



UNIVERSITY COLLEGE TATI (UC TATI)

FINAL EXAMINATION QUESTION BOOKLET	
COURSE CODE	: BMT 3013 <i>5/1</i>
COURSE	: ELECTRICAL MACHINE
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 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

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QUESTION 1

- a) State the difference between dc motor and dc generator. (2 marks)
- b) Describe commutation process in dc machine. (3 marks)
- c) 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)
- d) 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)

$$\left\{ \text{Hint: } \frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \right\}$$

QUESTION 2

- a) Describe the effect of interaction of three fluxes produced by 3-phase supply in induction motor. (3 marks)
- b) There are two types of rotor construction used for induction motor. Explain:
- i. Squirrel cage rotor (3 marks)
 - ii. Wound rotor (2 marks)
- c) A 440 V, 3-phase, 50 Hz, 4 pole, and a star connected induction motor has a full-load speed of 1425 rpm. The rotor has an impedance of $(0.4 + j4) \Omega$ 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)
- i. The output power if windage and friction losses are 500W. (5 marks)

QUESTION 3

- a) State 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) Explain the principles of magnetic locking in synchronous machine (5 marks)
- e) A 50kW, 2200V, 50Hz salient pole three-phase delta connected synchronous motor working at full load have an efficiency of 80% at 187.5 r.p.m and power factor of 0.6 leading. It has an effective resistance of 1.5Ω per phase and a synchronous reactance of 20Ω per phase.

Calculate:

- i. The input power of motor. (2 marks)
- ii. The value of line current. (2 marks)
- iii. The value of synchronous impedance and impedance angles. (2 marks)
- iv. The generated e.m.f per phase. (7 marks)
- v. The internal power developed by the motor (2 marks)

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QUESTION 4

- a) Describe the construction of the following single-phase induction motor parts:
- i. Stator (2 marks)
 - ii. Rotor (2 marks)
- b) Explain the operation of capacitor start induction motors complete with phasor diagram. (7 marks)

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

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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					
$N_s = \frac{120f}{P}$	$f_r = sf$	$s = \frac{N_s - N_r}{N_s}$	$Z = R_2 + jX_2$	$\frac{E_{1ph}}{E_{2ph}} = \frac{\text{stator turns}}{\text{rotor turns}}$	
$\tau_m = \left(\frac{60P_m}{2\pi N_r}\right)$	$\tau_o = \left(\frac{60P_{out}}{2\pi N_r}\right)$		$\eta = \left(\frac{P_{out}}{P_{in}}\right) \times 100\%$	$I_{2r} = \frac{sE_{2ph}}{\sqrt{R_2^2 + (sX_2)^2}}$	
$P_{in(rotor)} = P_{in(stator)} - (P_{scu} + P_c)$		$P_m = P_{in(rotor)} - P_{rcu}$		$P_{rcu} = 3 \times I_{2r}^2 \times R_2$	
$P_{in(rotor)} : P_{rcu} : P_m = 1 : s : 1 - s$		$P_{out} = P_m - P_\mu$		$\eta = \left(\frac{P_{out}}{P_{in}}\right) \times 100\%$	
Synchronous Generator / Alternator					
$P_{in} = \sqrt{3}V_L I_L \cos\phi$	$p.f = \cos\phi$	$E_{Rph} = I_{aph} Z_s $		$Z_s = R_a + jX_s$ $Z_s = Z_s \angle \theta$	
$\theta = \tan^{-1} \frac{X_s}{R_a}$	$ Z_s = \sqrt{R_a^2 + X_s^2}$	$P_m = P_{in} - P_{scu}$		$P_{scu} = 3I_{aph}^2 R_a$	
$(E_{bph})^2 = (V_{ph})^2 + (E_{Rph})^2 - 2V_{ph}E_{Rph} \cos(\theta \pm \phi)$				$\eta = \left(\frac{P_{out}}{P_{in}}\right) \times 100\%$	