UNIVERSITY OF JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA *ENGINEERING: ELECTRICAL*
SUBJECT	:	**ELECTRICAL MACHINES III**
CODE	:	**ELM3221**
DATE	:	MAIN EXAMINATION / NOVEMBER 2019 09 NOVEMBER 2019 : 8 :30
DURATION	:	3 HOURS
WEIGHT	:	40: 60
TOTAL MARKS	**:**	**100**
FULL MARKS	:	**100**

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MODERATOR	:	DR. L. MASISI
NUMBER OF PAGES	:	4 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:
THREE-PHASE TRANSFORMERS

QUESTION 1 **[19 Marks]**

The following data pertains to a 500-kVA, 11-kV/0.4-kV, delta-star, and three-phase, 50 Hz, distribution transformer.

Open-circuit (LV)	400 V	10 A	3.2 kW
Short-circuit (HV)	500 V	26.243 A	3.9 kW

Compute;

1.1. The series equivalent parameters as referred to HV side **(4)**
1.2. The % resistance and reactance of the transformer **(4)**
1.3. The % regulation at a power factor of 0.8 lagging **(2)**
1.4. The efficiency at half load for a power factor of 0.8 lagging **(2)**
1.5. The load at maximum efficiency for unity power factor **(3)**
1.6. The % magnetizing current. **(4)**

QUESTION 2 **[10 Marks]**

A 500-kVA, 11-kV/3.3-kV three-phase transformer with an impedance drop of (2+j3) % is connected in parallel with a 1-MVA transformer with an impedance drop of (1+j5) % at full load. They supply a load of 1.5 MVA at a lagging power factor of 0.8. Determine the load current and current supplied by each transformer, as well as the terminal voltage.

[29 Marks]

SECTION B
APPLICATION, PERFORMANCE OF THREE-PHASE INDUCTION MACHINES AND BASICS OF INDUCTION MOTOR CONTROL

QUESTION 3 **[34 marks]**

3.1. A 22 kW , 440 V, 1461 rpm, 50 Hz, three-phase, squirrel-cage induction motor having a rated current of 35.7 A and locked rotor current of 60 A. The parameters of the motor are found in the table below.

Stator resistance (Ω)	0.25
Rotor Resistance (Ω)	0.42
Total Leakage Reactance (Ω)	1.42
Magnetizing Reactance (Ω)	18.3
Core loss resistance (Ω)	146

Compute the breakdown down torque and corresponding speed and current. Assume the no-load losses include the iron losses plus windage and friction. **(8)**

3.2. The tests conducted on a 6-pole, Delta connected, 37.3 kW, 978 rpm, 440 V, 3-phase, 50-Hz, squirrel cage induction motor yielded the following results:

No-load test	440 V	20 A	2750 W
Locked rotor test (Full load)	110 V	62.5A	3070 W

3.2.1. Determine the equivalent circuit parameters of the motor if the resistance per phase is 0.54 Ω. **(10)**

3.2.2. Calculate the power absorbed when the motor is operating a lagging power factor of 0.82; *Hint* (Current drawn by motor is 62.5 A). **(2)**

3.2.3. Compute the electromagnetic power developed by the motor **(2)**

3.2.4. Determine the rotor output mechanical power. **(3)**

3.2.5. Calculate the shaft power and shaft torque when the windage and friction losses are found to be 1.2 kW. **(4)**

3.2.6. Compute the efficiency of the motor on full-load **(2)**

[31 Marks]

SECTION C:

BASIC OF INDUCTION MOTOR CONTROL

QUESTION 4

The speed of a 4-pole, 50-Hz, 550-V, 1420 rpm three-phase induction motor is controlled by means of a Frequency Variable Speed Drive for constant airgap flux density. Using typical torque/speed characteristics, elaborate how the regenerative braking is taking place during operation when the speed has been changed from base speed to half.

[8 Marks]

SECTION D:

SPECIAL MACHINES AND INTRODUCTION TO SYNCHRONOUS MACHINES

QUESTION 5 **[8 marks]**

The main winding of capacitor-start single-phase motor when connected to the power supply, the power factor was 0.4 lagging. The impedance of the auxiliary winding is (24.51+j20.56) Ω. Determine that value of the electrolytic capacitor that would give a 90^{o} phase-shift between the currents of the two windings. Draw the phasor diagram to support your computation. **(8)**

QUESTION 6 **[10 marks]**

A hand-drill is driven by a 230-V, 50-Hz, 200-W, universal motor at the speed of 1800-rpm. The motor takes a current of 0.75-A when connected to a **dc** source. The resistance and inductance measured at the motor terminals are 20 Ω and 0.35 H respectively. If the motor is connected to the above **ac** source, Determine:

6.1. The speed **(5)**
6.2. The torque **(3)**
6.3. The power factor **(2)**

QUESTION 7 **[14 Marks]**

A 16-pole, 50-Hz, 144-slots, three-phase, star-connected, synchronous generator has 10 conductors per slot in two layers. The flux per pole has a fundamental component of 25 mWb and 20 % third component. Coils are short-pitched by 1 slot. Compute the RMS value of the induced (line) e.m.f.

[32 Marks]

END