MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

SECOND YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 214: ELECTRICAL ENGINEERING 11

DATE: 26/9/2019 **TIME: 8.30-10.30 AM**

INSTRUCTIONS:

Answer question 1 (compulsory) and any other TWO questions

QUESTION 1 (Compulsory)

a) An Electromechanical System is as shown in Figure Q 1 a).The system is assumed to be a magnetically linear Electromechanical System. Explaining all the symbols used, derive the Torque expression for the system using the Energy-Approach (6.5 marks)

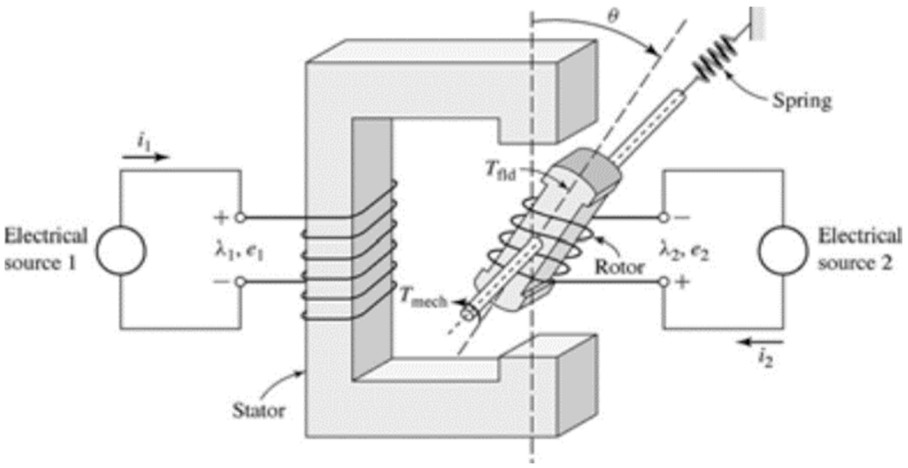

Figure Q.1a)

b) Beginning with a circuit diagram and a derivation, explain the methods of Speed Control of a Short Compound Motor (2.5 marks)

c) Derive and Explain the *Need of a Starter* in Electrical Machines (2.5 marks)

d) Beginning from a well labelled Circuit diagram, derive and sketch the Torque-Speed Relationship of a DC Series Motor (2.5 marks)

e) From the first principles show that

$$\frac{E_s}{E_P} = \frac{N_s}{N_P} = \frac{V_s}{V_P}$$

Explain all the symbols used (4 marks)

f) Distinguish between Up and Down Voltage Regulation (2 marks)

g) State the Information that must be contained in the Transformer Nameplate (2 marks)

h) State five methods of Speed Control of an Induction Motor (2.5 marks)

i) With the help aid of circuit diagrams, explain the three tests that can be carried out on an Induction Motor, clearly stating the parameters being determined in each case (5.5 marks)

QUESTION 2

a) State and Explain the three categories of Electro Mechanical Conversion Devices (EMCDs), giving examples of each (4.5 marks)

b) Using a diagram, explain the Electro Mechanical System Model(EMSM) (3.5 marks)

c) Beginning from a circuit diagram of a *Singly Excited Lossless Linear Electromagnetic System*, derive the expressions for the *Force* on the moving part using *Energy* and *Co-Energy* approaches. (6 marks)

d) The $\lambda - i$ relationship for an electromagnetic system in 7 c) above is given by $i = \left(\frac{\lambda g}{0.09}\right)^2$,which is valid for the limits $0A < i < 4A$ and $3cm < g < 10cm$ .For a current $i = 3A$ and a gap length $g = 5cm$,determine the mechanical force on the moving part using both the *Energy* and *Co-Energy* of the field. (6 marks)

QUESTION 3

a) From the first principles derive the Induced *EMF* and *Induced Torque Equations* of a DC Machine. Explain all the symbols used. (6 marks)

b) With the help of a circuit diagram and equations, explain the operation of a DC shunt Motor (4 marks)

c) A 4-pole, 240V, wave-connected shunt motor gives 11.19KW when running at 1000rpm and drawing armature and field currents of 50A and 1.0A respectively. It has 540 conductors and its armature resistance is 0.1Ω .Assuming a voltage drop of 1V per brush, determine the

i. Armature torque (3 marks)

ii. Useful torque (1 mark)

iii. Useful flux per pole (2 marks)

iv. Rotational losses (2 marks)

v. Efficiency (2 marks)

QUESTION 4

a) Define the following terms as used in the study of Transformers

(i) Power Efficiency

(ii) Constant Losses

(iii) Variable Losses (3 marks)

b) Derive the condition of *Maximum Power Efficiency* of a transformer, hence state the expression of maximum power efficiency and Maximum KVA (4 marks)

c) Using Circuit Diagrams and Equations, discuss Open Circuit Test (OCC) and Short Circuit Test (SCC) as applied in the determination of Transformer Losses (6 marks)

d) A 10KVA,2500/250V ,single phase transformer gave the following results

Open Circuit Test	250V,0.8A,50W
Short Circuit Test	60V,3A,45W

Determine

(i) Variable Losses at full load (2 marks)

(ii) The power efficiency at full load and 0.8 power factor (2 marks)

(iii)The load (KVA Output) at which maximum efficiency occurs and the value of maximum power efficiency at 0.8pf (3 marks)

QUESTION 5

a) From the first principles, derive the equivalent circuit of an Induction Machine. Define all the symbols used (8 marks)

b) The power input to a 500V, 50Hz, 6pole, three phase induction motor running at 975rpm is 40KW.The stator losses are 1KW. Determine the following

(i) Synchronous Speed

(ii) Slip

(iii) Rotor copper losses

(iv) BHP

(v) Efficiency (5 marks)

c) An induction motor is rated as 5KW at 1440rpm, 50Hz, 400V line to line. The rotational losses due to friction and the internal windings are 279W. If the maximum torque is found at 900rpm, determine the maximum toque developed (7 marks)