ENG159

UNIVERSITY OF GREATER MANCHESTER

SCHOOL OF ENGINEERING AND BUILT ENVIRONMENT

BENG (HONS) ELECTRICAL & ELECTRONIC ENGINEERING

SEMESTER ONE EXAMINATIONS 2025/2026

ELECTRICAL MACHINES & POWER ELECTRONIC DRIVES

MODULE NO: EEE6011

Date: Tuesday 13th January 2026 **Time: 2pm – 4:30pm**

INSTRUCTIONS TO CANDIDATES:

There are SIX questions.

Answer ANY FOUR questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

Electronic calculators may be used provided that data and program storage memory is cleared prior to the examination.

CANDIDATES REQUIRE: **Formula Sheet (attached).**

Question 1

(a) A 50 kVA , 2400:240 V transformer is tested without load and the following are the test results:

Short Circuit Test: 48 V, 20.8 A, 617 W (instruments located on high-voltage side)

Open circuit test: 240 V, 5.41 A, 186 W (instruments located on low-voltage side)

1. Calculate the approximate equivalent circuit parameters referred to the high voltage side. **[9 marks]**
2. Calculate voltage regulation and efficiency at full load at 0.8 power factor lagging. **[7 marks]**

(b) A magnetic circuit shown in Figure Q1b has the following parameters:

$A_C = A_g = 9\ cm^2, g = 0.05\ cm, l_C = 30\ cm, N = 500\ turns,$

$\mu_r = 70000\ for\ core\ material, B_C = 1.0\ Tesla$

compute:

1. The flux in the core and air gap assuming $B_{air-gap} = B_C$ **[6 marks]**
2. The required current to produce the flux **[3 marks]**

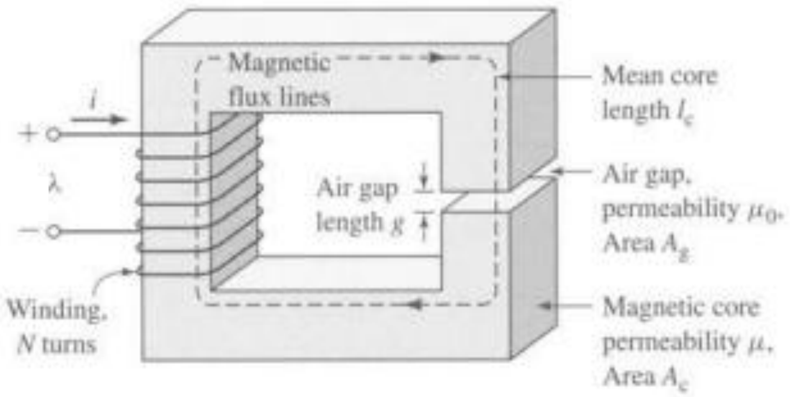

Figure Q1b magnetic circuit with air gap

[Total 25 marks]

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Question 2

(a) Explain with drawings a compound DC generator and comment on its voltage-current characteristics

[8 marks]

(b) A 25 kW , 125 V separately-excited DC machine is operated at a constant speed of 3000 revolutions/minute with a constant field current such that the open-circuit armature voltage is 125 V. The armature resistance is 0.02 ohm. Compute:

1. The armature current, terminal power, and electromagnetic power and torque when the terminal voltage is 128 V. What is the mode of operation in this case?

[10 marks]

2. The armature current, terminal power, and electromagnetic power and torque when the terminal voltage is 124 V. What is the mode of operation in this case?

[7 marks]

[Total 25 marks]

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Question 3

(a) Explain with the aids of diagrams and mathematical formulae how a 3-phase induction motor produce a rotating magnetic field.

[7 marks]

(b) A three-phase, star-connected 220 V (Line-to-line) , 60 Hz, six-pole induction motor has the following parameter values in ohm/phase referred to the stator:

$$R_1 = 0.294 \quad R_2 = 0.144$$

$$X_1 = 0.503 \quad X_2 = 0.209 \quad X_m = 13.25$$

The total friction, windage, and core losses may be assumed to be constant at 403 Watts independent of load. For rated voltage and frequency and slip of 2 percent, compute:

1. Speed **[2 marks]**
2. Stator current and power factor **[10 marks]**
3. Output power and torque **[4 marks]**
4. efficiency **[2 marks]**

[Total 25 marks]

Question 4

A 3300 V, 3-phase, 50 Hz, star-connected synchronous motor has a synchronous impedance of 2+j 15 Ω per phase. Operating with a line emf of 2500 V, it just falls out of step at full load.

