



UNIVERSITY COLLEGE TATI (UCTATI)

FINAL EXAMINATION QUESTION BOOKLET

COURSE CODE	: DEE 3103
COURSE	: ELECTRICAL MACHINE
SEMESTER/SESSION	: 1-2021/2022
DURATION	: 3 HOURS

Instructions:

- a) This booklet contains 4 questions. Answer **ALL** questions.
- b) All answers should be written in answer booklet.
- c) Write legibly and draw sketches wherever required.
- d) 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 7 PRINTED PAGES INCLUDING COVER PAGE

ELECTRICAL MACHINE (DEE 3103)

QUESTION 1

- a) Define electrical machine. (2 marks)
- b) Describe characteristic of series, shunt and cumulative compound DC motor. (3 marks)
- c) A dc series motor is consumed a 7.5kW when the 12 A of armature current is passing through the armature and field resistance of 3.4Ω and 2.2Ω respectively. Assume stray losses of 1.2kW.

Calculate:

- i. The terminal voltage, V_T (3 marks)
- ii. The back emf, E_b (3 marks)
- iii. The net torque if the speed is at 3360rpm (5 marks)
- iv. The efficiency of the machine (2 marks)
- d) A voltage of 240V is applied to armature of shunt DC motor results in a full load armature currents of 202A. Assume that armature resistance is 0.4Ω . Assuming the stray losses are 1445W at full load speed of 1200rpm.

Calculate:

- i. The back emf of the motor (2 marks)
- ii. The output power and torque (5 marks)

QUESTION 2

a) Describe the following transformer principles.

- i. Voltage Transformation Ratio. (2 marks)
- ii. Transformer Rating (2 marks)

b) The measurement test has been conducted on 1500VA 220/115V single phase transformer to determine the parameter of the transformer. The results of the test have been given as:

$$\begin{array}{ll} P_{OC} = 35W & P_{SC} = 20.5W \\ V_{OC} = 220V & V_{SC} = 13.2V \\ I_{OC} = 0.45A & I_{SC} = 6.818A \end{array}$$

All data given were taken from the primary side of transformer.

- i. Calculate the equivalent circuit parameter of this transformer referred to high voltage side (13 marks)
- ii. Produce the equivalent circuit diagram with all parameters determined in Q2b(i) properly labeled. (2 marks)
- iii. Determine the approximate value of secondary voltage at full load of 0.8 lagging power factor, when primary supply is 220V. (4 marks)
- iv. Determine voltage regulation of the transformer using equivalent circuit (2 marks)

QUESTION 3

- a) List four (4) comparison between star and delta connection (8 marks)
- b) There are two types of rotor construction used for induction motor. Briefly explain
- i. Squirrel cage rotor (3 marks)
 - ii. Wound rotor (2 marks)
- c) The full load input power of 2 pole, 50 Hz three-phase full lose induction motor is 60kW and has a slip of 8% when operating at full load conditions. At full-load conditions, friction and windage losses are 420W and the stator losses are 400W. Calculate the following values for full-load conditions:
- i. The synchronous speed (1 mark)
 - ii. The rotor speed (2 marks)
 - iii. The rotor power input (2 marks)
 - iv. The rotor copper losses (2 marks)
 - v. The output power (3 marks)
 - vi. The net torque (2 marks)

QUESTION 4

- a) Define synchronous machine. (4 marks)
- b) There are two types of rotor used in synchronous machines. State four (4) differences between Salient pole and Smooth cylindrical type of rotor. (8 marks)
- c) A 2300-V, 8 pole, 50 Hz three phase star connected alternator is required to supply 7.5kW to a load at power factor of 0.65 lagging. The synchronous reactance of the generator is 2.5Ω and resistance 0.75Ω .

Calculate,

- i. The rotor speed (2 marks)
- ii. Line value of e.m.f generated (7 marks)
- iii. The regulation at this load (2 marks)
- iv. Resistance between R-Y terminals, R_{RY} (2 marks)

