MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

P.O. Box 972-60200 – Meru-Kenya.
Tel: +254(0) 799 529 958, +254(0) 799 529 959, +254 (0)712 524 293
Website: www.must.ac.ke Email: info@mucst.ac.ke

UNIVERSITY EXAMINATIONS 2024/2025

SECOND YEAR, FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF TECHNOLOGY IN ELECTRICAL AND ELECTRONIC ENGINEERING

EET 3203: ELECTRICAL MEASUREMENTS

DATE: JANUARY 2025 **TIME: 2 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

a) Explain the significance of measurements in engineering. (2 Marks)

b) Differentiate between the following terms as used in measurement systems.
   i. Accuracy and precision
   ii. Threshold and resolution (4 Marks)

c) Explain the term *static characteristics* of a measuring instrument. (1 Mark)

d) Based on the fundamental units, show that SI unit for resistance, ohm (Ω) is given by:

$$\Omega = \frac{kg \cdot m^2}{s^3 \cdot A^2}$$

(4 Marks)

e) State two advantages of digital instruments over analogue instruments. (2 Marks)

f) List two sources of random errors in measurements. (2 Marks)

g) Describe the working principle of the following measuring instruments.
   i) Indicating instrument.
   ii) Integrating instrument.
   iii) Recording instruments. (3 Marks)

h) A 20 V DC voltage is measured using a digital multimeter. The digital meter has 3½ digit display and an accuracy of ± (0.6+1). Determine the measurement accuracy. (3 Marks)

i) A meter reads 115.50 V and the true value of the voltage is 115.44 V. Determine the static error, and the static correction for this instrument. (3 Marks)

j) Briefly describe the working of measurement devices that use ultrasonic sensors. (3 Marks)

k) Assume that the bridge shown in Fig. Q1(k) is used to determine the resistance of an unknown resistance R_x. The variable resistance is adjusted until null position in the meter observed. Calculate the unknown resistance if the variable resistance setting indicates 625.4Ω. (3 Marks)

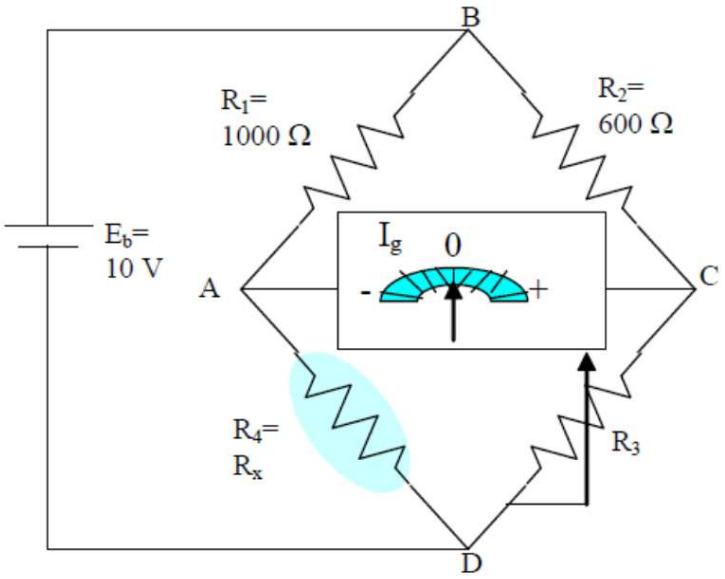

Fig. Q1(k)

QUESTION TWO (15 MARKS)

a) Discuss two uses of piezoelectric transducers. (2 Marks)

b) Describe the construction and working of a potential transformer. (4 Marks)

c) As a design engineer you are required to design a multirange ammeter shown in Fig. Q2(c). The required current ranges are 10 mA, 100 mA, 1 A, 10 A, and 100 A. Given a d'Arsonval meter with an internal resistance of 10 Ω and a full-scale current of 1 mA, realize this design using the direct method. (5 Marks)

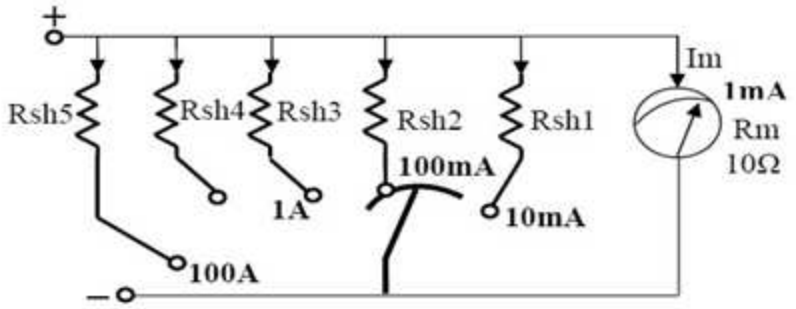

Fig. Q2 (c)

d) A spring balance is calibrated at a temperature of 20^{0}C and has the deflection/load characteristics as shown in Table Q2(d-1), while when it is used at 30^{0}C, its characteristics change to those presented in Table Q2(d-2). Determine:

i. Zero drift

ii. Sensitivity drift

iii. Sensitivity drift per °C change in ambient temperature

(4 Marks)

Table Q2(d-1)

