Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2008-2009 (2 hours)

Machine Design 3

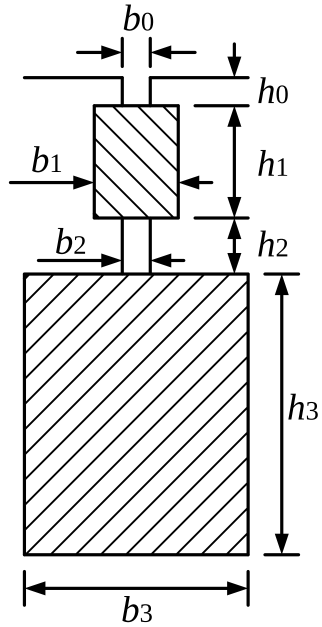
Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1. Figure 1 shows a cross-section of a double-cage rotor slot for an induction motor.

a. Assuming the upper cage and the lower cage can be considered independently, derive the specific permeances associated with self-inductances of upper cage and lower cage, respectively. **(10)**

b. Assuming that the current density is uniformly distributed throughout the upper cage and lower cage conductors, derive an expression for the specific permeance for the upper cage, i.e. the section of $b_1 \times h_1$. **(8)**

c. Explain the functions of upper cage and lower cage of the rotors. **(2)**



(In the slot, shaded areas are conductors and non-shaded areas are airspace)

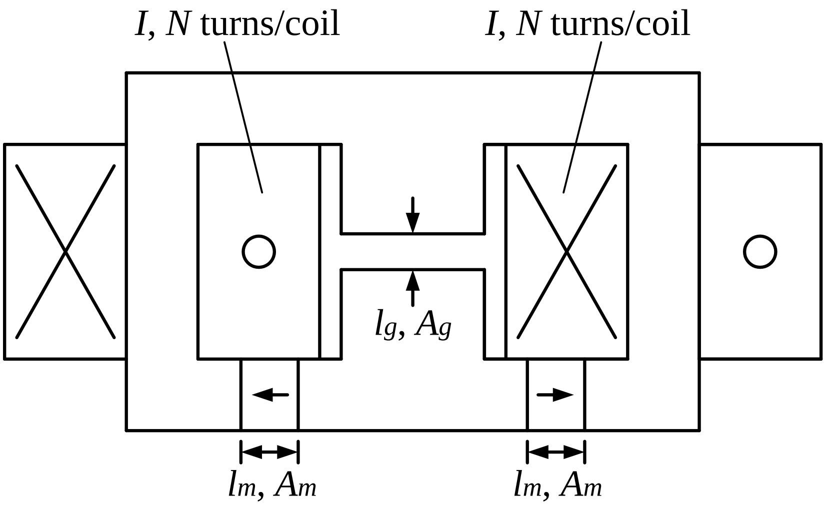
Figure 1

2. **a.** Derive the expressions of winding factors and mmfs of a short-pitched and distributed single-phase winding. **(8)**

b. Explain why a motor having only a single-phase winding cannot start. Full marks will only be given if all assumptions underlying the analysis are clearly stated. **(4)**

c. Derive the expression of mmfs for a three-phase motor and discuss the features of each mmf harmonic. **(8)**

3. Figure 2 shows a magnetic circuit which consists of two identical permanent magnets, two identical excitation coils having N turns per coil, an airgap and a symmetrical iron core. The mmf drop in the iron and the leakage flux in the airspace can be neglected. The remanence and the coercivity of the permanent magnet are B_r and H_c, respectively.



A_g, l_g are the cross-sectional area and length of the airgap, respectively. A_m, l_m are the cross-sectional area and length of each permanent magnet, respectively. Both magnets are identical.

Figure 2

a. Derive expressions for the open-circuit magnet working point and the airgap flux density. **(6)**

b. Derive the magnet working point when each coil carries a current of I Amperes. **(8)**

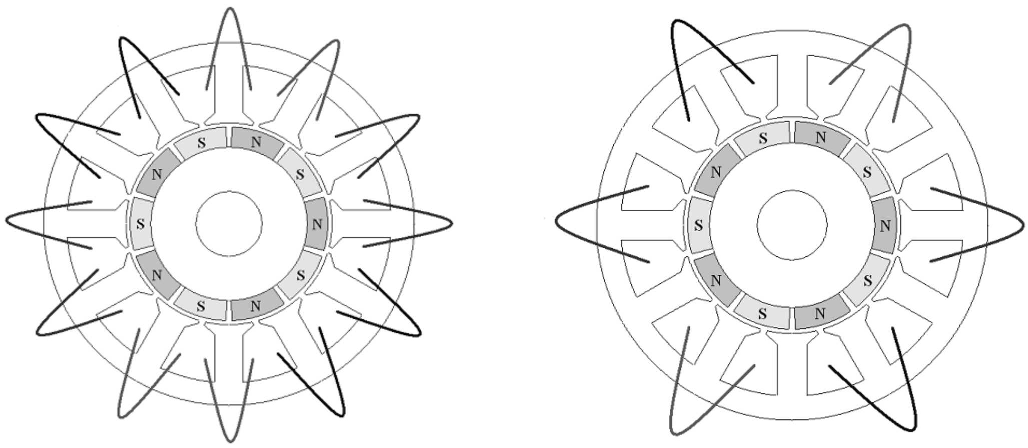
c. Determine the minimum magnet thickness which is required to prevent irreversible demagnetisation. Full marks will only be given if all assumptions underlying the analysis are clearly stated. **(6)**

4. Figure 3 shows cross-sections of two 3-phase, 12-slot, 10-pole permanent magnet brushless ac motors having surface-mounted magnets and internal rotors. One motor is all teeth wound and another is alternate teeth wound. For both motors,

a. Based on coil EMF vectors, determine the coil connections for each set of 3 phases. **(10)**

b. Derive the expression of winding factors. **(8)**

c. Compare the advantages and disadvantages of the two winding configurations. **(2)**



(a) 12-slot/10-pole (b) 12-slot/10-pole

Figure 3

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