



MACHAKOS UNIVERSITY

University Examinations for 2019/2020 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 313: MEASUREMENT AND INSTRUMENTATION

DATE: 23/11/2020

TIME: 8:30 – 10:30 AM

INSTRUCTIONS

- 1) This paper consists of FIVE questions.
- 2) Answer QUESTION ONE and any other TWO questions.
- 3) Use CLEAR, NEAT and WELL-LABELLED sketches.
- 4) Marks will be awarded for reasonably drawn and labeled diagrams.

QUESTION ONE (COMPULSORY) (30 MARKS)

- a) Briefly explain the following terminologies associated with measurement and instrumentation engineering: (1/2 mark)
- i) Measurement
 - ii) Instrumentation (1/2 mark)
 - iii) Accuracy (1/2 mark)
 - iv) Precision (1/2 mark)
 - v) Sensitivity (1/2 mark)
 - vi) Measurand (1/2 mark)
- b) State and briefly explain the THREE standards of measurements (3 marks)

- c) With an example in each case, state and briefly explain the TWO broad classifications of methods of measurement (4 marks)
- d) With the aid of a neat sketch, briefly explain the generalized measurement system, its functional elements and the three stages of a typical generalized measurement system (10 marks)
- e) State any ONE merit and ONE demerit of using mechanical or electrical measuring instruments and briefly state any TWO factors that would determine the selection of either type of instrument (4 marks)
- f) State the TWO conditions necessary to achieve balance in an AC or DC bridge (2 marks)
- g) Differentiate between static error and relative static error and show that: (4 marks)

$$V_t = \frac{V_m}{1 + E_r}$$

Where V_m is the measure value of quantity, V_t is the true value of quantity and E_r is the relative static error

QUESTION TWO (20 MARKS)

- a) With ONE example in each case, differentiate between static and dynamic characteristics of measuring instruments (3 marks)
- b) The accuracy of a measuring instrument is measured in terms of its errors:
- i) A voltmeter reads 112.68 volts. If the true value of the voltage is 112.6 volts, determine the static error and the static correction for the voltmeter (2 marks)
 - ii) A pressure indicator shows a reading of 42 bar on a scale range of 0-50 bar. If the true value is 41.4 bar determine the static error, the static correction and the relative error (5 marks)
- c) Differentiate between average deviation and standard deviation in relation to statistical analysis of measurement test data (2 marks)

- d) The following readings were taken of a certain physical length using a micrometer screw gauge: 1.34, 1.38, 1.56, 1.47, 1.42, 1.44, 1.53, 1.48, 1.40, 1.59 mm. Assuming that only random errors are present, determine the following:
- (i) Arithmetic mean (2 marks)
 - (ii) Average deviation (2 marks)
 - (iii) Standard deviation (2 marks)
 - (iv) Variance (2 marks)

QUESTION THREE (20 MARKS)

- a) Figure Q 3(a) shows the schematic diagram of a Wheatstone bridge with values of the bridge elements. The battery voltage is 5 V and its internal resistance is negligible. The galvanometer has a current sensitivity of 10 mm/μA and an internal resistance of 100 Ω.

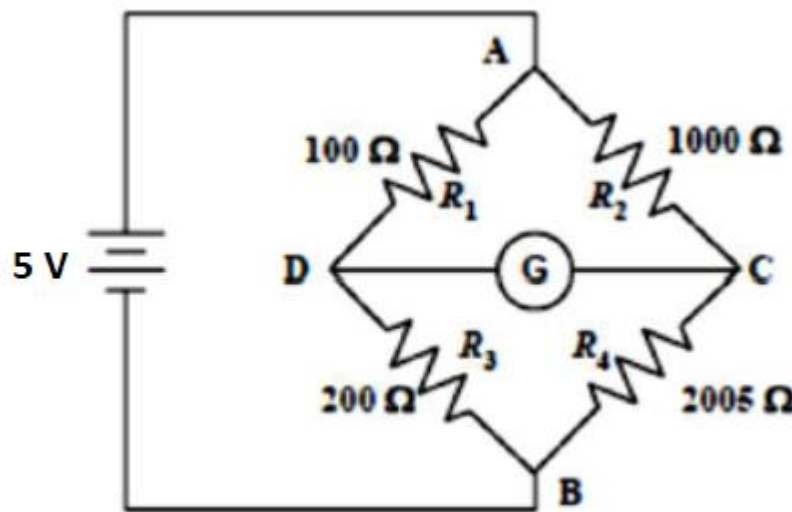


Figure Q 3(a)

