

**UNIVERSITY COLLEGE TATI (UC TATI)****FINAL EXAMINATION QUESTION BOOKLET**

COURSE CODE	: BET 3043
COURSE	: ELECTRICAL MACHINE
SEMESTER/SESSION	: 1-2023/2024
DURATION	: 3 HOURS

Instructions:

1. This booklet contains 4 questions. Answer **ALL** questions.
2. All answers should be written in answer booklet.
3. Write legibly and draw sketches wherever required.
4. If in doubt, raise up 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) Define dc generator. (2 marks)
- b) The data of magnetization for 4-pole, 225V, 1500rpm 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. (4 marks)
- ii. Calculate residual flux per pole. (2 marks)
- iii. Identify 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) Describe the commutation action process in DC machine based on Figure 1. (7 marks)

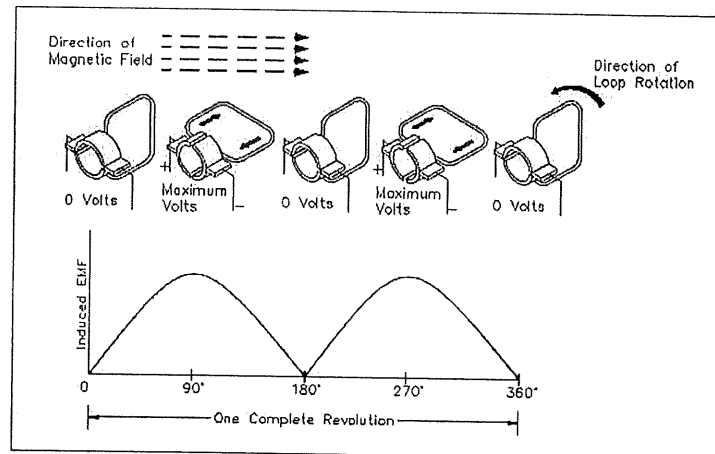


Figure 1

- b) A voltage of 220 V is applied to armature of shunt DC motor results in full load armature currents of 20A. Assume that armature and field resistance are 0.5Ω and 440Ω respectively. Assuming the stray losses is 132 W at full load speed of 650rpm.

Calculate:

- i. The line current of the motor (3 marks)
- ii. The back e.m.f of the motor (3 marks)
- iii. The mechanical power and torque (3 marks)
- iv. The output power and torque (2 marks)
- v. The motor efficiency (2 marks)

QUESTION 3

- a) Construction of single-phase induction motor can be divided into two main parts namely rotor and stator. Describe:
- i. Stator (2 marks)
 - ii. Rotor (2 marks)
- b) Explain the operation of split phase induction motors complete with phasor diagram. (6 marks)
- c) There are two types of rotor construction used for induction motor. Explain:
- i. Squirrel cage rotor (2 marks)
 - ii. Wound rotor (2 marks)
- d) A 3-phase, 4-pole, 60Hz induction motor has delta connected stator winding and runs on 300V supply. Rotor resistance and standstill reactance per phase are 0.15Ω and 0.85Ω respectively. Ratio of stator to rotor turns is 1.85. Full load speed is 1750rpm.

Calculate:

- i. The slip at full load. (2 marks)
- ii. The full load copper loss in rotor winding. (6 marks)
- iii. The useful power if mechanical losses are 750W. (5 marks)
- iv. The full load efficiency of the motor if stator losses are 250W. (6 marks)

QUESTION 4

- a) Synchronous machine can be classified into synchronous generators and synchronous motor. Define synchronous machine. (2 marks)
- b) There are two types of rotors used in synchronous machines. State **three (3)** differences between Salient pole and Smooth cylindrical type of rotor in synchronous machine. (6 marks)
- c) The synchronous machine construction consists of two main parts. Explain:
- i. Stator (2 marks)
 - ii. Rotor (4 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. (8 marks)
- iii. Resistance between R-Y terminals, R_{RY} (3 marks)

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

ELECTRICAL MACHINE (BET 3043)

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	$E = \frac{\phi PNZ}{60A}$	Lap type	Wave type		
		$E = \frac{\phi NZ}{60}$	$E = \frac{\phi PNZ}{120}$		
	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					
$N_s = \frac{120f}{P}$	$f_r = sf$	$s = \frac{N_s - N_r}{N_s}$	$\frac{E_{1ph}}{E_{2ph}} = \frac{\text{stator turns}}{\text{rotor turns}}$		
$\tau_m = \left(\frac{60P_m}{2\pi N_r}\right)$	$\tau_o = \left(\frac{60P_{out}}{2\pi N_r}\right)$	$\eta = \left(\frac{P_{out}}{P_{in}}\right) \times 100\%$	$I_{2r} = \frac{sE_{2ph}}{\sqrt{R_2^2 + (sX_2)^2}}$		
$P_{in(rotor)} = P_{in(stator)} - (P_{scu} + P_c)$		$P_m = P_{in(rotor)} - P_{rcu}$	$P_{rcu} = 3 \times I_{2r}^2 \times R_2$		
$P_{in(rotor)} : P_{rcu} : P_m = 1 : s : 1 - s$		$P_{out} = P_m - P_\mu$	$\eta = \left(\frac{P_{out}}{P_{in}}\right) \times 100\%$		
Synchronous Generator / Alternator					
$f = \frac{PN}{120}$	$E_A = K\phi\omega$	$V_\phi = E_A - I_A(R_A + jX_s)$			
$P_{in} = \sqrt{3}V_L I_L \cos\theta$	$\% V.R = \frac{E_{ph} - V_{ph}}{V_{ph}} \times 100\%$	$P_{in} = P_{out} + P_{F\&W} + P_{core}$			
$(E_{ph})^2 = (V_{ph} \cos\theta + I_a R_a)^2 + (V_{ph} \sin\theta \pm I_a X_s)^2$					