Load (kg)	0	1	2	3
Deflection (mm)	0	20	40	60

Table Q2(d-2)

Load (kg):	0	1	2	3
Deflection (mm)	5	27	49	71

QUESTION THREE (15 MARKS)

a) Determine the resolution of a voltmeter which has a range readout scale with 100 divisions and a full-scale reading of 100 V. If one tenth of a scale division can be read with certainty, determine the resolution of the voltmeter (2 Marks)

b) A bridge circuit shown in Fig. Q3(b) is used to measure the value of the unknown resistance Ru of a strain gauge of nominal value 500 ohm. Given that $R_1 = 500\Omega$, $R_2 = R_3 = 5000\Omega$, $R_n = 10k\Omega$ and $v_i = 10\,V$, calculate the measurement sensitivity in volts per ohm change in R_u under the following conditions:

i. When the resistance R_m of the measuring instrument is neglected.

ii. When accounting for the value of R_m . (6 Marks)

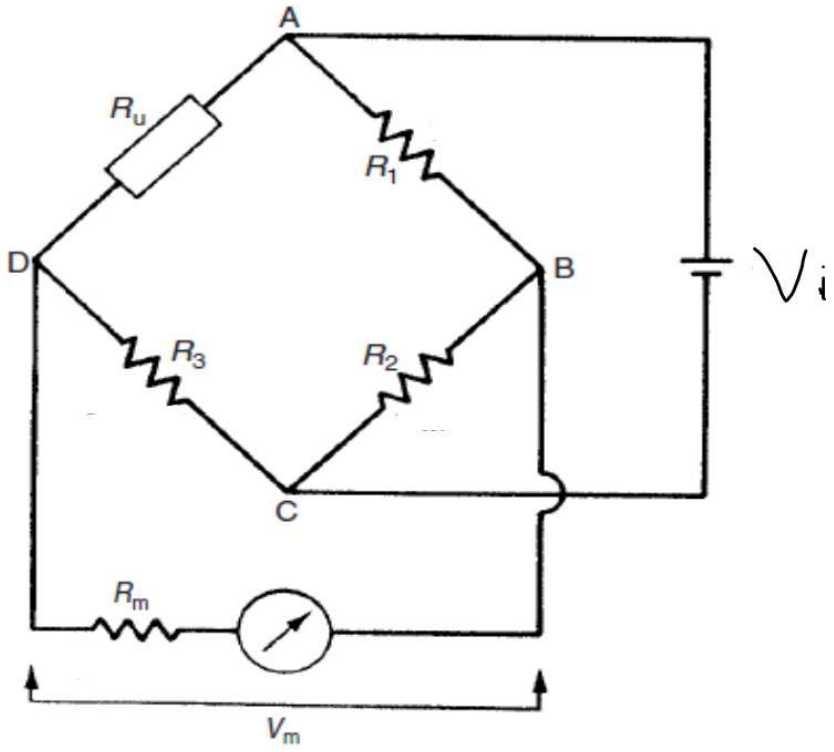

Fig. Q3(b)

c) With aid of a block diagram, discuss the functional elements of a generalized measurement system, explaining the role of each element in the measurement process. (7 Marks)

QUESTION FOUR (15 MARKS)

a) Differentiate between span and range in the context of an instrument's calibration. (2 Marks)

b) All instruments are calibrated at the time of manufacture against a measurement standard. Discuss the following categories of measurement standards.

i. International standards

ii. Primary standards

iii. Secondary standards

iv. Working standards (4 Marks)

c) Explain the significance of the following signal conditioning techniques.
   i. Amplification
   ii. Filtering
   iii. Linearization (3 Marks)

d) The output of an LVDT is connected to a 10 V voltmeter through an amplifier with a gain of 250. The voltmeter scale has 100 divisions and the scale can be read up to 1/5th of a division. An output of 2 mV appears across the terminals of the LVDT, when core is displaced through 0.5 mm. Determine the following:
   i. Sensitivity of the measuring system
   ii. Resolution of instrument (6 Marks)

QUESTION FIVE (15 MARKS)

a) A rectangular-sided block has edges of lengths a, b, and c, and its mass is m. If the values and possible errors in quantities a, b, c, and m are given below, calculate the value of density and the possible error in this value.

$a = 100\,\text{mm} \pm 1\%,\ b = 200\,\text{mm} \pm 1\%,\ c = 300\,\text{mm} \pm 1\%,\ m = 20\,\text{kg} \pm 0.5\%.$

(3 Marks)

b) A moving coil has following parameters: Area = 2 cm^2, turns of wire on the coil = 90 turns, flux density in the air gap = 0.2 Tesla, the coil resistance = 50Ω, current = 1 mA. Calculate the following parameters:
   i) Power dissipated by the coil;
   ii) The electromagnetic torque established;
   iii) Find the angle of deflection of the coil at equilibrium, assuming that the electromagnetic torque of the coil is compensated by a spring torque and the spring constant k = 3.6×10^{-8} N-m/degrees. (6 Marks)

c) Describe the functions of following components of Cathode Ray Tube (CRT):
   i. Electron gun
   ii. Deflection System. (3 Marks)

d) With aid of a diagram, describe the working a reluctance sensor. (3 Marks)