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UNIVERSITY COLLEGE TATI

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FINAL EXAMINATION QUESTION BOOKLET

COURSE CODE	: DEE 3103
COURSE	: ELECTRICAL MACHINE
SEMESTER/SESSION	: 02 - 2024/2025
DURATION	: 3 HOURS

Instructions:

1. This booklet contains **4** question sets. Answer **ALL**.
2. All answers should be written in answer booklet.
3. Write legibly and draw sketches wherever required.
4. If in doubt, raise your hands and ask the invigilator.

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO

THIS BOOKLET CONTAINS 8 PRINTED PAGES INCLUDING COVER PAGE

QUESTION 1

a) Define electric motor. (2 marks)

b) Define electric generator. (2 marks)

c) Describe the basic idea of electromagnetism. (2 marks)

d) Name the hand rule that is used for electric generators. (1 mark)

e) State the **two (2)** types of transformer constructions. (2 marks)

f) Describe the ideal transformer. (4 marks)

g) Name the type of wire used as transformer windings. (1 mark)

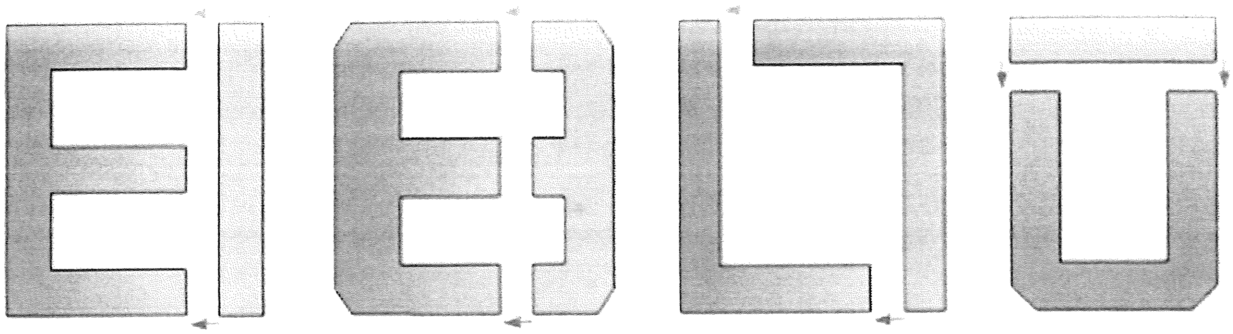
h) A 2.0 kVA single phase transformer has rated voltage of 144/240 V. Calculate;

i. Its primary full load current, I_{1FL}. (3 marks)

ii. Its secondary full load current, I_{2FL}. (3 marks)

QUESTION 2

a) State the name of each transformer core lamination designs shown in Figure 1 (a) – (d).



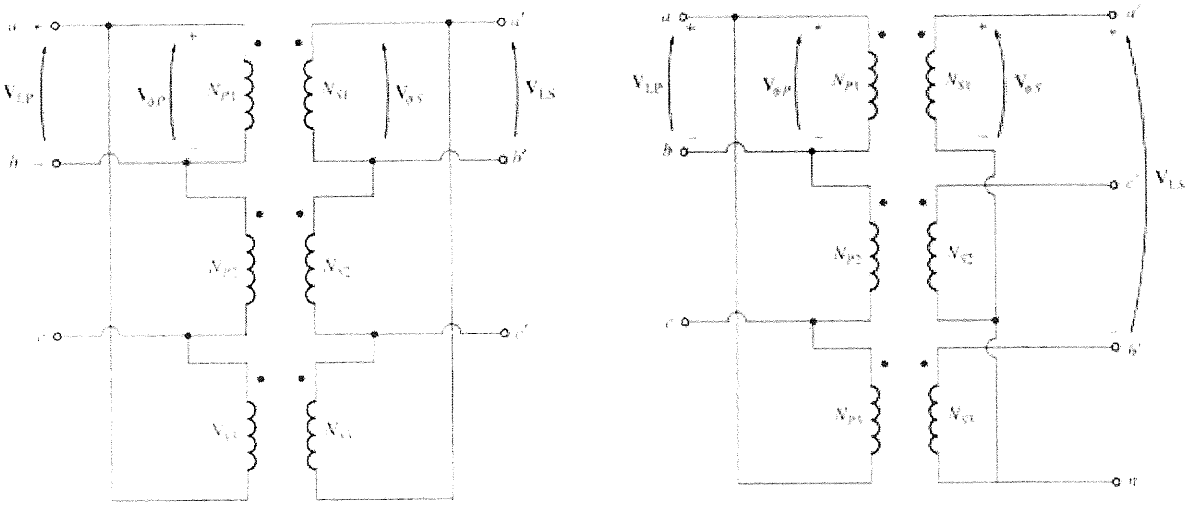
(a) (b) (c) (d)

