



TECHNICAL UNIVERSITY OF MOMBASA

**FACULTY OF ENGINEERING AND TECHNOLOGY
ELECTRICAL AND ELECTRONICS ENGINEERING**

UNIVERSITY EXAMINATION FOR:

DEGREE

EEE 4505: ELECTRICAL MACHINE DESIGN

END OF SEMESTER EXAMINATION

SERIES: MAY 2025

TIME: 2 HOURS

DATE:

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of FIVE questions. Attempt Question 1, Compulsory and any other Two Questions.

Do not write on the question paper.

Question ONE

- a) List and explain six (6) factors considered in the design of electrical of machine and apparatus **[6 MARKS]**
- b) Explain one (1) similarity and two differences between a motor and a generator **[5 MARKS].**
- c) Briefly explain three electrical machines and their characteristics. **[3 MARKS]**
- d) Determine the number of poles, armature diameter and core length for the preliminary design of a 500kW,400V,600RPM, DC shunt generator assuming an average flux

density in the air gap of 0.7T and specific electric loading of 38400 ampere-conductors per metre. Assume core length/pole arc=1.1. **[8 MARKS]**

- e) A 20HP, 4 pole, 250V, 1000rpm wave wound DC machine has the following design data. Diameter of armature =25cm, number of slots=41, number of coil sides/slot=4 turns, turns/coil=2. Calculate the number of segments, outside width of one segment and mica, brush thickness, length of the commutator and brush contact loss

[8 MARKS]

Question TWO

- a) Show that the rating of an electrical machine is proportional to the specific magnetic loading, specific electric loading dimensions of the machine and the speed of the machine. **[6 MARKS]**
- b) Find the main dimensions D and L of a three phase induction machine with the following data: 20hP, 415V, 50Hz, 4 pole, efficiency of 85%, power factor of 0.85 lagging and a winding factor of 0.95 **[5 MARKS]**
- c) A 250kW, 500V, 6 pole, 600rpm DC generator is built with an armature of 0.75m and core length of 0.3m. The lap connected armature has 720 conductors. Using data obtained from this machine, determine the armature diameter, core length, number of armature slots, armature segments for a 350kW, 440V, 720RPM, 6 pole DC generator. **[9 MARKS]**

Question THREE

- a) Explain the differences between power transformer and a distribution transformer **[3 MARKS]**
- b) Explain five (5) types of cooling systems **[5 MARKS]**
- c) Show that for a fan supplying air flow at a pressure p , N/m^2 with an efficiency of η , the power required to provide this quantity of air is given by Equation below

[4 MARKS]

$$P_{fan} = \frac{pQ}{\eta \cdot 10^3} kW$$

- d) Calculate the volume of cooling air in cubic metres/sec required to carry off the losses in a 10MW generator having an efficiency of 97.5%. The inlet and outlet temperature of air maybe taken at 15°C and 35°C. Barometer 750mm. Find the power required to drive the fan to provide this circulation of air at pressure 1000N/m² assuming an efficiency of 30%. **[6 MARKS]**

Question FOUR

- a) Using the net cross-sectional area and the correct parametric variables in the design of a transformer derive the expression of the kVA rating of a single and three phase transformer on load **[5 MARKS]**
- b) At the beginning of loading of a transformer its temperature is 25°C. After two hours of running on full load it is 55°C and after four hours run it is 70°C **[6 MARKS]**.
- i. Calculate the maximum final temperature rise with full load on the transformer.
- ii. Find the heating time constant
- iii. How much time will it take after start for the transformer to reach $\frac{5}{6}^{th}$ of its final steady state temperature rise?
- c) Derive the volt/turn equation of a transformer **[3 MARKS]**
- d) Determine the main dimensions of the core , number of turns and crosssectional area of conductors of primary and secondary of a 125kVA,6600/460V, 50Hz, single phase core type distribution transformer. The maximum flux density in the core is 1.2T, current density 250A/cm². Assume a cruciform core allowing 8% for the insulation between laminations. Yoke cross-section at 15% greater than that of core, window height = 3 times window core, window space factor =0.3 **[6 MARKS]**

Question FIVE

- a) Using a well labelled diagram explain the principle of temperature rise due to thermal action **[4 MARKS]**
- b) Using a well labelled diagram and appropriate equations derive the output equation of DC machine **[4 MARKS]**

- c) Using approximate equations and diagrams explain any six (6) main factors considered in the design of machines regarding the number of poles **[12MARKS]**