UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACHELOR OF ENGINEERING TECHNOLOGY *ENGINEERING: ELECTRICAL*
SUBJECT	:	**MACHINES 3A**
CODE	:	**EMAELA3**
DATE	:	MAIN EXAMINATION / JUNE 2019 31-MAY-2019 - 08 :30
DURATION	:	3 HOURS
WEIGHT	:	40: 60
TOTAL MARKS	:	**100**
FULL MARKS	:	**100**

ASSESSOR	:	Dr. M MUTEBA
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.
- THE END OF SECTION SHOULD BE MARKED WITH A SOLID LINE

SECTION A
TRANSFORMERS

QUESTION 1 **[10 Marks]**

1.1. The magnetic circuit of a single-phase transformer with a cross-sectional area of 15 cm^2 is to operate at 50-Hz from a 220-V r.m.s supply in order to deliver a no-load voltage of 20-V r.m.s. What will be the number of primary and secondary turns to achieve a peak magnetic flux density of 1.8 tesla in the core? **(4)**

1.2. A 3.7-kV/0.22-kV, 50-Hz, single-phase transformer is found to have a no-load current of 2 A and a core loss of 1.2-kW when it is energised at rated voltage on the high voltage side.

1.2.1. With the low voltage side supplying 100 A at a lagging power of 0.8, compute the HV side current and power factor. **(3)**

1.2.2. Draw the phasor diagram for these conditions (Transformer resistances and leakage reactances are neglected). **(3)**

QUESTION 2 **[15 Marks]**

The following data were obtained for a 100-kVA, 6.6-kV/0.4-kV, 50-Hz, delta-star, three-phase distribution transformer.

Open-circuit test (Low Voltage): 400-V, 1.4 A, 1.5-kW
Short-circuit test (High Voltage): 527 V, 8.75 A, 2-kW

2.1. Determine the series parameters of the equivalent circuit referred to HV side **(4)**
2.2. Compute the % resistance and leakage reactance drops **(3)**
2.3. Compute the % full-load voltage regulation for 0.8 leading power factor **(2)**
2.4. Compute the half-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, 25-kW, 125-V, separately excited brush dc machine is operated at constant speed of 3000-rpm with constant field such that the open-circuit (no-load) armature voltage is 125-V. The armature resistance is 0.02 Ω. Compute the armature current, terminal power, and electromagnetic power and torque when the terminal voltage is 124-V. **(7)**

3.2. The brush dc machine in **question 3.1** has an armature lap winding housed in 30 slots. There are 10 conductors in two layers per slot. Determine the peak magnetic flux per pole required to produce the no-load armature voltage of 125-V. **(3)**

QUESTION 4 **[15 Marks]**

4.1. A brush dc series motor runs at 2000-rpm when taking 100 A from 240-V supply. The armature and the series-field resistances are 0.4 Ω and 0.2 Ω respectively. Design the additional resistance required in series with the machine to drop the speed to 1500-rpm if the gross torque is:

4.1.1. Proportional to the speed. **(5)**
4.1.2. Proportional to the square of speed. **(5)**

4.2. A brush permanent magnet dc motor has an armature resistance of 1.8 Ω. When operating at no-load from a dc source of 230-V, it observed to operate at the speed of 1500-rpm and draws a current of 4 A. Compute:

4.2.1. The torque constant **(3)**
4.2.2. The no-load rotational losses of the motor **(2)**

[25 MARKS]

SECTION C
INDUCTION MACHINES

QUESTION 5 **[14 Marks]**

5.1. An 11-kW, 380-V, 1460-rpm, 50-Hz, delta-connected, three-phase, squirrel-cage induction motor having a rated current of 23 A and locked rotor current of 40 A. The parameters of the motor are found in table below.

Stator resistance (Ω)	0.156
Rotor Resistance (Ω)	0.125
Total Leakage Reactance (Ω)	1.2
Magnetizing Reactance (Ω)	18
Core loss resistance (Ω)	144

Compute the breakdown down torque and corresponding speed and current. Assume the no-load losses include the iron, windage and friction losses. **(7)**

5.2. The parameters of a 6-pole, 400-V, 960-rpm, 50-Hz, star-connected, three-phase, squirrel-cage induction motor are found in table below.

Stator resistance (Ω)	1.2
Rotor Resistance (Ω)	0.8
Stator Leakage Reactance (Ω)	2.4
Rotor Leakage Reactance (Ω)	1.5
Magnetizing Reactance (Ω)	22.5

Use the Thevenin-equivalents to compute the:

5.2.1. load component of the stator current **(4)**

5.2.2. electromechanical torque and power for a full-load slip **(3)**

QUESTION 6 **[11 Marks]**

6.1. The tests conducted on a 4-pole, star-connected, 3.5-kW, 1476-rpm, 380-V, 3-phase, 50-Hz, squirrel cage induction motor gave the following results:

No-load test	380-V	3.5 A	350-W
Locked rotor test (Full load)	100-V	8 A	400-W

Determine the equivalent circuit parameters of the motor if the stator resistance per phase is 1.1 Ω. **(7)**

6.2. The stator of a 4-pole, 50-Hz, three-phase, star-connected, induction machine has 36 slots. Each slot accommodates 24 conductors configured in two layers. For a distributed winding, determine the:

6.2.1. number of coils per phase **(1)**

6.2.2. number of turns per phase **(1)**

6.2.3. number of slots per pole per phase **(1)**

6.2.4. slot pitch in electric degree **(1)**

[25 MARKS]

SECTION D
SYNCHRONOUS MACHINES

QUESTION 7 **[17 marks]**

7.1. The following dada were taken from the open-and short-circuit characteristics of a 10-MW 50-Hz, 14-kV (line-line), three-phase, star-connected, six-pole, synchronous generator.

Field current, I_f (A)	150	200
Open-circuit line voltage, E_o (kV)	12.1	14
Short-circuit current I_{sc} (A)	350	412.41
Airgap line voltage, E_a (kV)	16	-

Compute:

7.1.1. The unsaturated value of the synchronous reactance in ohms and per unit **(3)**

7.1.2. The saturated value of the synchronous reactance at rated voltage in ohms and per unit **(3)**

7.1.3. The per unit full-load voltage regulation for a 0.8 lagging power factor **(3)**

7.2. A 1.492-GW, 13.5-kV, unity-power factor, three-phase, star-connected, 30-pole, 50-Hz synchronous motor has a reactance of 37.4 Ω/phase. Neglecting all losses, compute the maximum power and torque which this motor can deliver if it is supplied with power directly from 50-Hz, 13.5-V infinite bus. Assuming that the field excitation is maintained constant at the value which it will result in unity power factor. **(8)**

QUESTION 8 **[8 Marks]**

The direct-and quadrature axis reactances of a salient pole synchronous generator are 0.8 and 0.5 per unit respectively. The armature resistance may be negligible. Compute the generated voltage when the generator delivers its rated kVA at 0.8 lagging power factor and terminal voltage.

[25 MARKS]

END