



(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS
2023/2024 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER EXAMINATIONS

FOR THE DEGREE
OF
BACHELOR OF SCIENCE IN ELECTRICAL AND
COMMUNICATION ENGINEERING

COURSE CODE: EEC 224

COURSE TITLE: ELECTRICAL MEASUREMENTS

DATE: WEDNESDAY, APRIL 17TH 2024 TIME: 8:00 AM - 10:00 AM

INSTRUCTIONS TO CANDIDATES:

ANSWER QUESTION ONE AND ANY OTHER TWO QUESTIONS.
QUESTION ONE CARRIES 30 MARKS AND ALL OTHERS 20 MARKS EACH.

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

This paper consists of 4 Printed Pages. Please Turn Over

QUESTION ONE

- a) i) Explain the following characteristics of measuring instruments terms as used in electrical measurements (4 Marks)
- i) Resolution
 - ii) Sensitivity
 - iii) Precision
 - iii) Accuracy
- ii) Giving example in each, explain the difference between active and passive transducers (2 Marks)
- b) i) With an aid of diagram, explain how Linear Variable Differential Transformer (LVDT) is applied in the determination of liquid levels (5 Marks)
- ii) The output of an LVDT is connected to a 5V voltmeter through an amplifier of gain 250. The voltmeter scale has 100 divisions and can be read to 1/5th of a division. An output of 2mV appears across the terminals of the LVDT when the core is displaced through a distance of 0.5mm. Calculate:
- i) The sensitivity of the LVDT
 - ii) Sensitivity of the whole system
 - iii) The resolution of the instrument (6 Marks)
- c) A ceramic piezo-electric crystal with plate dimensions of $5\text{ mm} \times 5\text{ mm}$ and thickness of 1.25 mm is subjected to 5 N force. The crystal's charge sensitivity is 150 pC/N , its permittivity is $12.5 \times 10^{-9}\text{ F/m}$ and modulus of elasticity of the crystal is $12 \times 10^6\text{ N/m}^2$, by taking $\epsilon_0 = 8.85 \times 10^{-12}\text{ F/m}$, calculate the:
- i) strain
 - ii) capacitance
 - iii) charge (6 Marks)
- d) With an aid of a diagram, explain the principle of compressive strain gauge in the measurement of force as applied in the weigh bridges. (4 Marks)
- e) Explain any *three* advantages of using Cathode Ray oscilloscope (CRO) as a measurement instrument. (3 Marks)

force

$150 \times 10^{-12} \times 25 \times 10^{-12}$
-E

2 | 10

QUESTION TWO ✕

- a) Highlight any *four* differences between sensors and transducers (4 Marks)
- b) A capacitance transducer with two plates having an area of 600mm^2 and plate separation of 4mm is connected to the diaphragm gauge. With no pressure applied to the diaphragm, the output of the capacitor is $350 \times 10^{-12}\text{F}$. If a pressure of 800kN/m^2 is applied to the diaphragm, the average deflection in the diaphragm is 0.5mm . Calculate the change in the capacitance. (4 Marks)
- c) With an aid of a block diagram, describe how voltage, resistance and continuity can be achieved using a digital multimeter (6 Marks)
- d) Strain in a cantilever beam is monitored using a strain gauge of resistance $1\text{k}\Omega$, $GF = 2$ and temperature Coefficient of resistance of $10^{-5}/^\circ\text{C}$ at room temperature, connected into bridge circuit. At maximum beam deformation, the strain is 4.5 .
 - i) Calculate the change in resistance of the gauge if it is strained 0.1%
 - ii) Calculate the change in effective strain when the room temperature increases by 10°C (6 Marks)

QUESTION THREE ✕

- a) State and explain the *three* main elements of a measurement instrument (6 Marks)
- b) The circuit shown in Fig. 1 below shows a Hay's bridge used in the measurement of unknown inductance L_1 .