Figure 1

(4 marks)

b) A single phase transformer has 400 primary and 1000 secondary turns. The primary winding is connected to a 50Hz a.c. supply of 520V. Calculate the induced voltage in the secondary windings, V_2. (3 marks)

c) Name the three-phase transformer connections shown in Figure 2 (a) and Figure 2 (b). (2 marks)



(a) (b)

Figure 2

d) List the **four (4)** classifications of induction motor. (4 marks)

e) Name the induction motor rotor type shown in Figure 3. (1 mark)

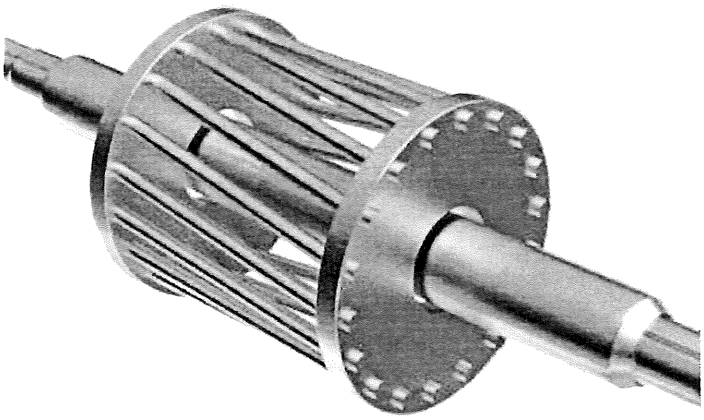


Figure 3

f) An 8-pole, 3-phase induction motor is supplied from an AC power supply with frequency of 50 Hz. On full load, the frequency of induced e.m.f in the rotor is 2 Hz. Calculate the full load slip. (3 marks)

g) A 208-V, 10HP, 4 pole, 60 Hz, Y-connected induction motor has a full-load slip of 5%. Calculate the synchronous speed of this motor. (3 marks)

QUESTION 3

a) State the direction of rotation for the induction motors shown in Figure 4 (a) and (b). (2 marks)

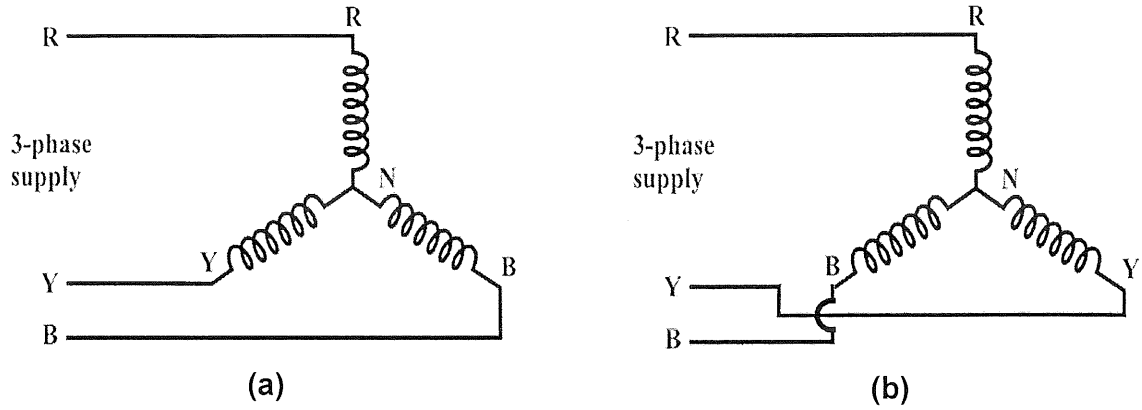


Figure 4

b) The full load power input to a 4 pole, 50 Hz, 3-phase induction motor is 50kW, running at 1440 rpm. If stator losses are 1000 W and frictional losses are 650 W, calculate;

i. The synchronous speed, N_S (3 marks)

ii. The slip, s. (3 marks)

iii. The rotor input power, $P_{in(rotor)}$. (3 marks)

c) State the type of power supply used to excite the field windings of a synchronous motor. (1 mark)

d) State the **two (2)** types of rotor used in a synchronous machines. (2 marks)

e) A 240-V, 4 pole, 50 Hz three phase star connected alternator is required to supply 15kW to a load at power factor of 0.75 lagging. The synchronous reactance of the generator is 3.0Ω with resistance of 0.7Ω. Calculate;

i. The rotor speed, ***N***. (3 marks)

ii. The resistance between the R-Y terminals, R_{RY}. (3 marks)

