JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF ENGINEERING AND TECHNOLOGY

UNIVERSITY EXAMINATION FOR THE DEGREE IN SCIENCE IN RENEWABLE ENERGY TECHNOLOGY AND MANAGEMENT

2ND YEAR 1ST SEMESTER 2024/2025 ACADEMIC YEAR

CENTRE: MAIN CAMPUS

COURSE CODE: TEB 1211

COURSE TITLE: MEASUREMENT AND INSTRUMENTATION

EXAM VENUE: **STREAM: BSc. REN ENGY TEC & MGT**

DATE: 15/1/2025 **EXAM SESSION:9-11.00 AM**

DURATION: 2 HOURS

Instructions

1. **Answer question 1 (Compulsory) and ANY other two questions**
2. **Candidates are advised not to write on question paper**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**

QUESTION ONE (COMPULSORY) (30 Marks)

a. Examine the following terms, giving examples of each and discuss their advantages:
   i. Active instruments (2 Marks)
   ii. Passive instruments (2 Marks)
b. Compare and contrast null and deflection types of measuring instruments. (4 Marks)
c. A pressure gauge with a measurement range of 0–20 bar has a quoted inaccuracy of ± 1.0% f.s. (± 1% of full-scale reading).
   i. What is the maximum measurement error expected for this instrument? (2 Marks)
   ii. What is the likely measurement error expressed as a percentage of the output reading if this pressure gauge is measuring a pressure of 4 bar? (1 Mark)
d. The recalibration frequency of a pressure transducer with a range of 0 to 15 bar is set so that it is recalibrated once the measurement error has grown to + 1% of the full-scale reading. How can its inaccuracy be expressed in the form of a ± x % error in the output reading? (2 Marks)
e. Calculate σ and V for measurement sets A, B, and C given below. (6 Marks)

   398 420 394 416 404 408 400 420 396 413 430 (Measurement set A)

   409 406 402 407 405 404 407 404 407 407 408 (Measurement set B)

   409 406 402 407 405 404 407 404 407 407 408 406 410
   4065 408 406 409 406 405 409 406 407 (Measurement set C)
f. Examine the contents of a calibration certificate as provided by Kenya Bureau of Standards (KEBS). (6 Marks)
g. A certain type of pressure transducer, designed to measure pressures in the range 0–10 bar, consists of a diaphragm with a strain gauge cemented to it to detect diaphragm deflections. The strain gauge has a nominal resistance of 120 Ω and forms one arm of a Wheatstone bridge circuit, with the other three arms each having a resistance of 120 Ω. Bridge output is measured by an instrument whose input impedance can be assumed infinite. If, in order to limit heating effects, the maximum permissible gauge current is 30 mA, calculate the maximum permissible bridge excitation voltage.

   If the sensitivity of the strain gauge is 338 mΩ/bar and the maximum bridge excitation voltage is used, calculate the bridge output voltage when measuring a pressure of 10 bar. (5 Marks)

QUESTION TWO (20 Marks)

a. Using illustrations, examine the deflection-type d.c.bridge. (5 Marks)
b. Examine are the main factors governing the choice of a measuring instrument for a given application. (3 Marks)
c. Using illustrations, examine four main alternative mechanisms used for effecting analogue-to-digital conversion in a digital voltmeter. (10 Marks)
d. Examine the need for calibration of instruments. (2 Marks)

QUESTION THREE (20 Marks)

a. State and explain functions of the main elements in a measurement system. (6 Marks)
b. A packet of resistors bought in an electronics component shop gives the nominal resistance value as 500 Ω and the manufacturing tolerance as ± 2%. If one resistor is chosen at random from the packet, what is the minimum and maximum resistance value that this particular resistor is likely to have? (2 Marks)
c. Using illustrations, examine the function of an oscilloscope (8 Marks)
d. Examine the difference between systematic and random errors. What are the typical sources of these two types of errors? (4 Marks)

QUESTION FOUR (20 Marks)

a. Compare and contrast analogue and digital instruments. (4 Marks)
b. Compare and contrast sensitivity drift and zero drift. What factors can cause sensitivity drift and zero drift in instrument characteristics? (4 Marks)
c. Using illustrations, examine the mode of operation of a moving coil meter. (6 Marks)
d. How does a piezoelectric transducer work and what materials are typically used in their construction? Discuss some common applications of this type of device. (6 Marks)

QUESTION FIVE (20 Marks)

a. Examine three application areas for measurement systems. (3 Marks)
b. Using illustrations, examine the mode of operation of a moving iron meter. (8 Marks)
c. The following resistance values of a platinum resistance thermometer were measured at a range of temperatures. Determine the measurement sensitivity of the instrument in ohms/°C. (2 Marks)

Resistance (Ω)	Temperature (°C)
107	100
114	130
121	160
128	190

d. Define and explain all the static characteristics of measuring instruments. (2 Marks)
e. A spring balance is calibrated in an environment at a temperature of 20°C and has the following deflection/load characteristics:

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

It is use in an environment at a temperature of 30°C, and the following deflection/load characteristic is measured:

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

Determine the zero drift and sensitivity drift per °C change in ambient temperature. (5 Marks)