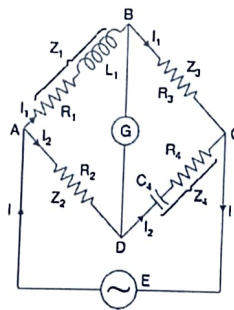


Fig. 1

- i) Derive an equation for L_1 when the choke coil is at balance conditions (6 Marks)
- ii) Given that $R_2 = 4,20\Omega$, $R_3 = 1500\Omega$, $C_4 = 0.7\mu\text{F}$ and $R_4 = 129\Omega$, calculate the Inductance L_1 of the coil. (3 Marks)
- c) With an aid of a diagram, illustrate how a three-phase energy meter is connected as used in the measurement of power consumed. (5 Marks)

QUESTION FOUR ✓

- a) With reference to Cathode Ray Oscilloscope (CRO), explain the following; (1 Marks)
- Deflection factor (1 Marks)
 - Deflection sensitivity (1 Marks)
 - Lissajous pattern
- b) A microphone connected to the Y-plates of CRO is placed in front of a loudspeaker and produces the trace on the screen shown in Fig. 2. The time base setting is 0.5ms/cm and Y-plate sensitivity is 0.2mV/cm . Determine the amplitude and frequency of the sound from the loudspeaker. (4 Marks)

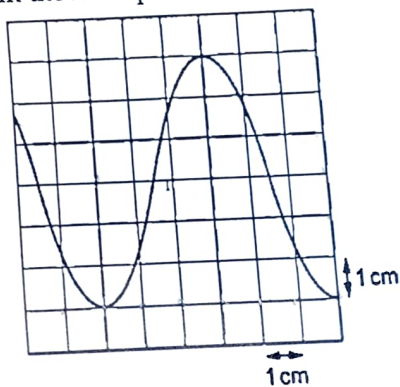
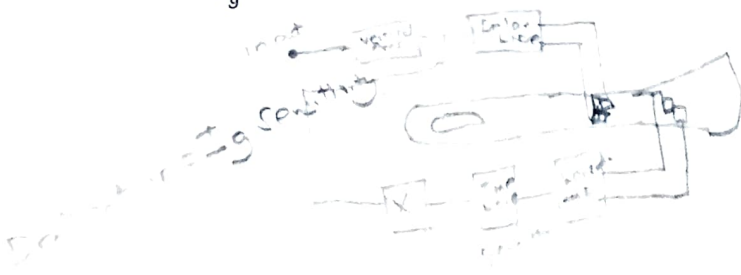


Fig.2

- c) State any *four* differences between dual trace CRO and Dual Beam CRO. (4 Marks)
- d) With an aid of a well labelled diagram, explain any six parts of a Cathode Ray Oscilloscope (CRO) (9 Marks)

QUESTION FIVE ✓

- a) Explain how the principle of piezo electric sensors is applied in stethoscope in the determination of the heart rate. (6 Marks)
- b) i) State any *two* types of instruments used in temperature measurements (1 Mark)
- ii) A copper RTD at 20°C is connected into a Wheatstone bridge on arm BC as shown in Fig. 3. The temperature coefficient of the RTD is $0.0042\Omega/^\circ\text{C}$. If the RTD is dipped into boiling water at 100°C , determine the deflection of the galvanometer if its sensitivity is $1\text{mm}/\mu\text{A}$ and internal resistance $R_g = 100\Omega$. At balanced condition, the other three arms of the bridge are;



$R_1 = 1000\Omega, R_2 = 842\Omega, R_3 = 500\Omega$ and supply voltage is $V_s = 10V$.

(8 Marks)

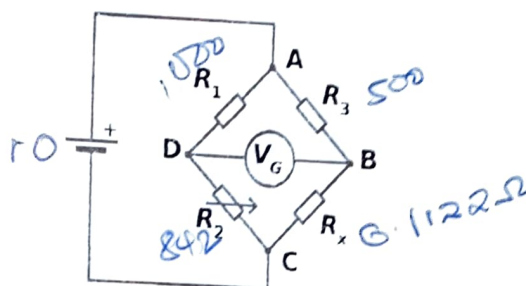


Fig. 3

- c) List any *five* criteria for choosing the most suitable measuring instrument for a given application

(5 Marks)

$$1^{\circ}\text{C} = 0.0042$$

$$20^{\circ}\text{C} = 20 \times 0.0042$$

$$\begin{aligned} 10^{-3} &= 10^{-3} \\ 10^{-3} &= 10^{-3} \\ 10^{-3} &= 10^{-3} \\ -6 &= -3 \end{aligned}$$

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