



# MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIRD YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 313: MEASUREMENT AND INSTRUMENTATION

DATE: 25/7/2019

TIME: 8.30-10.30 AM

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## INSTRUCTIONS:

Answer Question One and Any Other Two Questions

All symbols have usual meaning unless otherwise stated

Use **CLEAR**, **NEAT** and **WELL-LABELLED** sketches

### QUESTION ONE (30 MARKS)

- a) Define the term an error. (1 mark)
- b) Giving examples, explain the various types of errors in measurement. (3 marks)
- c) Explain the various steps taken in the calibration procedure. (6 marks)
- d) With the aid of a diagram, explain how hysteresis occurs in an instrument. (4 marks)
- e) With the aid of a well labelled diagram, explain the various elements of a measurement system. (8 marks)
- f) Using a diagram, show the various characteristics of a first order instrument. (3 marks)
- g) Name four types of A.C bridges. (2 marks)
- h) Name the various types of damping. (3 marks)

### QUESTION TWO (20 MARKS)

- a) Explain the six parameters that an electrical transducer must possess. (6 marks)
- b) Explain three static and dynamic characteristics of an instrument. (6 marks)

- c) Suppose that the length of a steel bar is measured by several different observers and the following sets of 11 measurements in Table Q 2 (d) are recorded (units mm). Determine the following: (6 marks)
- Arithmetic mean ( $\bar{X}$ )
  - Deviation from the mean (d)
  - Average deviation (D)
  - Standard deviation ( $\sigma$ )
  - Variance ( $v$ )
  - Probable error ( $\pm r$ )
  - Which set of measurements is more accurate? Explain your answer. (2 mark)

Table Q 2 (d)

|       |     |     |     |     |     |     |     |     |     |     |     |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| SET A | 398 | 420 | 394 | 416 | 404 | 408 | 400 | 420 | 396 | 413 | 430 |
| SET B | 409 | 406 | 402 | 407 | 405 | 404 | 407 | 404 | 407 | 407 | 408 |

### QUESTION THREE (20 MARKS)

- Explain giving examples the various classifications of analog instruments. (3 marks)
- Draw the schematic of a Wheatstone bridge then show that the Thevenin voltage is given by: (10 marks)

$$V_{TH} = V_S \left( \frac{R_1}{R_1 + R_3} - \frac{R_2}{R_2 + R_4} \right)$$

- The control spring of an instrument has the following dimensions: length of strip = 370 mm, thickness of strip = 0.073mm, width of spring = 0.51 mm and the young's modulus is 112.8 GPa. What will be the torque exerted by spring when it's turned through 90 degrees? (2 marks)
- Using a diagram, explain how eddy current damping is achieved. (3 marks)
- Explain the working principle of ultrasonic transducers then give examples where such a principle can be applied. (2 marks)

### QUESTION FOUR (20 MARKS)

- The impedance of a basic AC bridge are given as follows:  $Z_1 = 100\Omega \angle 80^\circ$  (inductive impedance)  $Z_2 = 250\Omega$  (pure resistance)  $Z_3 = 400\Omega \angle 30^\circ$  (inductive impedance) and  $Z_4 = \text{unknown}$ . Determine the value of  $Z_4$  in polar form. (3 marks)
- Explain why the secondary coil of a current transformer is never left open. (4 marks)

- c) Highlight two types of errors in a current transformer. (2 marks)
- d) A 250:5 current transformer is used along with an ammeter. If the ammeter reading is 3.5 A, estimate the line current. (2 marks)
- e) Explain using a diagram how a sample microprocessor-based instrumentation system for an industry can be used for measurements. (9 marks)

**QUESTION FIVE (20 MARKS)**

- a) Define the term signal conditioning. (1 mark)
- b) Explain the following signal conditioning techniques: (3 marks)
  - i. Attenuation
  - ii. Sampling
  - iii. Filtering
- c) Using diagrams, explain the four broad categories of filters. (9 marks)
- d) Other than filters, explain four other methods that can be used to reduce noise and interference. (7 marks)