MACHAKOS UNIVERSITY

University Examinations for 2024/2025 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FIFTH YEAR FIRST SEMESTER EXAMINATION FOR DEGREE IN BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING

EEE 538: ELECTRICAL MACHINE DESIGN

DATE: 20TH JANUARY 2025 **TIME: 11.00 AM - 1.00 PM**

INSTRUCTIONS:

- *This Paper Consists of FIVE Questions.*
- *Question **ONE** is **Compulsory.***
- *Attempt **ANY OTHER TWO** of the remaining **FOUR** Questions*

QUESTION 1 (30 Marks): COMPLUSORY

a) State and explain Five factors that should be considered in the Design of Electrical Machines (5marks)

b) State and explain Five constraining factors in the Design of Electrical Machines (6marks)

c) Discuss Four merits of Computer Aided Design of Electrical Machines (4marks)

d) Discuss the Five Steps involved in Computer Aided Design (CAD) of Electrical Machines (5marks)

e) Draw the Flow Chart for the Computer Aided Design (CAD) of a General Electrical Machine (6marks)

f) Discuss the recent trends in the Computer Aided Design (CAD) of Electrical Machines (4marks)

QUESTION 2 (20 Marks)

a) Give the main expressions for the Design of the Field Windings of a DC Machines. Explain all the Symbols used (4marks)

b) 6A rectangular field coil is to supply 7000 ampere turns when dissipating 200W at a temperature of $60℃$. The inner diameter of the coil is 20cm x 12cm. The height of the coil is 12cm. The heat dissipation is not to exceed $0.005W/℃\cdot rise\ in\ temperature/cm^2$ of the outside surface, neglecting top & bottom of the coil. Temperature of the ambient air may be taken as $25℃$. Determine the following

   i) Depth of the Coil (2marks)
   ii) Lenth Mean of Turn (2marks)
   iii) Current Density (2marks)
   iv) Space Factor (2marks)

c) The field coil of a 6 pole, 440V, DC shunt generator is to supply 4000 ampere turns. The length of inside turn is 74cm. The length available for the winding is 13cm. The space factor of the winding is 0.52, permissible dissipation of external surface excluding the ends is $0.12W/cm^2$, voltage drop across the regulator being 20% and the resistivity is assumed to be $2.1x10^{-6}\Omega - cm.$ Determine the following:

   i) Depth of the Coil (6marks)
   ii) Size of the conductor (1mark)
   iii) Number of turns of the coil (1mark)

Hint: Solution should not be attempted by assuming a value for the depth of the winding

QUESTION 3 (20 Marks)

A manufacturer catalogue has the B-H Curve for the magnetic circuit of a 440V, 6 pole, 3-phase Y-connected 50HZ induction motor shown in Table Q 3.1. Further, the machine has the particulars shown in Table Q 3.2. *Required: The magnetization current for the machine internal circuit* (20marks)

Table Q 3.1						
$B(T)$	0.5	0.7	1.0	1.2	1.4	1.6
$H(AT/m)$	95	110	200	300	600	2500

Table Q 3.2	
Particular	Value
Core length	0.15m
Stator teeth length	30mm
Stator Tooth width at 1/3 height from the narrow end	7mm
Rotor Tooth width at 1/3 height from the narrow end	10.5mm
Rotor teeth length	15mm
Stator bore diameter	0.4m
Effective airgap length	0.9mm
Stator and Rotor core depth	6.5mm
Mean 60° length of magnetic circuit per pole pair in stator	0.25m
Mean 60° length of magnetic circuit per pole pair in Rotor	0.16m

Number of stator slots	72
Conductors per stator slot	8
Rotor slots	49
Stacking factor	0.9

QUESTION 4 (20 Marks)

a) Define the following terms with respect to Transformer Design

i) Series Resistance (4 marks)

ii) Series Reactance (4marks)

iii) Voltage Regulation (1mark)

b) A 300 kVA, 6600/400V, delta-star connected core type transformer has the data shown in Table Q 4b). From first principles, determine the following at $0.8\ pf$ lag and full load

i) Equivalent series impedance referred to the primary side (9marks)

ii) Percentage voltage regulation (2marks)

Table Q 4b)			
Winding	Diameter (cm)		Conductor cross-sectional area (mm^2)
	Inside	Outside	
H.V	29.5	36	5.4
L.V	22	26.5	70
$Length\ of\ coils\ = 50cm, Volt/turn = 8, Resistivity\ = \frac{0.021\Omega}{m}/mm^2)$			

QUESTION 5 (20 Marks)

a) Derive the Output Equation of a Three Phase Synchronous Machine, clearly defining the Specific Magnetic Loading and Electric Loading Expressions (5 marks)

b) State the merits and demerits of having the following in the design of any the machine in a) above

i) High Specific Magnetic Loading (4marks)

ii) High Specific Magnetic Loading (4marks)

c) A 1000KVA, 3300V, 50 Hz, 300 rpm, 3 phase alternator has 180 slots with 5 conductors per slot. Single layer winding with full pitched coils is used. The winding is star connected with one circuit per phase. If the stator bore is 2m and core length is 0.4m, determine the following:

i) Specific Electric Loading (3marks)

ii) Specific Magnetic Loading (3marks)

iii) Peripheral Speed (1mark)