



# MACHAKOS UNIVERSITY

University Examinations 2016/2017

## SCHOOL OF ENGINEERING AND TECHNOLOGY

### DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

### THIRD YEAR SECOND SEMESTER EXAMINATION FOR BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

### EMM 313: MEASUREMENTS AND INSTRUMENTATION

DATE: 15/6/2017

TIME: 8:30 – 10:30 AM

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#### INSTRUCTIONS

*This paper consists of FIVE questions.*

*Question ONE is COMPULSORY and carries 30 MARKS.*

*Answer QUESTION ONE and any other TWO questions.*

*All workings MUST be clearly shown*

#### QUESTION ONE: 30 MARKS

- a) Define the following terms as used in measurements (4 marks)
- i. Accuracy ii. Precision iii. Tolerance iv. Sample rate
- b) With the aid of suitable diagrams, describe any ONE instrument that may be used for
- i. Fluid flow measurement (4 marks)
- ii. Torque measurement (4 marks)

For each of the instruments, describe the

- Construction
- Principle of operation
- Areas of application
- Advantage and disadvantage

- c) i. Show that, for deflection type of a.c. bridge circuit is shown in Figure 1, if  $Z_u$  and  $Z_1$  are capacitances  $V_0 = V_s \frac{C_1}{C_1 + C_u} - \frac{R_3}{R_2 + R_3}$  and if  $Z_u$  and  $Z_1$  are inductances,

$$\text{then } V_0 = V_s \frac{L_u}{L_1 + L_u} - \frac{R_3}{R_2 + R_3}.$$

(6 marks)

- ii. A deflection bridge as shown in Figure 1 is used to measure an unknown capacitance,  $C_u$ . The components in the bridge have the following values:  $V_s = 20V_{r.m.s}$ ,  $C_1 = 100\mu F$ ,  $R_2 = 120\Omega$ ,  $R_3 = 40\Omega$ . If  $C_u = 100\mu F$ , calculate the output voltage  $V_0$ .  
(3 marks)

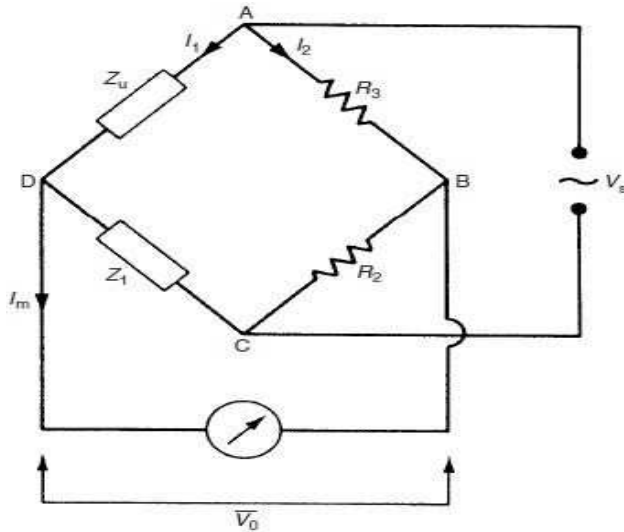


Figure 1:

- d) i. For the wheat stone bridge shown in Figure 2, derive the expression for the equivalent Thevenins resistance ( $r_{th}$ )  
(4 marks)
- ii. Calculate the current that passes through the galvanometer shown in Figure 2  
(5 marks)

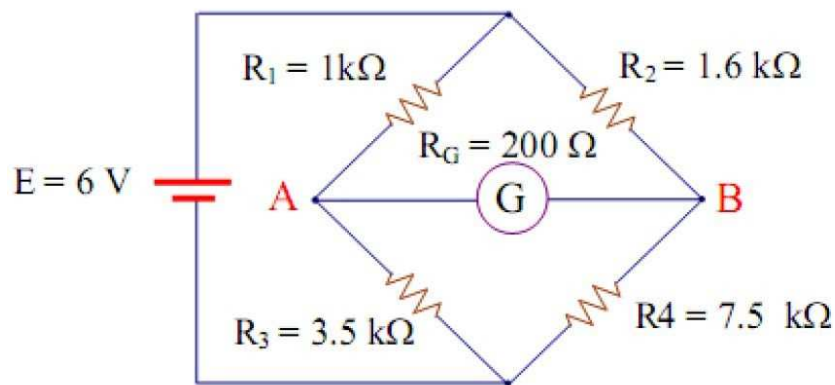


Figure 2:

## QUESTION TWO: 20 MARKS

- a) With the aid of suitable diagrams and examples, explain the following types of errors. (6 marks)
- Hysteresis error
  - Non-linearity error
  - Insertion error
- b) A linear variable displacement transformer can be used to measure pressure. With the aid of a neat sketch, briefly explain its principle of working. (6 marks)
- c) With the aid of suitable diagrams, describe any ONE instrument that may be used for
- Power measurement (4 marks)
  - Vibration measurement (4 marks)

For each of the instruments, describe the

- Construction
- Principle of operation
- Areas of application
- Advantage and disadvantage

## QUESTION THREE: 20 MARKS

- (a) i. Differentiate between random errors and systematic errors. (2 marks)
- ii. Consider the circuit shown in Figure 3 in which the voltage across resistor  $R_5$  is to be measured by a voltmeter with resistance  $R_m$ . Show the extent of the disturbance by calculating the open circuit voltage  $E_0$  and comparing it with  $E_m$ . (8 marks)

