MACHAKOS UNIVERSITY

University Examination 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 538: ELECTRICAL MACHINE DESIGN

DATE: 13/5/2019 **TIME: 8.30-10.30 AM**

INSTRUCTIONS

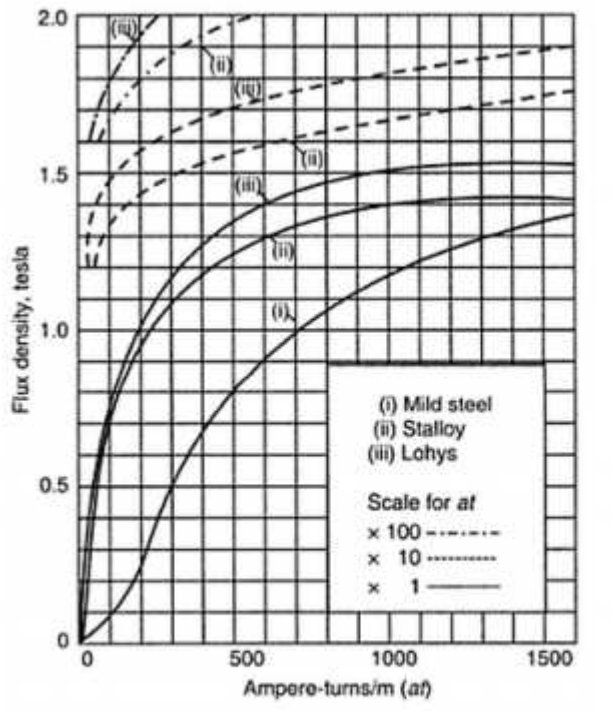
Answer Question ONE and any other TWO Questions.

QUESTION ONE (30 MARKS): COMPLUSORY

While designing the stator of a 3 phase 10 kW, 400V, 50 Hz, 4 pole, delta-star connected, *Wound Rotor Induction Motor,* the data in Table Q 1 is obtained.

Table Q 1	
Internal diameter of stator	0.19 m
Gross length	0.125 m
Number of stator slots	36
Number of conductors/slot	38
Dimension of stator slot	1.1 cm x 3.5 cm
Depth of the stator core	3 cm
Number of rotor slots	30
Dimension of the rotor slot	0.7 cm x 3.0 cm
Depth of rotor core	3.0 cm
Carter's coefficient for the air gap	1.33
Power loss per Kg at the tooth	23W/Kg
Power loss per Kg at the stator core	17W/Kg
Winding Factor	0.955
Density	$7.8x10^3 kg/m^3$
Duct width (single)	1cm

The B-H Curve for the various materials are as shown in Figure Q.1



Flux Density (Tesla) vs. (Amp-turns/m) for (i) Mild Steel, (ii) Stalloy and (iii) Lohys

Figure Q .1

Based on the above data, determine the following performance details for this motor

a) Flux per pole (2 marks)

b) Iron losses (8.5 marks)

c) Active component of no load current (1.5 marks)

d) Magnetizing current (16.5 marks)

e) No load current and power factor (1.5 marks)

QUESTION TWO (20 MARKS)

a) Explain the desirable properties of a *Good Insulator* (2.5 marks)

b) No insulating material in practice satisfies all the desirable properties. Therefore materials which satisfy most of the desirable properties must be selected. Based on the temperature withstanding ability, the insulating materials have been classified as indicated below according to *ISI (now BIS) – 1271, 1985, First Revision*. Discuss this classifications (5 marks)

c) Explain the Properties of a *Good Magnetic Material* in the Manufacture of a Electrical Machine (2 marks)

d) Giving examples, explain the difference between *Hard and Soft Magnetic* Materials (2 marks)

e) Discuss the factors for consideration in electrical machine design and the additional factors which lead to an Optimal Design. Hence or otherwise, explain the parameters that pose a limitation in the design process (6.5 marks)

f) Explain the properties of a *Good Conducting Material* for Electrical Machine (2 marks)

QUESTION THREE (20 MARKS)

A $150Hp$, $500V$, $6pole$, $450rpm$, dc shunt motor has the design data shown in Table Q.3

Table Q.3	
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 FOUR (20 MARKS)

a) A 1000 kVA, 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. Determine the Specific Electric and Magnetic Loading if the stator bore is 2 m and core length is 0.4 m (10 marks)

b) Using the same Specific Electric and Magnetic Loadings in 4a) above, determine the diameter(D), length(L) and the actual turns per phase(T_{ph}) for a 1250 kVA, 3300V, 50 Hz, 250 rpm, 3 phase star connected alternator having 2 circuits per phase. The machines have 600 phase spread (10 marks)

QUESTION FIVE (20 MARKS)

A three phase, 350KVA, 11/3.3KV, delta-star, 50Hz, three-leg, ON cooled, core type transformer has the design data shown in Table Q.5

Table Q.5

Net core cross section	$A_i = 0.6d^2$
Window space factor	0.27
Window proportion	3:1
Current density	$250A/cm^2$
Volt/turn	11
Peak flux density	1.25T
Tapping	$\pm 2.5\%$ and $\pm 5.0\%$ on H.V windings

You are required to design the transformer by providing the following:

a) The value of the core stampings (3.5 marks)

b) Transformer yoke height (1 mark)

c) Window dimensions (4.5 marks)

d) Transformer dimensions (3 marks)

e) Number of turns with rated voltage (1 mark)

f) The tappings position (2 marks)

g) The cross-sectional area of primary and secondary winding conductors (2 marks)

h) A Labeled sketch of the *Core* and *Leg &Yoke* sections (3 marks)