MACHAKOS UNIVERSITY

University Examinations for 2019/2020Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EEE 538: ELECTRICAL MACHINE DESIGN

DATE: 19/10/2020 **TIME: 8.30-10.30 AM**

INSTRUCTIONS

Answer Question One and Any Other Two Questions

QUESTION ONE (30 MARKS): COMPLUSORY

a) A 20 Hp, 4 pole, 250V, 1000 rpm wave wound D.C. machine has the design data shown in Table Q 1a).

Table Q 1a)	
Parameter	**Value**
Diameter of the armature	25 cm
Number of slots	41
Number of coil sides / slot	4
Turns / coil	2

Determine the following

i. Number of segments (1 mark)

ii. Outside width of one segment and mica (2 marks)

iii. Length of the commutator (2.5 marks)

iv. Brush contact loss (1 mark)

b) A $350kVA, 3\,phase, 50Hz, Y-\Delta, 11000\,/\,3300\,V$ core type distribution transformer is to be designed. Assume distance between core centres is twice the width of the core, a three-stepped core and natural cooling. Design the transformer by determining the following:

i. Net core area (2 marks)

ii. Core diameter and length of stampings (2 marks)

iii. Yoke height (1 mark)

iv. Widow dimensions (3 marks)

v. Main (overall) dimensions (2.5 marks)

c) A 15 kW 440V, 4 pole, 50 Hz, 3 phase induction motor is built with a stator bore of 0.25 m and a core length of 0.16 m. The specific electric loading is 23000 ac/m.

i. Output coefficient of the machine (2 marks)

ii. Specific magnetic loading (1 mark)

iii. Pole pitch and length-pitch ratio (1 mark)

Using the data of the machine above, determine the following for a $11kW, 460V, 6\,pole, 50\,Hz$ motor. Assume full load efficiency of 84 %, power factor of 0.82 and a winding factor of 0.955

i. Core dimensions (3 marks)

ii. Number of slots (2 marks)

iii. Flux per pole (1 mark)

iv. Number of stator conductors (3 marks)

QUESTION TWO (20 MARKS)

A $150Hp$, $500V$, $6pole$, $450rpm$, dc shunt motor has the design data shown in Table Q.2

Table Q.2

Armature diameter	54cm
Average flux density in the air gap	0.55T
Width of each duct	1.0cm
Length of armature core	24.5cm
Stacking factor	0.92
Number of ducts	2
Efficiency	90%

Current density per conductor	$5A/mm^2$
ψ per unit enclosure	0.7
Slots per pole	9
Insulation thickness on conductor	0.075mm
Insulation over the coil side	1.5mm
Height of the auxiliaries	10mm
Lap progressive winding , round conductors	
Maximum Flux density in the tooth at one third height from the root	2.1T

Design the DC machine by providing the following:

a) Armature current (2 marks)

b) Actual number of slots (3 marks)

c) Actual number of conductors (3 marks)

d) Back and Front Pitch (2 marks)

e) Cross sectional diameter of each conductor (2 marks)

f) A sketch of proportionate conductor arrangements in the slot (2 marks)

g) Slot dimensions (2 marks)

h) Average flux density in the tooth (3 marks)

i) Maximum flux density at the tooth area (1 mark)

QUESTION THREE (20 MARKS)

The information in Table Q.3 has been obtained during the preliminary design of a 3 phase 500 kVA, 6.6 kV, 12 pole, 500 rpm, star connected salient pole alternator.

Table Q.3	
Parameter	**Value**
Stator diameter	1.3 m
Gross length of stator	0.21m
Air gap flux per pole	0.0404 Wb
SCR	1.1
Carters coefficient for air gap and leakage factor of the pole	1.15
Axial length is 1cm less than that of gross stator length	

Based on the above information, design the field system of the alternator by giving the following details. State and explain clearly the assumptions made in the design.

a) Length of the air gap (9 marks)

b) Diameter of the rotor at the air gap surface. Verify using the Peripheral Velocity (2 marks)

c) Dimensions of the pole (9 marks)

QUESTION FOUR (20 MARKS)

a) Derive the Output Equation for a Single Phase Core Type Transformer (3 marks)

b) State the expressions for overall dimensions of a stepped core (2.5marks)

c) A 125 kVA, 6600 / 460V, 50Hz, single phase core type distribution transformer has the parameters shown in Table Q 4.

Table Q 4	
Parameter	**Value**
Maximum flux density in the core	1.2T
Current density	$250\ A/\ cm^2$
Cruciform core allowing 10% for the insulation between laminations	
Yoke cross-section is 15% greater than that of the core	
Window height	3 times window width
Net cross-section of copper in the window	0.23 times the net cross-section of iron in the core
Window space factor	0.3

Determine the following

i. Net iron area of the core (3 marks)

ii. Core diameter (1 mark)

iii. Yoke dimensions (2 marks)

iv. Dimensions of the Transformer Window (2 marks)

v. Main dimensions of the Core (1.5 marks)

vi. Draw a neat sketch to a suitable scale (2 marks)

vii. Number of turns and cross-sectional area of conductors of primary and secondary (3 marks)

QUESTION FIVE (20 MARKS)

During the stator design of a 3 phase, 30 kW, 400V, 6 pole, 50Hz, squirrel cage induction motor, the data in Table Q.5 has been obtained.

Table Q.5

Parameter	**Value**
Gross length of the stator	0.17 m
Internal diameter of stator	0.33 m
Number of stator slots	45
Number of conductors per slot	12
Efficiency	0.88
Power factor	0.86
K_{ws}	0.955
Current density	$6\ A/mm^2$

Based on the above design data, you are required to design a suitable rotor by determining the following: (State and explain clearly the assumptions made in the design)

a) Diameter of the Rotor (1.5 marks)

b) Number of Rotor Slots (6 marks)

c) Rotor Slot Pitch (1 mark)

d) Copper Losses in the Rotor (6 marks)

e) Copper Loss in the End Rings (4 marks)

f) Equivalent Rotor Resistance (1.5 marks)