Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022

COURSE NAME	:	ELECTRICAL MACHINES
COURSE CODE	:	BEV 20803/ BEF 24103
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	JULY 2022
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS
		2. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **OPEN BOOK**.

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) List **TWO (2)** types of losses that can occur in ferromagnetic core.

(2 marks)

(b) In the magnetic circuit as shown in **Figure Q1(b)** the relative permeability of the ferromagnetic material is 1200. The core wound for 400 turns and carries a current of 3 A. The iron core has a cross-sectional area of 2 cm by 2 cm. All dimensions are in centimeters.

(i) Sketch the complete magnetic equivalent circuit.

(2 marks)

(ii) Calculate the total reluctance.

(7 marks)

(iii) Calculate the flux in air gap *b*.

(3 marks)

(iv) Calculate the flux density in air gap *b*.

(1 marks)

(c) A single-phase transformer rated at 3000 kVA, 69 kV/4.16 kV, 60 Hz has a total internal impedance Z_p of 127 Ω as referred to primary side.

(i) Determine the rated primary and secondary currents.

(2 marks)

(ii) Determine the voltage regulation from no-load to full-load for 2000 kW resistive load if the primary supply voltage is fixed at 69 kV.

(8 marks)

Q2 (a) Describe why induction motor is mostly used as motor rather than generator.

(3 marks)

(b) Based on **Figure Q2(b)**, if the motor is used for cooling application, explain which types of motor class is the most suitable with proper justification.

(2 marks)

(c) Explain based on your opinion the reason of doing different motor test such as no-load test and locked rotor test.

(2 marks)

(d) A 415 V, three-pole pairs, 50 Hz, Δ-connected induction motor is rated at 30 hp. The induction motor is running at a slip of 7.5%. Its friction and windage losses are 400 W and the core loss is 300 W. The equivalent circuit components are:

Components	R_1	R_2	X_1	X_2	X_m
Value (Ω)	0.540	0.432	0.450	0.450	20.0

(i) Sketch the equivalent circuit of the induction motor.

(2 marks)

(ii) Calculate the line current.

(3 marks)

(iii) Calculate the stator copper losses, P_{SCL}, the air gap power, P_{AG} and the converted power from electrical to mechanical, P_{CONV}.

(3 marks)

(iv) Analyse the induced torque and the load torque.

(7 marks)

(v) Analyse the induction motor efficiency.

(3 marks)

Q3 (a) Describe the main difference between synchronous generator and synchronous motor.

(4 marks)

(b) A 20 MVA, 12.2 kV, 0.8 PF-lagging, Y-connected synchronous generator has a negligible armature resistance and a synchronous reactance of 1.1 per-unit. The generator is connected in parallel with a 60 Hz 12.2 kV infinite bus that is capable of supplying or consuming any amount of real or reactive power with no change in frequency or terminal voltage.

(i) Determine the synchronous reactance of the generator in ohms.

(3 marks)

(ii) Calculate the armature current, I_A in this machine at rated conditions.

(2 marks)

(iii) Calculate the internal generated voltage, E_A of this generator under rated conditions.

(2 marks)

(iv) Suppose the generator is initially operating at rated conditions. If the internal generated voltage, E_A is decreased by 5 percent, analyze the new armature current, I_A.

(3 marks)

(c) Electric energy usage for a Y-connected, 50 Hz synchronous motor at chips factory in Parit Raja for a was 230 V, 60 kVA, and 0.85 leading power factor. The synchronous motor has a synchronous reactance of 1.5 ohm and negligible armature resistance. Initially, the shaft is supplying 30 hp load with a power factor of 0.75 lagging. Its friction and windage losses are 2.5 kW and its core losses are 0.5 kW.

(i) Calculate the I_A and E_A.

(4 marks)

(ii) If the motor's flux is decreased by 15%, analyse the new I_A, E_A and the power factor.

