UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACHELOR OF ENGINEERING TECHNOLOGY *ENGINEERING: ELECTRICAL*
SUBJECT	:	**MACHINES 3A**
CODE	:	**EMAELA3**
DATE	:	SUPPLEMENTARY EXAMINATION / JULY 2019
DURATION	:	3 HOURS
WEIGHT	:	40: 60
TOTAL MARKS	:	**100**
FULL MARKS	:	**100**

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MODERATOR	:	Dr. L MASISI
NUMBER OF PAGES	:	5 PAGES

REQUIREMENTS

- STANDARD STATIONARY.
- NO-PROGRAMMABLE CALCULATOR MAY BE USED

INSTRUCTIONS

- READ INSTRUCTIONS CAREFULLY.
- ALL CALCULATIONS AND ANSWERS MUST BE DONE WITH A MINIMUM OF 3 DECIMALS.
- WRITING MUST BE IN BLUE OR BLACK INK PEN ONLY- NO PENCIL WRITING WILL BE MARKED
- WORK NEATLY, UNTIDY WORK MAY BE PENALIZED.
- ALL UNITS MUST BE SHOWN-MARKS WILL BE DEDUCTED FOR NO OR WRONG UNITS
- ALL CALCULATIONS MUST BE DONE IN COMPLEX NOTATION AND ANSWERS MUST BE WRITTEN IN POLAR FORM, WHERE APPLICABLE.

SECTION A
TRANSFORMERS

QUESTION 1 **[8 Marks]**

1.1. A single-phase transformer has 2000 turns on the primary and 800 turns on the secondary. Its no-load current is 5A at a power factor of 0.20 lagging. Assuming the volt drop in the windings is negligible, determine the primary current and power factor when the secondary current is 100A at a power factor of 0.85 lagging**.** **(4)**

1.2. A 220-V/55-V, 50-Hz, single-phase transformer has primary and secondary resistances of 0.25 Ω and 0.01 Ω respectively and the corresponding leakage reactances are 1.0 Ω and 0.04 Ω respectively. Determine the series equivalent parameters referred to:

1.2.1. the high voltage winding **(2)**
1.2.2. the low voltage winding **(2)**

QUESTION 2 **[17 Marks]**

A 300-kVA, 5-kV/0.5-kV, 50-Hz, delta-star, three-phase power transformer gave the following test results:

Open-Circuit test (Low Voltage): 500-V, 3 A, 3.75-kW
Short-Circuit test (High Voltage): 400-V, 34.64 A, 5-kW

2.1. Obtain the branch and series parameters of the equivalent circuit referred to LV side **(6)**
2.2. Compute the per unit resistance and leakage reactance drops **(3)**
2.3. Compute the per unit full-load voltage regulation for 0.8 lagging power factor **(2)**
2.4. Compute the full-load efficiency for 0.8 lagging power factor **(2)**
2.5. Determine the load at which the maximum efficiency occurs. **(2)**
2.6. Compute the maximum efficiency for 0.8 lagging power factor. **(2)**

[25 MARKS]

SECTION B
BRUSH DC MACHINES

QUESTION 3 **[10 marks]**

3.1.A 4-pole brush DC generator has a lap-wound armature with 50 slots with 16 conductors per slot. The useful flux per pole is 30mWb. Determine the speed at which the machine must be driven to generate an e.m.f. of 240-V. **(4)**

3.2.A short-shunt brush DC compound generator supplies 80A at 200-V. If the shunt, series and armature resistances are 40 Ω, 0.02 Ω and 0.04 Ω respectively, determine the e.m.f. generated for 1-V contact drop per brush. **(6)**

QUESTION 4 **[15 marks]**

4.1. The shaft torque of a diesel motor driving a 100-V brush DC shunt-wound generator is 25-Nm. The armature current of the generator is 16 A at this value of torque. Compute the armature current if the shunt field regulator is adjusted so that the flux is reduced by 15%, the torque increases to 35-Nm. **(7)**

4.2. A series motor runs at 800 rpm when the voltage is 400-V and the current is 25 A. The armature resistance is 0.4 Ω and the series field resistance is 0.2 Ω. Design the value of the resistance to be connected in series to reduce the speed to 600 rpm with the same current. **(8)**

[25 MARKS]

SECTION C
INDUCTION MACHINES

QUESTION 5 **[16 Marks]**

5.1. The power supplied to a 4-pole, 50-Hz, start-connected, 0.8 lagging power factor, 380-V, three-phase induction motor is 50-kW and the iron losses are 1-kW. If the slip and phase stator resistance are is 4% and 0.125 Ω respectively, Compute:

5.1.1. The rotor copper loss. **(2)**
5.1.2. The total mechanical power developed by the rotor. **(2)**
5.1.3. The shaft power and torque of the motor if friction and windage losses are 1-kW. **(3)**
5.1.4. The efficiency of the motor, neglecting rotor iron losses. **(2)**

5.2. The tests conducted on a 4-pole, star-connected, 5.5-kW, 1460-rpm, 380-V, 3-phase, 50-Hz, squirrel cage induction motor gave the following results:

No-load test	380-V	5 A	500-W
Locked rotor test (Full load)	120-V	12.8 A	565-W

Determine the equivalent circuit parameters of the motor if the stator resistance per phase is 0.555 Ω. **(7)**

QUESTION 6 **[9 Marks]**

Compute the r.m.s value of the line induced back-e.m.f of a 4-pole, 3-phase, 50-Hz, star-connected three-phase induction motor with 3 slots per pole per phase and 24 conductors per slot in two layers. The coil span is 160 degrees electrical. The flux per pole has a fundamental component of 0.24 Wb, 20 % third component and 15 % fifth component. All the conductors per phase are in series.

[25 MARKS]

SECTION D
SYNCHRONOUS MACHINES

QUESTION 7 **[14 marks]**

7.1. During an open-circuit test on a 2-pole, 10-kVA, 0.4-kV, 50-Hz, three-phase, Star-connected, synchronous generator, a field current of 6 A produced the terminal voltage of 380-V. On short-circuit; the same excitation circulated the full-load current. For an effective armature resistance of 0.45 Ω, determine the percentage voltage regulation for a full-load lagging power factor of 0.8**.** **(4)**

7.2. The input power to the turbine that drives the synchronous generator in **question 7.1** is increased until the power angle doubles, compute:

7.2.1. The new power angle **(4)**
7.2.2. The new output power **(2)**
7.2.3. The new power developed (airgap power) **(2)**
7.2.4. The new torque developed **(2)**

QUESTION 8 **[11 Marks]**

A three-phase, 16-pole, 50-Hz, 50-MVA, 11-kV, salient-pole synchronous motor has a direct- and quadrature-axis synchronous reactance of 0.8 p.u and 0.4 p.u respectively. The synchronous motor is loaded to draw rated current at a lagging power factor of 0.8. The rotational losses are found to be 0.15 p.u. neglecting the armature and field resistance losses, determine:

8.1. The actual value of the induced back e.m.f. **(4)**
8.2. The actual value of the power developed due to the field and due to saliency **(3)**
8.3. The actual value of the shaft power and torque **(4)**

[25 MARKS]

END