Tutorial Sheet – 4 (Magnetic Circuits)

1. The magnetic circuit shown in Fig. 1 has dimensions $A_c = A_g = 9\ \text{cm}^2$, $g = 0.050$ cm, $l_c = 30$ 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 $B_c = 1.0$ T, find (b) the flux and (c) the current i.

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

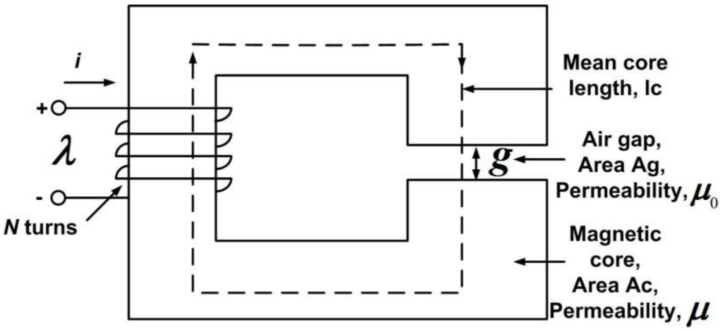

Fig. 1

2. A 680 turns coil is wound on the central limb of the cast steel frame as shown in Fig. 2. 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]

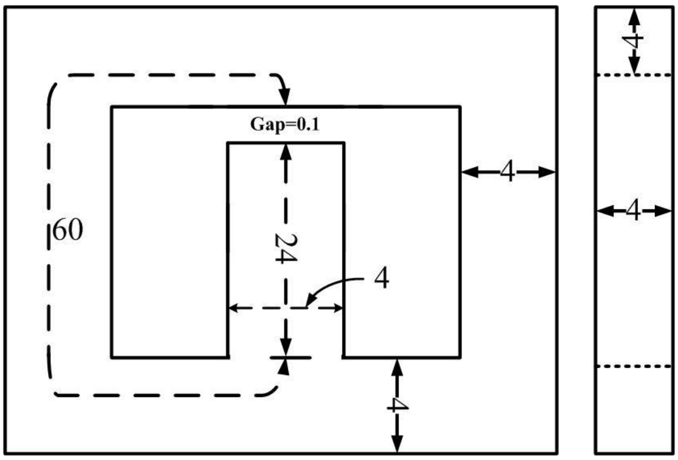

Table 1: B-H values for cast steel

H (AT/m)	500	600	800	900
B (Wb/m^2)	0.5	0.6	0.9	1

Fig. 2

3. The mean diameter of a steel ring is 50 cm and a flux density of 1.0 Wb/m^2 is produced by a field intensity of 40 AT/cm. If the area of cross section of the ring is 20 cm^2 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/m^2 then find the new inductance of the coil. Ignore the effects of leakage and fringing.

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

4. The magnetic circuit of Fig. 3 has a cast steel core with dimensions as shown. It is required to establish a flux of 0.8mWb 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].

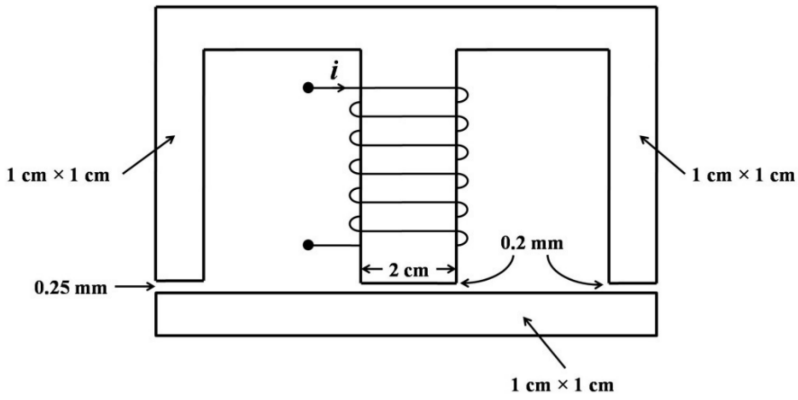

Fig. 3

5. In the magnetic circuit shown in Fig. 4, the area of cross section of the central limb is 12cm^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]

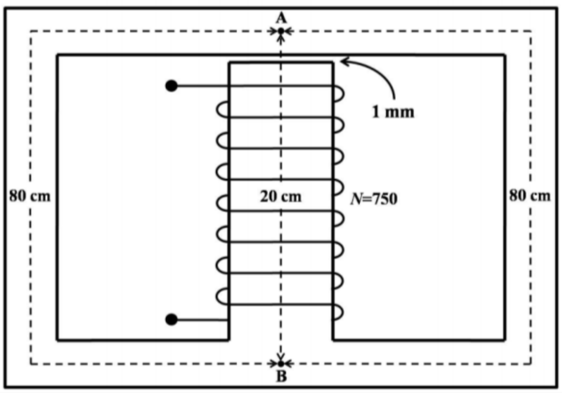

Fig. 4

6. For the magnetic circuit shown in Fig. 5, 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].

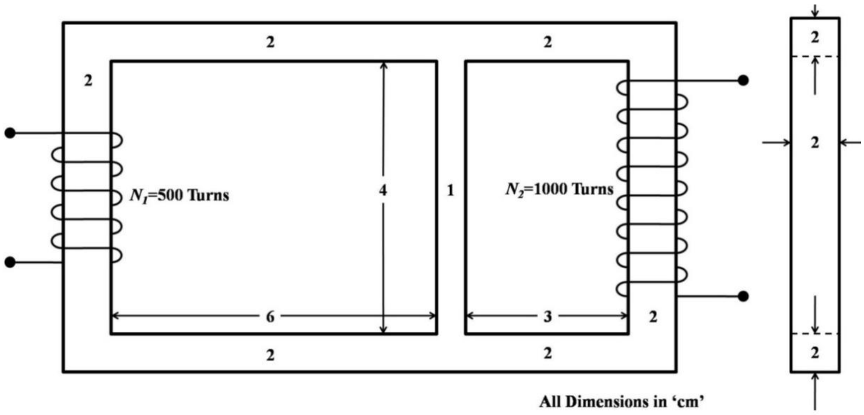

Fig. 5

7. An iron ring (Fig. 6) of mean length 30 cm has an air gap of 2 mm and a winding of 200 turns. The iron has a permeability of 1.25×10^{-4} and the coil carries 1 A current. What is the flux density in the core? [Ans: 50.1 mWb/m2].