QUESTION 4

a) Describe the magnetic locking principle. (5 marks)

b) List any **two (2)** synchronous motor starting methods. (2 marks)

c) A 2200V, 40kW,3-phase delta connected synchronous motor is working on full-load at an efficiency of 80% and power factor of 0.6 leading. It has a resistance of 0.22Ω per phase and a synchronous reactance of 2.4 Ω per phase. Calculate;

i. Motor's input power, P_{in}. (3 marks)

ii. Value of line current, I_L. (3 marks)

d) Describe the following motors.

i. Synchronous reluctance motor. (3 marks)

ii. Hysteresis motor. (3 marks)

e) Name the type of DC motor used in stepper motor. (1 mark)

---------------------------------------**End of Questions**---------------------------------------

TABLE OF FORMULAS

Transformer	
$a = \frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$	$E = 4.44fN\Phi_m$
$VA = V_1I_1 = V_2I_2$	$pf = \cos\theta$
$R_2{}' = a^2R_2$	$X_2{}' = a^2X_2$
$R_{01} = R_1 + R_2{}'$	$X_{01} = X_1 + X_2{}'$
$Z_{01} = R_{01} + jX_{01}$	$Z_{SC} = \left(\frac{V_{SC}}{I_{SC}}\right)\angle\theta_{SC}$
$I_C = I_{OC}\cos\theta_{OC}$	$I_m = I_{OC}\sin\theta_{OC}$
$R_C = \frac{V_{OC}}{I_C}$	$X_m = \frac{V_{OC}}{I_m}$
$R_c{}' = a^2R_c$	$X_m{}' = a^2X_m$
$V.R = \frac{V_{NL} - V_{FL}}{V_{NL}} \times 100\%$	$V.R = \frac{V_{FL} - V_{NL}}{V_{FL}} \times 100\%$
$V.R = \frac{V_{SC}\cos(\theta_{SC} \mp \theta_{pf})}{V} \times 100\%$	$V.R = \frac{I_1[R_{01}\cos\theta_{pf} \pm X_{01}\sin\theta_{pf}]}{V_1} \times 100\%$
$\eta_{FL} = \frac{VA\cos\theta}{VA\cos\theta + P_{sc} + P_{oc}} \times 100\%$	$\eta_{(load\ n)} = \frac{nVA\cos\theta}{nVA\cos\theta + n^2P_{sc} + P_{oc}} \times 100\%$
$P_{OC} = V_{OC}I_{OC}\cos\theta_{OC}$	$P_{SC} = V_{SC}I_{SC}\cos\theta_{SC}$
$V_1\angle 0° = (I_1\angle \mp \theta_{pf})(R_{01} + jX_{01}) + aV_2$	

Induction Machine

$N_S = \frac{120f}{P}$	$s = \frac{N_s - N_r}{N_s} \times 100\%$	$f_r = sf$
$\tau_m = \frac{60P_m}{2\pi N_r}$	$\tau_o = \frac{60P_{out}}{2\pi N_r}$	$\eta = \left(\frac{P_{out}}{P_{in}}\right) \times 100\%$

$P_{in(rotor)} = P_{in(stator)} - (P_{scu} + P_c)$	$P_m = P_{in(rotor)} - P_{rcu}$
$P_{in(rotor)}: P_{rcu}: P_m = 1: s: 1 - s$	$P_{out} = P_m - P_\mu$

Synchronous Machine

Synchronous generator/ Alternator	$f = \frac{PN}{120}$	$E_A = K\varphi\omega$	$V_\varphi = E_A - I_A(R_A + jX_s)$
	$P_{in} = \sqrt{3}V_L I_L \cos\theta$	$\% V.R = \frac{E_{ph} - V_{ph}}{V_{ph}} \times 100\%$	$P_{in} = P_{out} + P_{F\&W} + P_{core}$
	$(E_{ph})^2 = (V_{ph}\cos\theta + I_a R_a)^2 + (V_{ph}\sin\theta \pm I_a X_s)^2$		

Synchronous motor	$P_{in} = \sqrt{3}V_L I_L \cos\phi$	$N_S = \frac{120f}{P}$	$E_{Rph} = I_{aph}\lvert Z_s\rvert$	$Z_s = R_a + jX_s$ $Z_s = \lvert Z_s\rvert\angle\theta$

Synchronous motor	$p.f = \cos\phi$	$P_m = P_{in} - P_{scu}$	$P_{scu} = 3{I_{aph}}^2 R_a$
	$\theta = \tan^{-1}\frac{X_s}{R_a}$	$\lvert Z_s\rvert = \sqrt{{R_a}^2 + {X_s}^2}$	$\eta = \left(\frac{P_{out}}{P_{in}}\right) \times 100\%$
	$(E_{bph})^2 = (V_{ph})^2 + (E_{Rph})^2 - 2V_{ph}E_{Rph}\cos(\theta \pm \phi)$		