(4 marks)

(iii) Sketch and compare the initial phasor diagram with the new phasor diagram of the motor.

(3 marks)

Q4 (a) When a DC motor is running, sparks may generally be seen where the carbon brushes contact the commutator segments. Explain why this sparking occurs. Identify **ONE (1)** environment where a sparking motor would be unsafe to use.

(3 marks)

(b) A 200 kW, 200 V, 4-pole, 800 rpm, separately excited DC generator is suggested to deliver the rated load at the rated voltage in a factory. The generator has the following details:

$R_a = 0.03\ \Omega$,
$R_F = 20\ \Omega$,
$V_F = 100$ V,
$N_F = 400$ turns per pole, and
$P_{rot} + P_{core} = 8$ kW.

The demagnetising MMF due to armature reaction is 20% of the armature current. Its magnetisation curve is shown in **Figure Q4(b)**.

(i) Determine the induced EMF at full load.

(2 marks)

(ii) Identify the power developed.

(1 mark)

(iii) Discover the torque developed.

(2 marks)

(iv) Point out the applied torque.

(2 marks)

(v) Analyse the efficiency of this generator under the armature reaction effect.

(6 marks)

(c) A ventilating fan in a poultry farm is driven by a 240 V, 15 kW series DC motor and runs at 1000 rpm at full load. The total armature circuit resistance is 0.5 Ω. The efficiency of the motor is 85%. Assume flux is proportional to the field current. If the current taken by the motor reduces by 50% of the full load value,

(i) Analyse the motor speed.

(6 marks)

(ii) Evaluate the percentage change in torque.

(3 marks)

– END OF QUESTIONS –

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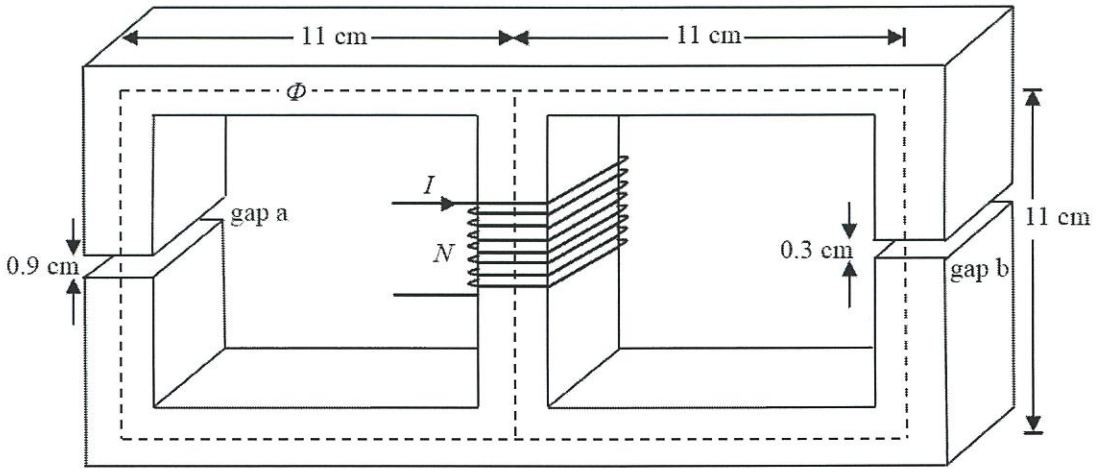

Figure Q1(b)

Motor Design Classes (NEMA)

