UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2022/2023 Academic Session

July/August 2023

EEK260 – Electrical Machine

Duration : 3 hours

Please check that this examination paper consists of **SIX (6)** pages of printed material including appendix before you begin the examination.

Instructions : This paper consists of **THREE (3)** questions. Answer **ALL THREE (3)** questions.

...2/-

1. A ferromagnetic core with a relative permeability of 1500 is shown in Figure 1. The dimensions are as shown in the diagram and the depth of the core is 5 cm. Each air gap between the rotor and the stator is 0.05 cm. Assume that fringing in the air gap increases the effective cross-sectional area of the air gap by 5 percent. If there are 300 turns in the coil wrapped around the center leg of the core and if the current in the coil is 1.0 ,

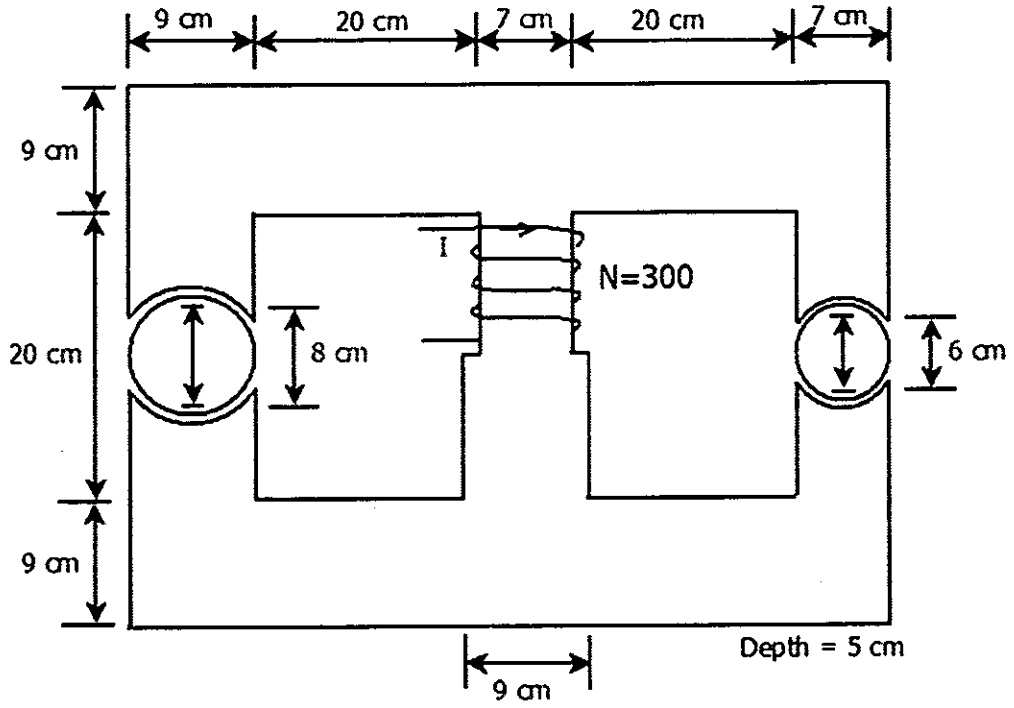

Figure 1. Ferromagnetic core with 300 turns winding at the middle leg

a) Draw the magnetic circuit corresponding to Figure 1. Show all necessary parameters in the magnetic circuit.

(15 marks)

b) Find the values of respective reluctances in part (a).

(45 marks)

c) Determine the flux values for the left, center, and right legs of the core.

(30 marks)

...3/-

d) What are the flux densities in the motor's air gap at the left and right sides respectively?

(10 marks)

2. A shunt DC motor is rated at 240 V, 100 A, 3000 r/min. The armature resistance of the motor is 0.14 Ω, and the shunt field resistance is 40 Ω. A variable resistor, R_{adj} is added in series with the field resistor. The number of shunt field windings per pole is 1400. The magnetization curve for this motor at 3000 r/min is given in Figure 2. This machine has compensating windings and interpoles.

