



# KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS  
2019/2020 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER  
SPECIAL/SUPPLEMENTARY EXAMINATIONS  
FOR THE DEGREE OF BSC RENEWABLE ENERGY AND BIOFUELS

**COURSE CODE:** SUT 362

**COURSE TITLE:** INSTRUMENTATION AND AUTOMATION

**DURATION:** 2 HOURS

**DATE:** 4/2/21

**TIME:** 2 - 4 pm

## INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.
- Indicate **answered questions** on the front cover.
- Start every question on a new page and make sure question's number is written on each page.

This paper consists of 3 printed pages. Please Turn Over 

KIBU observes ZERO tolerance to examination cheating

### Question One.

a) Define the following terms as applied in measuring instruments

- i) Deflecting force
- ii) Controlling force
- iii) Damping force

(3 marks)

b) A PMMC instrument with a coil resistance of  $100\Omega$  and gives a full scale deflecting (FSD) current of  $300\mu A$  is to be used in voltmeter circuit as shown in fig 1. The voltmeter ranges are to be  $100V$ ,  $150V$  and  $200V$ . Determine the required value of resistances for each range

(4 marks)

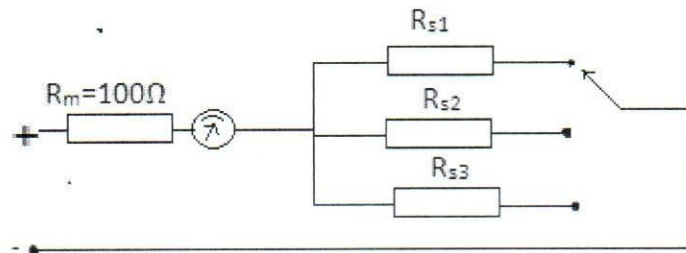


Fig 1

c) Calculate the maximum velocity of the beam of electrons in a CRT having anode voltage of  $800V$ . Assume that the electrons to leave the anode with zero velocity. Charge of electron =  $1.6 \times 10^{-19}C$  and mass of electron =  $9.1 \times 10^{-31}kg$ .

(3 marks)

d) In an electrodynamic instrument the total resistance of the voltage coil circuit is  $6200\Omega$  and the mutual inductance changes uniformly from  $-172\mu H$  at zero deflection to  $+174\mu H$  at full scale. The angle of full scale being  $95^\circ$ . If a potential difference of  $150V$  is applied across the voltage circuit and a current of  $4A$  at a power factor of  $0.75$  is passed through the current coil, what will be the deflection? Spring constant of the instrument is  $4.63 \times 10^{-6}N\cdot m/rad$ .

(4 marks)

e) State any **THREE** advantages of using an electronic instruments over convectional ones (analog)

(3 marks)

f) With the aid of a suitable diagram explain working principle of a potentiometric type recorder

(3 marks)

g) Define the following terms as applied in control system stability

- i) Bode plots
- ii) Nyquist plots
- iii) Polar plots

(3 marks)

h) With use of a well labeled diagram and mathematical expressions describe the working principle of DC motor

(4 marks)

i) State **THREE** basic requirements of a sensors and transducers

(3 marks)

### Question Two

a) The meter constant of  $200V, 12A$  energy meter is  $2000$  revolutions per kWh. The meter is tested at quarter load at rated voltage and unity power factor. The meter is found to make  $34$  revolutions in  $110$  seconds. Determine the meter error at quarter load.

(4 marks)



- b) Draw a well labeled diagram and explain using mathematical expressions the working principle of a moving iron instrument (8 marks)
- c) With aid of a suitable diagrams explain the construction and derive the expression for the power measurement by electro-dynamometer type wattmeter (8 marks)

**Question Three.**

- a) State THREE advantages of using potentiometric recorder in recording and control of process temperatures (3 marks)
- b) Draw the block diagram and explain the main components of an X-Y recorder (5 marks)
- c) With aid of a block diagram describe the principle of operation of a dual slope integrating digital voltmeter (DVM) (6 marks)
- d) Draw a well labelled block diagram of heterodyne spectrum wave analyser and explain the theory of operation (6 marks)

**Question Four.**

- a) Derive the expression of torque of a separately excited direct current (DC) motor and sketch its torque-speed characteristics curve (6 marks)
- b) With aid of a block diagram explain the construction and principle of operation of a cathode ray oscilloscope (6 marks)
- c) A series-connected DC motor has an armature resistance of  $0.5\Omega$  and field winding resistance of  $1.5\Omega$ . In driving a certain load at 1200 rpm, the current drawn by the motor is 20A from a voltage source of  $V_T = 220V$ . The rotational loss is 150W. Find the output power and efficiency (4 marks)
- d) Show that the gauge factor of strain gauge transducer is given by

$$G_f = 1 + 2\nu + \frac{\Delta\rho/\rho}{\epsilon}$$

where  $\nu$  is the Poisson's constant,  $\rho$  is the resistivity  $\epsilon$  is the strain (4 marks)

**Question Five.**

- a) State THREE important features of a feedback closed system (3 marks)
- b) Draw the bode plot of the following transfer function (6 marks)

$$G(s) = \frac{5(S+10)}{(S-0.2)(S+100)}$$

- c) Plot the polar plot for the transfer function (5 marks)

$$G(s) = \frac{2}{s(S+1)(S+2)}$$

- d) With aid of a block diagram describe how a room temperature control system can be physically realized. (6 marks)