



**MASINDE MULIRO UNIVERSITY OF
SCIENCE AND TECHNOLOGY
(MMUST)**

MAIN CAMPUS

**UNIVERSITY EXAMINATIONS
2023/2024 ACADEMIC YEAR**

THIRD YEAR FIRST SEMESTER EXAMINATIONS

FOR THE DEGREE OF

**BACHELOR OF SCIENCE
IN**

ELECTRICAL AND COMMUNICATIONS ENGINEERING

COURSE CODE: ECE 313

COURSE TITLE: ELECTRICAL MACHINES II

DATE: THURSDAY 07/12/2023 TIME: 8:00 AM – 10:00 AM

INSTRUCTIONS TO CANDIDATES

ANSWER QUESTION ONE AND ANY OTHER TWO QUESTIONS.
QUESTION ONE CARRIES 30 MARKS AND ALL OTHERS 20 MARKS EACH.

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

This Paper Consists of 4 Printed Pages. Please Turn Over. 

Question One (30 marks)

- (a) Mention four three-phase transformer connections. [2 marks]
- (b) Give three dissimilarities between a three-phase induction motor and a three-phase transformer. [3 marks]
- (c) Mention the conditions necessary for parallel operation of transformers. [4 marks]
- (d) The resistance and stand-still reactance per phase of a 3-phase induction motor is 0.2 ohm and 0.6 ohm respectively. If 100 V per phase is induced in the rotor circuit at start then calculate rotor current and rotor p.f. when:
- i) the rotor is stationary,
 - ii) the rotor is running with a slip of 5%. [4 marks]
- (e) Explain the working principle of a three-phase induction motor. [6 marks]
- (f) A 100 kVA, 3300/200 V, 50 Hz single phase transformer has 40 turns on the secondary, calculate:
- i) the values of primary and secondary currents, [2 marks]
 - ii) the number of primary turns, [1 mark]
 - iii) the maximum value of the flux, [1 mark]
- If the transformer is to be used on a 25 Hz system, calculate.
- iv) the primary voltage, assuming that the flux is increased by 10%, [1 mark]
 - v) the kVA rating of the transformer assuming the current density in the windings to be unaltered. [1 mark]
- (g) A 230V, 50 Hz transformer has 200 primary turns. It draws 5 A at 0.25 p.f lagging at no-load. Determine:
- i) Maximum value of flux in the core, [1 mark]
 - ii) Core loss, [1 mark]
 - iii) Magnetising current, [1 marks]
 - iv) Exciting resistance and reactance of the transformer. [2 marks]

Question Two (20 marks)

- (a) i) Mention two types of rotors used for three-phase induction motors. [1 mark]
- ii) Explain how the direction of rotation of a three-phase induction motor can be reversed. [1 mark]
- (b) Explain why rotor slots of an induction motor are skewed. [2 marks]
- (c) A 3-phase, 10 HP squirrel cage induction motor is wound for 6 poles. When the motor is connected to 230 V, 50 Hz supply, at full-load, it operates at 4% slip. Determine:

- i) speed of rotation of the stator mmf, [1 mark]
 - ii) full-load speed, [1 mark]
 - iii) full-load torque in Newton-metre, [1 mark]
 - iv) frequency of rotor current under this condition, [1 mark]
- (d) A 50 H.P., 3-phase, 6-pole induction motor delivers full load output at 960 rpm at 0.8 p.f. when supplied with 400V, 50Hz supply. Losses due to windage and friction come out to be 2H.P. and stator losses are 2 kW. Find out:
- i) total rotor Cu loss, [3.5 marks]
 - ii) efficiency, [1.5 marks]
 - iii) line current. [1 mark]
- (e) The impedance of the rotor circuit at standstill of a 1000 HP, 3-phase, 16-pole induction motor is $(0.02 + j0.15)$ ohm. It develops full-load torque at 360 rpm what will be:
- i) The ratio of maximum to full load torque, [3 marks]
 - ii) The speed at maximum torque, [2 marks]
 - iii) The rotor resistance to be added to get maximum starting torque. [1 mark]

