



MACHAKOS UNIVERSITY

University Examinations for 2021/2022

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

THIRD YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 313: INSTRUMENTATION AND MEASUREMENT SYSTEMS

DATE: 17/3/2022

TIME: 2.00-4.00 PM

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **FIVE** questions. Question **ONE** is **compulsory**. Attempt any other **two** questions.

Do not write on the question paper.

QUESTION ONE (COMPULSORY)

- a) State the three classes of systematic errors. (3 marks)
- b) With an aid of a diagram, describe the operation of electric tachometer as used in measuring speed of a rotating shaft. (10 marks)
- c) Draw a potentiometric A/D converter hence describe it's operation. (9 marks)
- d) The output of LVDT transducer is connected to a 20volts voltmeter through an amplifier whose amplification factor is 100. An output of 4mvolts appears across the terminals of the LVDT when the plugger moves through 0.8mm. the voltmeter has 50 divisions and scale reads $\frac{1}{10}$ of a division. Determine:
 - (i) Sensitivity of the LVDT
 - (ii) The sensitivity of the entire system
 - (iii) Final output voltmeter reading
 - (iv) Resolution of the system (8 marks)

QUESTION TWO (20 MARKS)

- a) With the aid of Fig Q2(a), derive expressions of the unknown inductance L_x and unknown resistance R_x . (12 marks)

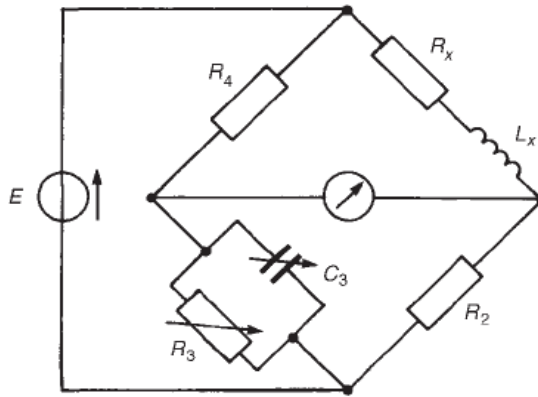


Fig Q2.(a)

- b) Show that the gauge factor of a strain gauge transducer is given by

$$G = 1 + 2\mu + \frac{\Delta\rho/\rho}{\Delta L/L} \quad (8 \text{ marks})$$

QUESTION THREE (20 MARKS)

- a) With an aid of a diagram, show that the resistance measurement using ammeter-voltmeter method is given by;

$$R_x = \frac{R_m R_v}{R_v - R_m} \quad (6 \text{ marks})$$

- b) The A.C bridge shown in Fig Q3(b) is used to measure the capacitance C_x and resistance R_x .
- Derive the balance equation of the bridge
 - Given that $R_3 = R_4$, $C_2 = 0.2\mu\text{F}$, $R_2 = 2.5\text{k}\Omega$ and the frequency of the supply is 1kHz. Determine the values of R_x and C_x at balance. (14 marks)

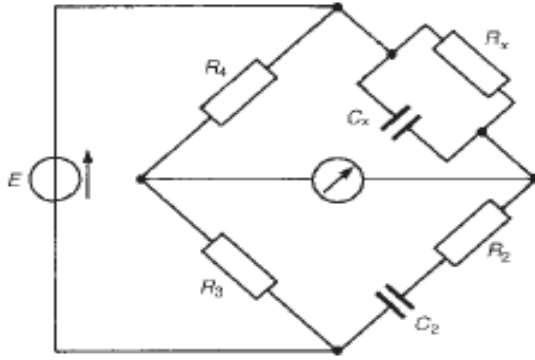


Fig Q3(b)

QUESTION FOUR (20 MARKS)

- a) With an aid of a circuit diagram, show that the power factor determined using a two-wattmeter method for power measurement is given by:

$$\text{P.F} = \cos \left\{ \tan^{-1} \sqrt{3} \left(\frac{P_1 - P_2}{P_1 + P_2} \right) \right\} \quad (12 \text{ marks})$$

- b) Two watt meters connected to a three phase motor indicate the total power input to be 12kw. The power factor is 0.6. Determine the reading of each watt meter. (8 marks)

QUESTION FIVE (20 MARKS)

- a) A strain gauge having a resistance of 120Ω and a gauge factor of 2 is connected in series with a ballast resistance of 120Ω across a 12 volts supply. Determine the difference between the output voltage with no stress applied and with a stress of $140\text{MN}/\text{m}^2$. The modulus of elasticity of the member undergoing strain is $200\text{GN}/\text{m}^2$. (10 marks)
- b) With the aid of a diagram, describe the operation of ballistic galvanometer as used in magnetic flux measurement. (10 marks)