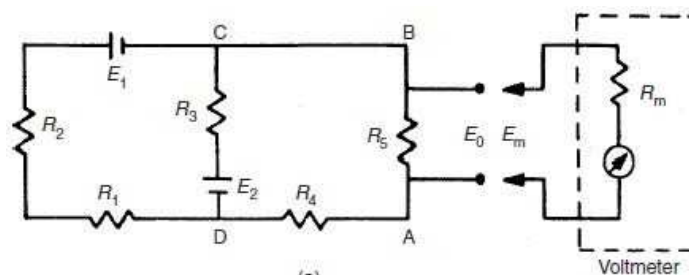


Figure 3:

- iii. Suppose that the components of the circuit shown in Figure 3 have the following values:  $R_1 = 400\Omega$ ;  $R_2 = 600\Omega$ ;  $R_3 = 1000\Omega$ ,  $R_4 = 500\Omega$ ;  $R_5 = 1000\Omega$ . The voltage across AB is measured by a voltmeter whose internal resistance is  $9500\Omega$ . What is the measurement error caused by the resistance of the measuring instrument? (4 marks)

- b) With the aid of a suitable schematic, explain the various elements of a typical measurement system. (6 marks)

**QUESTION FOUR: 20 MARKS**

- a) Name any TWO sources of random errors. (2 marks)
- b) Describe THREE techniques used in reduction of noise in measurement systems (6 marks)
- c) Explain the following types of sensors, giving their principles of operation (6 marks)
- i. Resistive sensors
  - ii. Capacitive sensors
  - iii. Inductive sensors
- d) Consider the potentiometer shown in Figure 4. If the resistance of AC is  $R_i$  and that of AB is  $R_t$  and a voltmeter with resistance  $R_m$  is used to measure the output voltage, derive an expression for  $V_m$  in terms of  $V_s$ ,  $R_t$ ,  $R_i$  and  $R_m$ . Also calculate the error due to the voltmeter given  $R_t = 10\text{K}\Omega$ ,  $R_i = 3.5\text{K}\Omega$ ,  $R_m = 4\text{K}\Omega$  and  $V_s = 20\text{V}$ . (6 Marks)

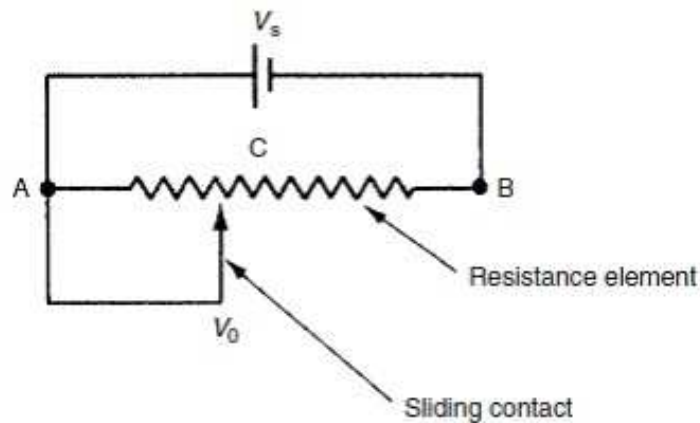


Figure 4:

## QUESTION FIVE: 20 MARKS

- a) Define the following terms as used in measurements and in so doing, show their difference.
- i. Dynamic range
  - ii. Sensitivity
  - iii. Resolution
  - iv. Threshold
- (4 marks)
- b) List the SIX items that will be contained in a calibration certificate.
- (3 marks)
- c) A certain type of pressure transducer, designed to measure pressures in the range of 0-20 bar consists of a strain gauge cemented to it to detect diaphragm deflections. The strain gauge has a nominal resistance of  $120\Omega$  and forms one arm of a Wheatstone bridge circuit, with the other three arms each having a resistance of  $120\Omega$ . The bridge output is measured by an instrument whose input impedance can be assumed to be infinite. If in order to limit heating effects, the maximum possible gauge current is 50 mA. Calculate the maximum possible bridge excitation. If the sensitivity of the strain gauge is  $450\text{m}\Omega/\text{bar}$  and the maximum bridge excitation voltage is used, calculate the bridge output when measuring a pressure of 20 bar.
- (9 marks)
- d) For an electrical system shown in Figure 6 express the input and output relationship, stating the order of the system.
- (4 marks)

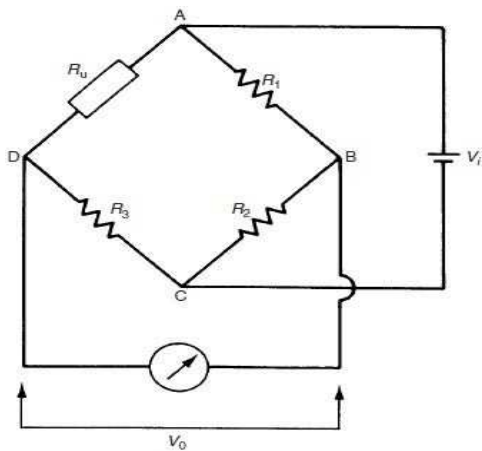


Figure 5:

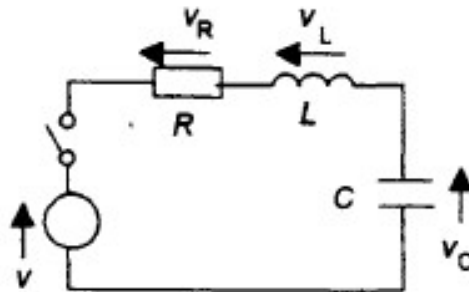


Figure 6

