UNIVERSITY COLLEGE TATI

UNIVERSITY COLLEGE TATI (UC TATI)

FINAL EXAMINATION QUESTION BOOKLET	
COURSE CODE	: BMT 3013
COURSE	: ELECTRICAL MACHINE
SEMESTER/SESSION	: 2-2024/2025
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 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) Describe the construction of DC machine. (2 marks)

b) Explain **two (2)** differences between lap wound and wave wound armature winding. (4 marks)

c) The data of magnetization for 4-pole, 240V and 1500rpm of shunt generator is shown in Table1.

Table 1

Field current (A)	0	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3
Terminal voltage (V)	4.8	48	96	138	162	176.8	184.8	189.6	192

Armature is wave-connected with 144 conductors and field resistance is 100Ω.

i. Plot graph for magnetization curve. (3 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)

d) 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 armature current of the motor (4 marks)
ii. The back e.m.f of the motor (2 marks)
iii. The mechanical power and mechanical torque (2 marks)
iv. The output power and torque (2 marks)

QUESTION 2

a) Describe function of no load test in induction motor (2 marks)

b) Explain how the direction of induction motor can be reversed. (3 marks)

c) There are two types of rotor construction used for induction motor. Explain:

i. Squirrel cage rotor (3 marks)

ii. Slip ring 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)

QUESTION 3

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 **four (4)** differences between Salient pole and Smooth cylindrical type of rotor in synchronous machine. (8 marks)

c) Explain principle operation of three-phase synchronous motor. (10 marks)

d) 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)

QUESTION 4

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. (7 marks)

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

TABLE OF FORMULAS

<table>
<tr><th colspan="5">Three-phase transformer</th></tr>
<tr><td colspan="2">$pf = \frac{P}{S} = cos\theta$</td><td colspan="3">$a = \frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$</td></tr>
<tr><td>$S_Z = VI$</td><td colspan="2">$S = \sqrt{3}V_L I_L$</td><td colspan="2">$S = \sqrt{P^2 + Q^2}$</td></tr>
<tr><th colspan="5">DC Machines</th></tr>
<tr><td rowspan="4">DC Generator</td><td rowspan="2">$E = \frac{\emptyset PNZ}{60A}$</td><td>Lap type</td><td colspan="2">Wave type</td></tr>
<tr><td>$E = \frac{\emptyset NZ}{60}$</td><td colspan="2">$E = \frac{\emptyset PNZ}{120}$</td></tr>
<tr><td>Separately-excited</td><td colspan="3">Shunt generator</td></tr>
<tr><td>$V_T = E_g - I_a R_a$</td><td>$V_T = E_g - I_a R_a$</td><td>$I_a = I_L + I_f$</td><td>$I_f = \frac{V_T}{R_f}$</td></tr>
<tr><td colspan="2">$P_L = V_T \times I_L$</td><td>$V.R = \frac{V_{NL} - V_{FL}}{V_{NL}} \times 100\%$</td><td colspan="2">$N_c = \frac{BC}{AC} \times N$</td></tr>
<tr><td rowspan="3">DC Motor</td><td colspan="2">Series Motor</td><td colspan="2">Shunt Motor</td></tr>
<tr><td colspan="2">$V_T = E_b + i_a(R_a + R_f) + V_{brush}$</td><td>$V_T = E_b + i_a R_a$</td><td>$i_L = i_a + i_f$ $V_T = i_f R_f$</td></tr>
<tr><td>$P_{in} = V_T i_L$</td><td>$P_m = E_b i_a$</td><td colspan="2">$P_{out} = P_{in} - \sum P_{loss}$ $P_{out} = P_m - P_\mu$</td></tr>
<tr><td colspan="2">$\tau_m = \left(\frac{60P_m}{2\pi N}\right)$</td><td>$\tau_o = \left(\frac{60P_{out}}{2\pi N}\right)$</td><td colspan="2">$\eta = \left(\frac{P_{out}}{P_{in}}\right) \times 100\%$</td></tr>
<tr><th colspan="5">Three-phase Induction Motor</th></tr>
<tr><td>$N_S = \frac{120f}{P}$</td><td>$f_r = sf$</td><td>$s = \frac{N_s - N_r}{N_s}$</td><td colspan="2">$\frac{E_{1ph}}{E_{2ph}} = \frac{\text{stator turns}}{\text{rotor turns}}$</td></tr>
<tr><td>$\tau_m = \left(\frac{60P_m}{2\pi N_r}\right)$</td><td>$\tau_o = \left(\frac{60P_{out}}{2\pi N_r}\right)$</td><td>$\eta = \left(\frac{P_{out}}{P_{in}}\right) \times 100\%$</td><td colspan="2">$I_{2r} = \frac{sE_{2ph}}{\sqrt{R_2^2 + (sX_2^2)}}$</td></tr>
<tr><td colspan="2">$P_{in(rotor)} = P_{in(stator)} - (P_{scu} + P_c)$</td><td>$P_m = P_{in(rotor)} - P_{rcu}$</td><td colspan="2">$P_{rcu} = 3 \times I_{2r}^2 \times R_2$</td></tr>
<tr><td colspan="2">$P_{in(rotor)} : P_{rcu} : P_m = 1 : s : 1 - s$</td><td>$P_{out} = P_m - P_\mu$</td><td colspan="2">$\eta = \left(\frac{P_{out}}{P_{in}}\right) \times 100\%$</td></tr>
<tr><th colspan="5">Synchronous Generator / Alternator</th></tr>
<tr><td>$f = \frac{PN}{120}$</td><td>$E_A = K\varphi\omega$</td><td colspan="3">$V_\varphi = E_A - I_A(R_A + jX_s)$</td></tr>
<tr><td>$P_{in} = \sqrt{3}V_L I_L \cos\theta$</td><td>$\%\, V.R = \frac{E_{ph} - V_{ph}}{V_{ph}} \times 100\%$</td><td colspan="3">$P_{in} = P_{out} + P_{F\&W} + P_{core}$</td></tr>
<tr><td colspan="5">$(E_{ph})^2 = (V_{ph}\cos\theta + I_a R_a)^2 + (V_{ph}\sin\theta \pm I_a X_s)^2$</td></tr>
</table>