(a) Draw the equivalent circuit of a synchronous motor. **[3 marks]**

(b) To what open-circuit emf will it have to be excited so that it will just remain in synchronism at 50% above rated torque? **[8 marks]**

(c) With this emf , what will then be:

1. the input power; **[6 marks]**
2. current; and **[4 marks]**
3. Power factor at full load. **[4 marks]**

[Total 25 marks]

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Question 5

A 2.5 kW, 120 V, 50 Hz capacitor-start motor has the following impedances for the main and auxiliary windings(at starting):

Z_{main}=4.5+j3.7 Ω , $Z_{auxiliary}$=9.5+j3.5 Ω

(a) Explain briefly the effect of adding capacitor to the auxiliary winding of a single-phase induction motor. **[6 marks]**

(b) Find the value of starting capacitance that will place the main and auxiliary winding currents in quadrature at starting. **[19 marks]**

[Total 25 marks]

Question 6

(a) Draw the voltage-current-magnetic field phasor diagram of a three-phase synchronous generator when it is connected to an inductive load **[5 marks]**. Comment on the effect of inductive load on the main magnetic field.
[5 marks]

(b) Draw the equivalent circuit of a three-phase induction motor and explain with the aid of formulae how you can represent the mechanical output power on the circuit [**6 marks]** for the circuit diagram and [**4 marks]** for representing the mechanical output power]. Show the power input, air-gap power, power losses on the circuit diagram **[5 marks]**.

[Total 25 marks]

END OF QUESTIONS

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Formula sheet

These equations are given to save short-term memorisation of details of derived equations and are given without any explanation or definition of symbols; the student is expected to know the meanings and usage.

DC Machines

$E=V+I_A.R_A$ (Generator voltage equation)

$E=V-I_A.R_A$ (Motor voltage equation)

$K_e=K_t=(2pCN/a)$, $E=K_e.\omega.\Phi$, $T=K_t.I_A.\Phi$

$P_{conv} = E.I_A = \omega.T$

Transformers and Induction motors

Transformer voltage ratio: $\frac{E_1}{E_2} = \frac{N_1}{N_2}$

Secondary parameters referred to primary side: $R_2' = (\frac{N_1}{N_2})^2 R_2$, $X_2' = (\frac{N_1}{N_2})^2 X_2$,

$I_2' = \frac{N_2}{N_1} I_2$, $V_2' = \frac{N_1}{N_2} V_2$, $P = \sqrt{3} V_L I_L \cos\theta$, $Q = \sqrt{3} V_L I_L \sin\theta$

$slip\ \ s = \frac{n_s - n_r}{n_s}$, $P_{AG} = 3I_2^2 \frac{R_2}{s}$, $P_{conv} = 3I_2^2 R_2\left(\frac{1-s}{s}\right)$, $P_{core} = 3E_1^2 G_C$,

$\tau_{ind} = \frac{(1-s)P_{AG}}{(1-s)\omega_{sync}}$

$\tau_{ind} = \frac{P_{AG}}{\omega_{sync}}$

Synchronous machines

Voltage vector equation: E =V + I.Z

Power equations: $P= \frac{EV}{Z}\cos(\psi - \delta) - \frac{V^2}{Z}\cos(\psi)$, $Q= \frac{EV}{Z}\sin(\psi - \delta) - \frac{V^2}{Z}\sin(\psi)$

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For generator

$$P_{in} = \tau_{app}\omega_m \text{ , } P_{conv} = \tau_{ind}\omega_m = 3E_A I_A \cos\gamma \text{ , } P_{out} = \sqrt{3}\, V_L \; I_L \cos\theta$$

For motor the above equations will be used in the reversed order.

Motor Drives

The rotor terminals ac voltage with the open-circuit rotor voltage at standstill, $E=sE_{oc}$

The rectified output voltage $E_d = 1.35\ E$

$s = \frac{E_2}{1.35 E_{OC}}$

DC Voltage developed by the inverter $E_2 = 1.35\ E_T cos\alpha$

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