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

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TABLE OF FORMULAS

Transformer			
$a = \frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$		$E = 4.44fN\Phi_m$	
$VA = V_1I_1 = V_2I_2$		$pf = \cos \theta$	
$R_2' = a^2R_2$		$X_2' = a^2X_2$	
$R_{01} = R_1 + R_2'$		$X_{01} = X_1 + X_2'$	
$Z_{01} = R_{01} + jX_{01}$		$Z_{SC} = \left(\frac{V_{SC}}{I_{SC}}\right) \angle \theta_{SC}$	
$I_c = I_{OC} \cos \theta_{OC}$		$I_m = I_{OC} \sin \theta_{OC}$	
$R_c = \frac{V_{OC}}{I_c}$		$X_m = \frac{V_{OC}}{I_m}$	
$R_c' = a^2R_c$		$X_m' = a^2X_m$	
$V.R = \frac{V_{NL} - V_{FL}}{V_{NL}} \times 100\%$		$V.R = \frac{V_{FL} - V_{NL}}{V_{FL}} \times 100\%$	
$V.R = \frac{V_{SC} \cos(\theta_{SC} \mp \theta_{pf})}{V} \times 100\%$		$V.R = \frac{I_1 [R_{01} \cos \theta_{pf} \pm X_{01} \sin \theta_{pf}]}{V_1} \times 100\%$	
$\eta_{FL} = \frac{VA \cos \theta}{VA \cos \theta + P_{sc} + P_{oc}} \times 100\%$		$\eta_{(load\ n)} = \frac{nVA \cos \theta}{nVA \cos \theta + n^2P_{sc} + P_{oc}} \times 100\%$	
$P_{OC} = V_{OC}I_{OC} \cos \theta_{OC}$		$P_{SC} = V_{SC}I_{SC} \cos \theta_{SC}$	
$V_1 \angle 0^\circ = (I_1 \angle \mp \theta_{pf})(R_{01} + jX_{01}) + aV_2$			
DC Machines			
DC Generator	$E = \frac{\Phi PNZ}{60A}$	Lap type	Wave type
		$E = \frac{\Phi NZ}{60}$	$E = \frac{\Phi PNZ}{120}$
DC Motor	$E_b = K_1K_2i_a\omega$		
Series Motor	$V_T = E_b + i_a(R_a + R_f) + V_{brush}$		$P_{in} = V_T i_L$
Shunt Motor	$V_T = E_b + i_a R_a$	$i_L = i_a + i_f$	$P_m = E_b i_a$
	$V_T = i_f R_f$		$P_{out} = P_{in} - \sum P_{loss}$ $P_{out} = P_m - P_\mu$
Long Shunt Compound Motor	$V_T = E_b + i_a(R_a + R_{se}) + V_{brush}$	$i_L = i_a + i_{sh}$ $i_{sh} = \frac{V_T}{R_{sh}}$	

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Short Shunt Compound Motor	$V_T = E_b + i_a R_a + i_L R_{se} + V_{brush}$		$i_L = i_a + i_{sh}$	$\tau_m = \left(\frac{60P_m}{2\pi N}\right)$
	$V_{sh} = i_{sh} R_{sh}$		$i_{sh} = \frac{V_T - i_L R_{se}}{R_{sh}}$	$\tau_o = \left(\frac{60P_{out}}{2\pi N}\right)$
			$i_{sh} = \frac{E_b + i_a R_a + V_{brush}}{R_{sh}}$	$\eta = \left(\frac{P_{out}}{P_{in}}\right) \times 100\%$
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	$f = \frac{PN}{120}$	$E_A = K\phi\omega$	$V_\phi = E_A - I_A(R_A + jX_s)$	
	$P_{in} = \sqrt{3}V_L I_L \cos \theta$	$\% V.R = \frac{E_{ph} - V_{ph}}{V_{ph}} \times 100\%$	$P_{in} = P_{out} + P_{F\&W} + P_{core}$	
	$(E_{ph})^2 = (V_{ph} \cos \theta + I_a R_a)^2 + (V_{ph} \sin \theta \pm I_a X_s)^2$			
Synchronous motor	$P_{in} = \sqrt{3}V_L I_L \cos \phi$	$N_s = \frac{120f}{P}$	$E_{Rph} = I_{aph} Z_s $	$Z_s = R_a + jX_s$ $Z_s = Z_s \angle \theta$
	$p.f = \cos \phi$	$P_m = P_{in} - P_{scu}$		$P_{scu} = 3I_{aph}^2 R_a$
	$\theta = \tan^{-1} \frac{X_s}{R_a}$	$ Z_s = \sqrt{R_a^2 + X_s^2}$		$\eta = \left(\frac{P_{out}}{P_{in}}\right) \times 100\%$
	$(E_{bph})^2 = (V_{ph})^2 + (E_{Rph})^2 - 2V_{ph}E_{Rph} \cos(\theta \pm \phi)$			