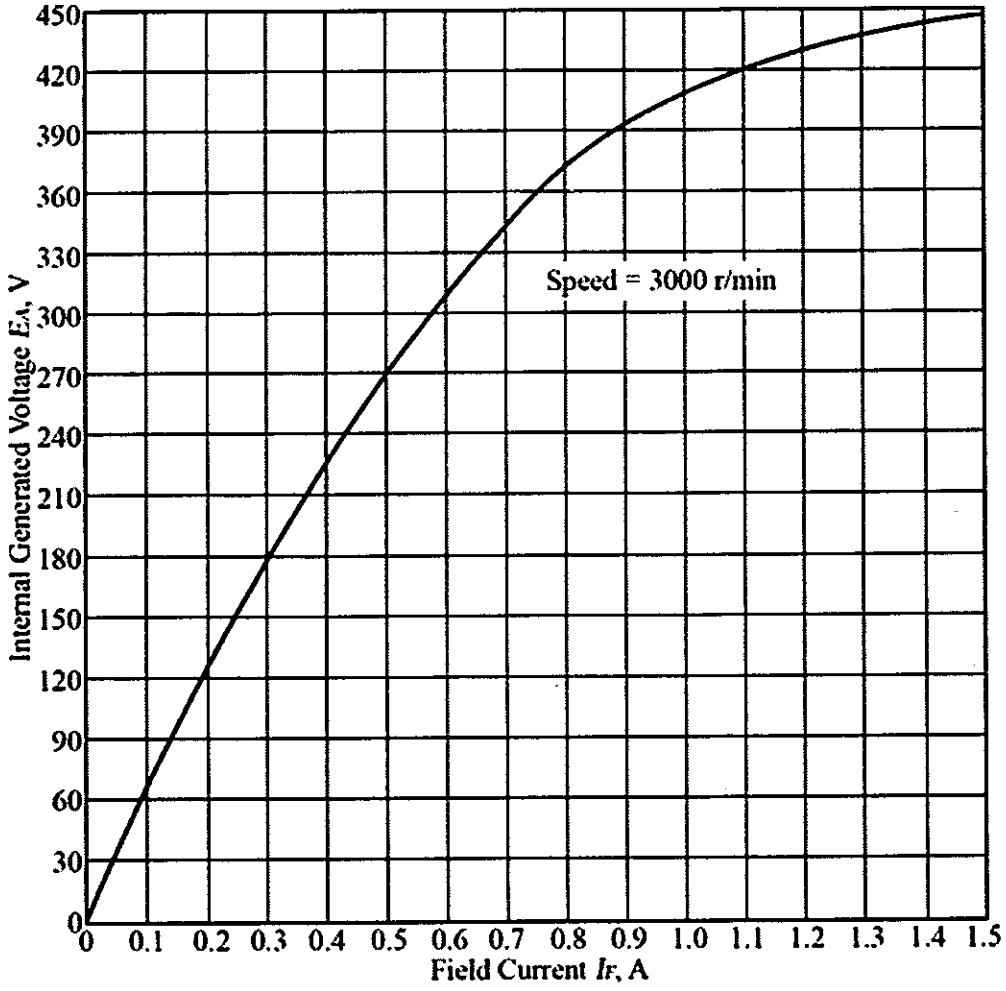

Figure 2. Magnetization curve for the shunt dc motor

...4/-

a) If the no-load speed of this motor is allowed to be within 1714 r/min and 2667 r/min, what is the range of R_{adj} required?.

(30 marks)

b) Calculate the speed regulation of this motor if R_{adj} is set to 280Ω.

(30 marks)

c) With similar R_{adj} of 280 Ω. If the compensating windings and interpoles are removed, the full-load armature reaction of the motor is found to be 630 A·turns. Determine the full-load speed of this motor now.

(20 marks)

d) Is the starting current of this motor within the safe range if the current is to be limited to twice its rated value?

(10 marks)

e) How many starting resistors are required for proper start-up of the motor?

(10 marks)

3. a) A 415V, 50Hz, Y-connected, four-pole, three-phase synchronous motor has per phase synchronous reactance X_S of 1.5Ω and per phase armature resistance R_A of 0.15Ω. At full-load operation, the armature current I_A is 50A and the power factor is 0.85 lagging. This motor also has friction and windage losses of 1.5kW, and core losses of 1kW at full-load.

(i). What is the synchronous speed of this motor?

(10 marks)

(ii). What is internal voltage EA during full-load operation?

(10 marks)

...5/-

(iii). Sketch the phasor diagram of this motor during full-load operation.

(10 marks)

(iv). Calculate the efficiency of the motor during full-load operation.

(10 marks)

b) A 415V, 50Hz, Y-connected, four-pole, three-phase induction motor has the following impedances per phase referred to the stator circuit:

$R_1 = 0.65\Omega \quad R_2 = 0.35\Omega \quad X_1 = 1.2\Omega \quad X_2 = 0.5\Omega \quad X_M = 30\Omega$

Total rotational losses P_{rot} are 1250W which are assumed to be constant. The core loss is lumped together with the rotational losses. For a slip of 3% at rated voltage and frequency, determine the followings:

(i). motor speed in rpm and rad/s respectively

(10 marks)

(ii). stator current I_1

(35 marks)

(iii). stator copper losses P_{copp} , motor input power P_{in} , and motor shaft power P_{shaft}

(15 marks)

-oooOooo-

APPENDIX

Question	Course Outcome (CO)	Programme Outcome (PO)
1	2	2
2	1	1
3	3	2