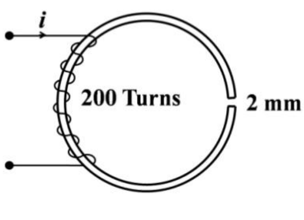

Fig. 6

8. The magnetic circuit of Fig. 7 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.

[Ans. (a) $\mu_o N^2\left(\frac{A_1}{g_1}+\frac{A_2}{g_2}\right)$ b) $\frac{\mu_o Ni}{g_1}$]

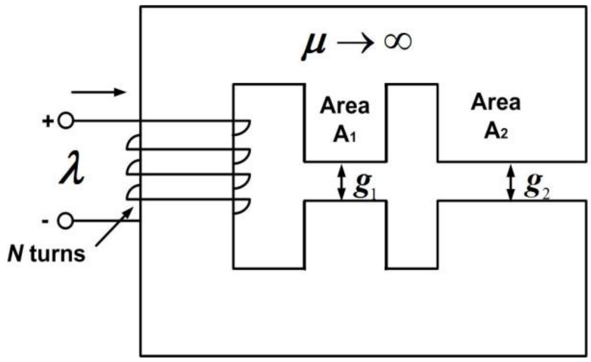

Fig. 7

9. A magnetic circuit with a single air gap is shown in Fig. 8. The core dimensions are: Cross-sectional area A_c = 1.8 × 10^{-3} m^2, Mean core length l_c = 0.6 m Gap length g = 2.3×10^{-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.

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

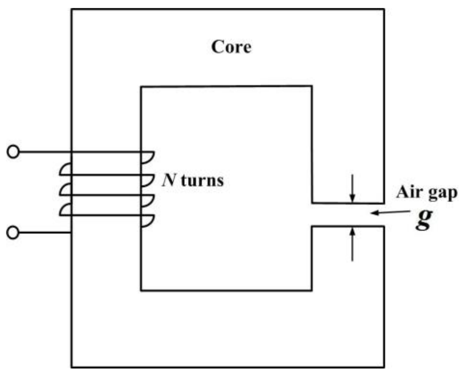

Fig. 8

10. Two identical inductors 1 H each, are connected in series as shown Fig. 9. 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.

[Ans. 4H; 9H;]

Fig. 9

11. (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 [67.5mH, 04108]

(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' and vice-versa. 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.

[6.3V, L=45mH, M=31.5mH]

12. The following parameters refer to two mutually coupled coils '*a*' and '*b*':

$Ra = 20\ \Omega$, $La = 120$ mH, $Na = 1500$; $Rb = 4\ \Omega$, $Lb = 31$ mH, $Nb = 750$;
Co-efficient of coupling, $k = 0.95$
An alternating voltage of 20V r.m.s. at angular frequency of 1000 rad/s is applied across coil '*a*'. Compute, under steady state condition, (i) voltage across the terminals of coil '*b*' when it is open circuited, and (ii) current in coil '*a*' when the terminals of coil '*b*' are short circuited.
[(i) $(9.4 + j1.56)$ V, (ii) $(0.511 - j0.2)$ A]

13. Find the impedance seen by the source in the circuit in Fig. 10. [$\mathbf{Z}_S = 2.25\angle 20.9°\ \Omega$]

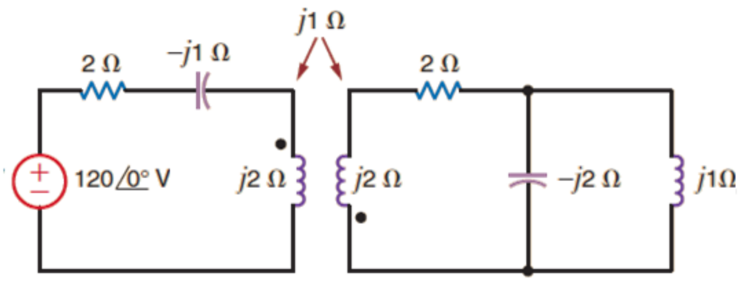

Fig. 10

14. Find the currents $\mathbf{I}_1$ and $\mathbf{I}_2$ and the output voltage $\mathbf{V}o$ in the network shown in Fig. 11.

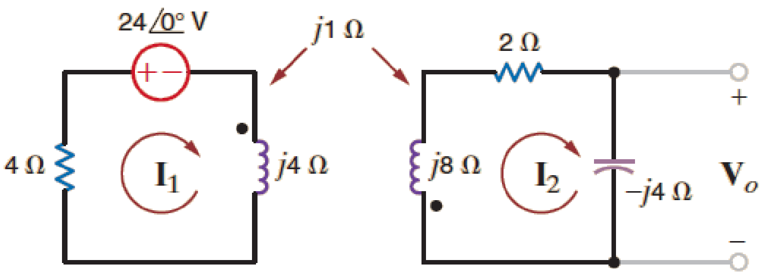

Fig. 11

[$\mathbf{I}_1 = 4.29\angle 137.2°$ A, $\mathbf{I}_2 = 0.96\angle -16.26°$ A, $\mathbf{V}o = 3.84\angle -106.26°$ V]