- (i) Apart from the Wheatstone bridge, name FOUR types of A.C bridges (2 marks)
- (ii) Show that (3 marks)

$$\frac{G}{V} = \frac{R_2 R_3 - R_1 R_4}{(R_1 + R_3)(R_2 + R_4)}$$

- (iii) Calculate the deflection of the galvanometer caused by the 5-Ω unbalance in arm BC (4 marks)

b) A transducer is a device that converts energy from one form to another:

- (i) Differentiate between analogue and digital transducers as measurement instruments

(2 marks)

- (ii) With ONE example in each case, state and briefly explain any TWO classifications of transducers based on the electrical principle used

(2 marks)

- c) A linear resistance potentiometer used as a transducer, is 50 mm long and is uniformly wound with a wire having a resistance of 10000 Ω . Under normal conditions the slider is at the center of the potentiometer:

- i) Find the linear displacements when the resistance of the potentiometer as measured by a Wheatstone bridge for two cases are 3760 and 7450 Ω respectively

(4

marks)

- ii) Comment on the direction of the two displacements above

(2

marks)

- iii) Determine the resolution of the above transducer in mm if there is a feasibility of measurement of 15 Ω with the above arrangement.

(1

mark)

QUESTION FOUR (20 MARKS)

- a) Briefly describe how manometers are used for measuring fluid pressure

(3

marks)

- b) A U tube manometer is used to measure the pressure of oil of specific gravity 0.85 flowing in a pipeline. Its left end is connected to the pipe and the right limb is open to the atmosphere. The center of the pipe is 100 mm below the level of the mercury (specific gravity of 13.6) in the right limb. If the difference of mercury level in the two limbs is

160 mm, determine the absolute pressure of the oil in the pipe (5

marks)

- c) State and briefly explain any THREE broad range of physical properties that temperature measurement instruments are based on (3 marks)

- d) State any TWO transducers that may be used to measure linear displacements. (2 marks)

- e) With a neat sketch briefly explain how a bimetallic thermometer operates (3 marks)

- f) Using a neat and appropriate sketch, briefly explain how measurement of velocity is carried out using electromagnetic transducers (4 marks)

QUESTION FIVE (20 MARKS)

- a) Figure Q5 shows an electric circuit connected to a voltmeter and a milliammeter for measuring voltage and current in the branches as shown. The internal resistance of the voltmeter, R_V , is $125\text{ k}\Omega$. If the voltmeter and current reading in two separate cases were 180 volts and 6 mA and 60 volts and 1.2 mA respectively:

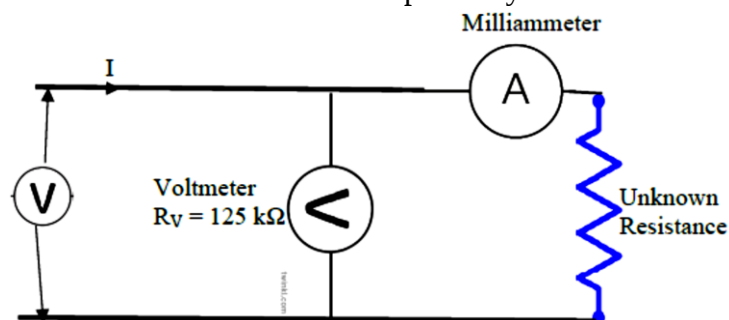


Figure Q5

- (i) Determine the percentage loading error in both cases (4 marks)
 - (ii) State any TWO conclusions from the above results (2 marks)
- b) Noise is a spurious current or voltage extraneous to the current or voltage of interest in an electrical or electronic circuit:
 - (i) State and briefly explain the TWO broad classifications of noise in a measuring instrument (4 marks)
 - (ii) Define the term filter as used in noise and interference reduction and state any TWO of its broad classifications (3 marks)
- c) A microprocessor is a computational, programmable electronic device that is able to perform complex tasks from basic computations logically arranged in a program such as LabVIEW:
 - i) State how a microprocessor-based instrumentation operates (2 marks)
 - ii) State TWO benefits of Microprocessor Based Instrumentation System (2 marks)
 - iii) State and briefly explain any THREE methods that a microprocessor-based instrument may be interfaced to a computer (3 marks)