring and the exciting current is changed to maintain a flux density of 1.0 Wb/m² then find the new inductance of the coil. Ignore the effects of leakage and fringing.

[Ans. (a) 79.6 mH (b) 35.2 mH]

7. A ring of cast steel has an external diameter of 24 cm and a square cross section of 3 cm side. Inside and across the ring an ordinary steel bar 18x3x0.4 cm is fitted with negligible gap. Calculate the number of ampere turns to be applied to one-half of the ring to produce a flux density of 1 Wb/m² in the other half.

[Ans. 700 ATs]
8. The magnetic circuit of Fig. Q8 has a cast steel core with dimensions as shown. It is required to establish a flux of 0.8 mWb in the air gap of the central limb. Determine the mmf of the exciting coil, if for the core material \( \mu_r = \infty \). Neglect fringing.  

[Ans: 1343.98 AT].

9. In the magnetic circuit shown in Fig. Q9, the area of cross section of the central limb is 12 cm\(^2\) and that of each outer limb (A to B) is 6 cm\(^2\). A coil current of 0.5 A produces 0.5 mWb in the air-gap. Find the relative permeability of the core material.  

[Ans: 7627.51]

10. For the magnetic circuit shown in Fig. Q10, find the self and mutual inductances between the two coils. The relative permeability of the core is 1600.  

[Ans: \( L_1 = 0.73 \) H; \( L_2 = 3.55 \) H; \( M = 0.64 \) H].
11. The magnetic structure of a synchronous machine is shown schematically in Fig. Q11. Assuming that rotor and stator iron have infinite permeability ($\mu \to \infty$), find the air-gap flux $\Phi$ and flux density $B_g$ for $I = 10$ A, $N = 1000$ turns, $g = 1$ cm, and $A_g = 2000$ cm$^2$. [Ans. 0.13 Wb, 0.65 T]

![Fig. Q11](image)

12. An iron ring (Fig. Q12) of mean length 30 cm has an air gap of 2 mm and a winding of 200 turns. The iron has a permeability of $1.25 \times 10^{-4}$ and the coil carries 1 A current. What is the flux density in the core? [Ans: 83.77 mWb/m2].

![Fig. Q12](image)

13. The magnetic circuit of Fig. Q13 consists of an N-turn winding on a magnetic core of infinite permeability with two parallel air gaps of lengths $g_1$ and $g_2$ and areas $A_1$ and $A_2$, respectively. Find (a) the inductance of the winding and (b) the flux density $B_l$ in gap 1 when the winding is carrying a current $i$. Neglect fringing effects at the air gap.

$[\text{Ans. (a)} \mu_0 N^2 \left( \frac{A_1}{g_1} + \frac{A_2}{g_2} \right), \text{ (b)} \frac{\mu_0 Ni}{g_1}]$
14. A magnetic circuit with a single air gap is shown in Fig. Q14. The core dimensions are: Cross-sectional area \( A_c = 1.8 \times 10^{-3} \) m\(^2\), Mean core length \( l_c = 0.6 \) m Gap length \( g = 2.3 \times 10^{-3} \) m, \( N = 83 \) turns. Assume that the core is of infinite permeability and neglect the effects of fringing fields at the air gap and leakage flux. (a) Calculate the reluctance of the core \( R_c \) and that of the gap \( R_g \). For a current of \( i = 1.5 \) A, calculate (b) the total flux, (c) the flux linkages of the coil, and (d) the coil inductance \( L \).

\[ \text{Ans. (a) } 0, 101.73 \times 10^4 \text{ (b) } 1.2 \times 10^{-4} \text{ Wb (c) } 0.01016 \text{ WbT (d) } 6.78 \text{ mH} \]

![Fig. Q14](image)

15. Two identical inductors 1 H each, are connected in series as shown Fig.Q15. Deduce the combined inductance. If a third inductance is similarly connected in series with this combined inductor, with the dots all at the left ends what are the resulting inductances? What do you infer is the relation between number of turns and the inductance of a coil? Assume coefficient of coupling as 1.0.

