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UNIVERSITY COLLEGE TATI

UNIVERSITY COLLEGE TATI (UC TATI)

FINAL EXAMINATION QUESTION BOOKLET

COURSE CODE	: BET 3043 571
COURSE	: ELECTRICAL MACHINES
SEMESTER/SESSION	: 1-2024/2025
DURATION	: 3 HOURS

Instructions:

1. This booklet contains 4 questions. Answer **ALL** questions.
2. All answers should be written in the 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 6 PRINTED PAGES INCLUDING COVER PAGE

QUESTION 1

a) Describe commutation process in dc machine. (3 marks)

b) The data of magnetization for 4-pole, 225V and 1500rpm of shunt generator is shown in Table1.

Table 1

Field current (A)	0	0.5	1.0	1.5	2	2.5	3	3.5	4
Terminal voltage (V)	6	60	120	172.5	202.5	221	231	237	240

Armature is lap-connected with 144 conductors and field resistance is 80Ω.

i. Plot graph for magnetization curve. (3 marks)

ii. Calculate residual flux per pole. (2 marks)

iii. Identify the voltage the machine will build up at no load. (5 marks)

iv. Identify the critical field circuit resistance. (4 marks)

v. Identify the speed at which the machine just fails to excite. (3 marks)

QUESTION 2

a) State the difference between dc motor and dc generator. (2 marks)

b) Choose any two (2) types of dc motor configuration and state two (2) characteristics of each motor. (6 marks)

c) A voltage of 220 V is applied to shunt dc motor results in no load currents of 5 A at 1500 rpm. The motor has an armature resistance of 0.2 Ω and field resistance of 110 Ω.

Calculate:

i. The armature current of the motor (4 marks)

ii. The back e.m.f of the motor (2 marks)

iii. The new speed if the motor draws 52 A at a rated voltage. (6 marks)

$\left\{\text{Hint: } \frac{N_2}{N_1} = \frac{E_{b2}}{E_{b2}}\right\}$

d) Describe the construction of the following single-phase induction motor parts:

i. Stator (2 marks)

ii. Rotor (2 marks)

e) Explain the operation of capacitor start induction motors complete with phasor diagram. (6 marks)

QUESTION 3

a) Define rotating magnetic field in induction motor (2 marks)

b) Describe how the direction of induction motor rotation can be changed. (3 marks)

c) Explain the following induction motor's rotor construction:

i. Squirrel cage rotor (3 marks)

ii. Wound rotor (2 marks)

d) A 440 V, 3-phase, 50 Hz, 4 pole, and a star connected induction motor have a full-load speed of 1425 rpm. The rotor has an impedance of (0.4 + j4) Ω and stator/rotor turn ratio of 1.25.

Calculate:

i. The slip at full load. (2 marks)

ii. The full load copper loss in rotor winding. (7 marks)

iii. The output power if windage and friction losses are 500W. (5 marks)

QUESTION 4

a) State the two (2) types of synchronous machine (2 marks)

b) State three (3) differences between Salient pole and Smooth cylindrical type of rotor in synchronous machine. (6 marks)

c) Describe the construction of the following synchronous machine parts:

i. Stator (2 marks)

ii. Rotor (3 marks)

d) A 2400-V line-to-line voltage, 6 pole, 60 Hz three phase star connected alternator is required to supply 11kW to a load at power factor of 0.75 lagging. The synchronous reactance of the generator is 2.0Ω and resistance 0.25Ω.

Calculate:

i. Rotor speed (2 marks)

ii. Line value of e.m.f generated (9 marks)

iii. Regulation at this load (2 marks)

----------**End of question**----------

TABLE OF FORMULAS

Three-phase transformer				
$pf = \frac{P}{S} = cos\theta$		$a = \frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$		
$S_Z = VI$	$S = \sqrt{3}V_L I_L$	$S = \sqrt{P^2 + Q^2}$		
DC Machines				
DC Generator	$E = \frac{\emptyset PNZ}{60A}$	Lap type	Wave type	
		$E = \frac{\emptyset NZ}{60}$	$E = \frac{\emptyset PNZ}{120}$	
	Separately excited	Shunt generator		
	$V_T = E_g - I_a R_a$	$V_T = E_g - I_a R_a$	$I_a = I_L + I_f$	$I_f = \frac{V_T}{R_f}$
	$P_L = V_T \times I_L$	$V.R = \frac{V_{NL} - V_{FL}}{V_{NL}} \times 100\%$	$N_c = \frac{BC}{AC} \times N$	
DC Motor	Series Motor	Shunt Motor		
	$V_T = E_b + i_a(R_a + R_f) + V_{brush}$	$V_T = E_b + i_a R_a$	$i_L = i_a + i_f$	$V_T = i_f R_f$
	$P_{in} = V_T i_L$	$P_m = E_b i_a$	$P_{out} = P_{in} - \sum P_{loss}$ $P_{out} = P_m - P_\mu$	
	$\tau_m = \left(\frac{60P_m}{2\pi N}\right)$	$\tau_o = \left(\frac{60P_{out}}{2\pi N}\right)$	$\eta = \left(\frac{P_{out}}{P_{in}}\right) \times 100\%$	
Three-phase Induction Motor				
$N_S = \frac{120f}{P}$	$f_r = sf$	$s = \frac{N_s - N_r}{N_s}$	$Z = R_2 + jX_2$	$\frac{E_{1ph}}{E_{2ph}} = \frac{\text{stator turns}}{\text{rotor turns}}$
$\tau_m = \left(\frac{60P_m}{2\pi N_r}\right)$	$\tau_o = \left(\frac{60P_{out}}{2\pi N_r}\right)$	$\eta = \left(\frac{P_{out}}{P_{in}}\right) \times 100\%$	$I_{2r} = \frac{sE_{2ph}}{\sqrt{R_2^2 + (sX_2)^2}}$	
$P_{in(rotor)} = P_{in(stator)} - (P_{scu} + P_c)$	$P_m = P_{in(rotor)} - P_{rcu}$	$P_{rcu} = 3 \times I_{2r}^2 \times R_2$		
$P_{in(rotor)} : P_{rcu} : P_m = 1 : s : 1 - s$	$P_{out} = P_m - P_\mu$	$\eta = \left(\frac{P_{out}}{P_{in}}\right) \times 100\%$		
Synchronous Generator / Alternator				
$f = \frac{PN}{120}$	$E_A = K\varphi\omega$	$V_\varphi = E_A - I_A(R_A + jX_s)$		
$P_{in} = \sqrt{3}V_L I_L \cos\theta$	$\% V.R = \frac{E_{ph} - V_{ph}}{V_{ph}} \times 100\%$	$P_{in} = P_{out} + P_{F\&W} + P_{core}$		
$(E_{ph})^2 = (V_{ph}\cos\theta + I_a R_a)^2 + (V_{ph}\sin\theta \pm I_a X_s)^2$				