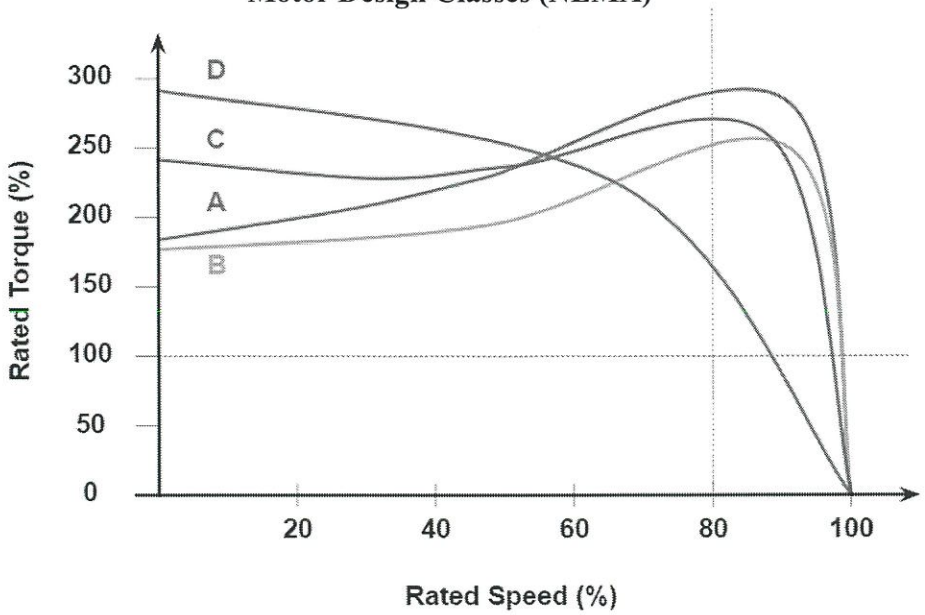

Figure Q2(b)

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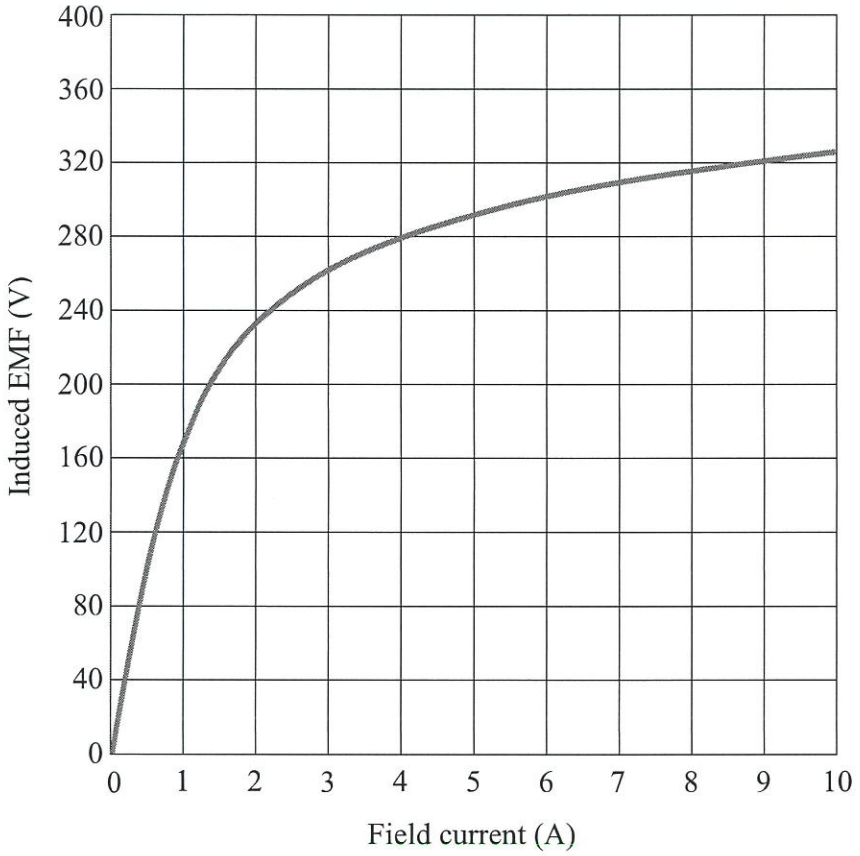

Figure Q4(b)