MACHAKOS UNIVERSITY

University Examinations for 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FIFTH YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 538: ELECTRICAL MACHINE DESIGN

DATE: **TIME:**

INSTRUCTIONS

- *This Paper Consists of* ***FIVE*** *Questions*
- *Question* ***ONE*** *is* ***Compulsory.*** *Attempt* ***ANY OTHER TWO*** *of the remaining* ***FOUR*** *Questions*
- *Candidates are reminded to read and follow the instructions on the Answer Booklet to the latter*

QUESTION ONE (COMPULSORY) (30 MARKS)

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)	
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

(ii) Outside width of one segment and mica

(iii) Length of the commutator

(iv) Brush contact loss **[7marks]**

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. Determine the main dimensions of the transformer [7 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. Using the data of this machine, determine the core dimensions, number of slots and number of stator conductors for a 11kW, 460 volts, 6 pole, 50 Hz motor. Assume full load efficiency of 84 % , power factor of 0.82 and a winding factor of 0.955 [7 marks]

d) A 3 phase, 10 pole, 50 Hz, salient pole alternator is designed based on the design information in Table Q 1 d).

Table Q 1 d)	
Diameter of the stator	1.2 m
Gross length of the stator	0.5 m
Section of the pole body	0.18 m x 0.6 m
Height of the pole	0.25 m
Ampere turns per pole	8500
Exciter voltage	120 V

Determine the full design of the field coil [9 marks]

QUESTION TWO (20 MARKS)

A 600kW, 500V 900rpm dc generator has the following specifications: *Average flux density= 0.6T,Ampere-conductors per meter=35000,Ratio of pole arc to pole pitch= 0.67,Efficiency=91%,Peripheral velocity should not exceed 40m/s ,Armature mmf per pole should be below 7500A,Current per brush arm should not exceed 400A,frequency of flux reversal should not exceed 50Hz,the mmf required for the air gap is 50% of the armature mmf and the air gap contraction factor is 1.15.* Explain all the assumptions made clearly and subjecting your results to design checks where possible, determine the following

a) The number of poles **[4 marks]**
b) D and L**[4 marks]**
c) Number of slots **[4 marks]**

d) Number of armature conductors **[4 marks]**

e) Air gap length **[4 marks]**

QUESTION 3 (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	
Stator diameter	1.3 m
Gross length of stator	0.21m
Air gap flux per pole	0.0404 Wb

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 4 (20 Marks)

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

Table Q 4	
Maximum flux density in the core	1.2T
Current density	$250\ A/\ cm^2$
Cruciform core allowing 8% 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

a) Yoke dimensions

b) Dimensions of the Transformer Window

c) Main dimensions of the Core

d) Number of turns and cross-sectional area of conductors of primary and secondary

e) Draw a neat sketch to a suitable scale **[20 Marks]**

QUESTION 5 (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

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

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 **[1mark]**
b) Number of Rotor Slots **[4marks]**
c) Rotor Slot Pitch **[1mark]**
d) Copper Losses in the Rotor **[7marks]**
e) Copper Loss in the End Rings **[5marks]**
f) Equivalent Rotor Resistance **[2marks]**