Question Three (20 marks)

- (a) i) Define polarity of a transformer. [1 mark]
 ii) Mention two types of polarity of a transformer. [1 mark]
- (b) Give two advantages and two disadvantages of Y – Y three-phase transformer connections. [4 marks]
- (c) A three-phase transformer, rated at 1000 kVA, 11/3.3 kV has its primary star-connected and secondary delta connected. The actual resistances per phase of these windings are, primary 0.375Ω , secondary 0.095Ω and the leakage reactances per phase are primary 9.5Ω , secondary 2Ω . Calculate:
- i) the voltage at normal frequency which must be applied to the primary when the secondary terminals are short circuited,
 - ii) the power under these conditions. [7 marks]
- (d) A 120-kVA 6000/400-V, Y/Y three-phase, 50 Hz transformer has an iron loss of 1600 W. The maximum efficiency occurs at $\frac{3}{4}$ full load. Find the efficiencies of the transformer at:
- i) full-load and 0.8 power factor, [3 marks]
 - ii) half-load and unity power factor, [2 marks]
 - iii) the maximum efficiency. [2 marks]

Question Four (20 marks)

- (a) Discuss the major losses in an induction motor. [3 marks]
- (b) i) Draw the torque-slip curve of a three-phase induction motor. [2 marks]
 ii) Consider a slip-ring induction motor whose rotor resistance is increased to 0.2 times the rotor reactance. If the rotor reactance remains constant, explain the effect of this additional resistance and draw the new torque-slip curve. [2 marks]

(c) A 4-pole, 50 Hz, 3-phase induction motor has an efficiency of 85% for useful output power at the shaft of 17 kW. For this load the total stator losses are 900 W and the windage and friction losses are 1100 W. Calculate the:

- i) slip, [3 marks]
- ii) torque developed by the rotor, [3 marks]
- iii) torque available at the rotor shaft. [1 mark]

(d) A no-load test was performed on a 400 V, 3-phase delta-connected induction motor and the results obtained were: 400 V; 2.5 A; 600 W. Assuming that stator winding resistance per phase is 5 ohm and friction and winding losses are 180 W, determine:

- i) the no-load power factor, [2.5 marks]
- ii) the working component and magnetising component of no-load current, [1.5 marks]
- iii) the exciting resistance and reactance per phase referred to stator side, [2 marks]

Question Five (20 marks)

- a) Mention the conditions necessary for parallel operation of transformers. [4 marks]
- b) A 33 kVA, 2200/220V, 50Hz single phase transformer has the following parameters. Primary winding resistance $r_1 = 2.4 \Omega$, leakage reactance $x_1 = 6 \Omega$, secondary winding resistance $r_2 = 0.03 \Omega$, leakage reactance $x_2 = 0.07 \Omega$. Find the equivalent resistance and reactance when:
 - i) referred to primary,
 - ii) referred to secondary. [4 marks]
- c) The primary and secondary of a 25 kVA single-phase transformer has 500 and 40 turns, respectively. If the primary is connected to 3000 V, 50 Hz mains, calculate:
 - i) primary and secondary currents at full load,
 - ii) the secondary emf,
 - iii) the maximum flux in the core. (Neglect magnetic leakage, resistance of the winding and the primary no-load current in relation to the full load current) [4 marks]
- d) The iron losses of a 400 V, 50 Hz single phase transformer are 2500 W. These losses are reduced to 850 W when the applied voltage is reduced to 200 V, 25 Hz. Determine the eddy current loss at normal frequency and voltage. [4 marks]
- e) A 230/110 V single-phase transformer has a core loss of 100 W. If the input under no-load condition is 400 VA, find:
 - i) core loss current, [1 mark]
 - ii) magnetising current, [1.5 marks]
 - iii) no-load power factor angle. [1.5 marks]