\[ \text{Ans. } 4 \text{H; 9H;} \]

![Fig.Q15](image)

16. (a) Two coils X of 12000 turns and Y of 15000 turns lie in parallel planes so that 45% of the flux produced by coil X links coil Y. A current of 5 A in X produces in it a flux of 0.05 mWb, while the same current in Y produces in it a flux of 0.075 mWb. Calculate (a) The mutual inductance and (b) The coupling coefficient

(b) Two similar air-cored coils of 600 turns mutually link each other so that coil ‘Y’ links 70% of the total flux developed in coil ‘X’. A current of 1.0 A in coil ‘X’ produces a total flux of 0.075 mWb in itself. When the current in coil ‘X’ changes at a uniform rate of 200 A/s, determine the voltage induced in coil ‘Y’. Also compute the self inductance of each coil and the mutual inductance between them.

17. A 1-phase transformer has 400 primary and 1000 secondary turns. The net cross-sectional area of the core is 60cm\(^2\). If the primary winding be connected to a 50-Hz at 500V, calculate (i) the peak value of the flux density in the core, and (ii) the voltage induced in the secondary winding.

\[ \text{Ans (i) } 0.94 \text{Wb/m}^2; \text{ (ii) } 1250 \text{V} \]
18. A 1-phase, 50Hz, core-type transformer has square cores of 20-cm side. The permissible maximum density is 1Wb/m². Calculate the numbers of turns on the high- and low-voltage sides for a 3000/220-V ratio. [Ans 341, 25]

19. 50 kVA 2400:240 V 60-Hz distribution transformer has a leakage impedance of $0.72 + j0.92 \, \Omega$ in the high-voltage winding and $0.0070 + j0.0090 \, \Omega$ in the low-voltage winding. At rated voltage and frequency, the impedance of the shunt branch (equal to the impedance of $Z_m$) accounting for the exciting current is $6.32 + j43.7 \, \Omega$ when referred to the low-voltage side. Draw the equivalent circuit referred to (a) the high-voltage side and (b) the low-voltage side.

[Ans. (a) HV side: $Z_1=0.72+j0.92 \, \Omega$, $Z_2=0.7+j0.9 \, \Omega$, $Z_m=632+j4370 \, \Omega$
(b) LV side: $Z_1=0.0072+j0.0092 \, \Omega$, $Z_2=0.007+j0.009 \, \Omega$, $Z_m=6.32+j43.7 \, \Omega$]

20. The core and winding of a single phase, 50Hz, 2kVA, 200V/200V transformer is shown in Fig. Q20(a). The terminals of the two windings are marked as ‘a’, ‘b’, ‘c’ and ‘d’. The permissible maximum flux density in the core is 1.0 Wb/m² and the cross sectional area of the core is 3220 square mm. The core is made up of mild steel having a relative permeability ($\mu_r$) of 4917 for the operating range. The resistance and leakage reactance of each winding is $0.1 \, \Omega$ and $0.5 \, \Omega$ respectively. The value of the resistance representing core (iron) loss is $2000 \, \Omega$.
(a) Find the magnetizing reactance of the transformer.
(b) If terminal ‘a’ is dotted then which of the other terminals (‘c’ or ‘d’) has to be dotted?
(c) The core (iron) loss of the transformer under rated voltage and frequency is 20W. The transformer is supplied from a 200V, 50Hz voltage source (between points ‘a’ and ‘b’) as shown in Fig. Q20(b). The points ‘b’ and ‘c’ are shorted and the points ‘a’ and ‘d’ are connected through a $1\, \Omega$ resistance as shown in the figure. Draw the equivalent circuit of the transformer under this condition showing all connections and marking all four terminals.
(d) Find the current flowing through the $1\, \Omega$ resistance and the total current drawn from the source under this condition.