10.

*(University of Choice)*

**MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)**

**MAIN CAMPUS**
**UNIVERSITY EXAMINATIONS**
**2021/2022 ACADEMIC YEAR**

**SECOND YEAR SECOND SEMESTER**

**MAIN EXAMINATIONS**

**FOR THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL COMMUNICATION ENGINEERING**

**COURSE CODE: ECE 224**

**COURSE TITLE: ELECTRICAL MEASUREMENTS**

**DATE: THURSDAY, APRIL, 28TH, 2022.** **TIME: 8:00 – 10:00 AM**

**INSTRUCTIONS TO CANDIDATES**

Question ONE (1) is compulsory
Answer Any Other TWO (2) questions

TIME: 2 Hours

**Question One (30mks)**

(a) i) With the aid of a block diagram, describe the elements of a measurement system.(6mks) (8mks)

ii) Explain the following static characteristics of instruments (2mks)

i) Precision

ii) Repeatability

iii) Zero drift

iv) Resolution

(b) An iron–constantan thermocouple is to be used to measure temperatures between 0 and 400°C. If the e.m.f. at $150°C = 7.268\,mV$; e.m.f. at $400°C = 21.846\,mV$, determine the non-linearity error as a percentage of the full-scale reading at 150°C if a linear relationship is assumed between e.m.f. and temperature over the full range. (4mks)

(c) i) Explain how strain gauge load cells can measure the weight of heavy duty trucks on a weighbridge. (10mks)

ii) A strain gauge with a gauge factor of 4 and resistance of $350\Omega$ is bonded on an Aluminium loadcell whose diameter is $5.6cm$, length $30cm$ and Young's modulus $E = 70GN/m^2$. The strain gauge is connected into a bridge circuit with three other precision resistances each at $350\,\Omega$ and supplied by +15V. If a weight of $4500N$ is exerted on the loadcell.

Calculate;

i) the strain in the beam

ii) the percentage change in resistance

iii) the offset voltage of the bridge

(d) Briefly describe how Lissajous patterns can be used to determine the phase difference between two signals. (8mks)

**Question Two (20mks)**

(a) i) With the aid of sketches, explain the working principle of Hall effect sensors and state three industiral applications. (12mks)

ii) Distinguish between *Hall effect* and *magneto-resistive effect*

iii) A specimen of silicon doped semiconductor of area 15mm × 1mm and 1mm thickness, has a hall coefficient of $3.55 \times 10^{-4}\text{m}^3/$ Coulomb. Calculate the hall voltage when a current of 15mA is flowing and the flux density is $0.48\text{Wb/m}^2$.

(b) The circuit diagram in Figure 2 shows Maxwell's inductance-capacitance bridge. Show that the unknown inductance and its internal resistance are given by: (4mks)

$$R_x = \frac{R_2 R_3}{R_1}$$

$$L_x = R_2 R_3 C_1$$

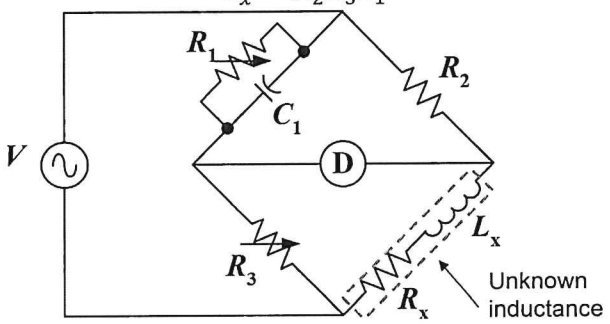


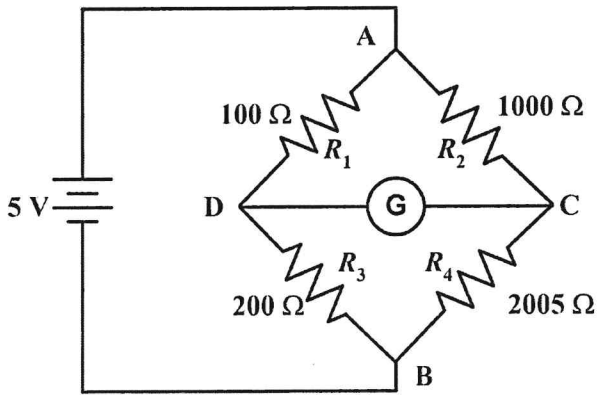

**Figure 2**

(c) Briefly explain how a cathode ray oscilloscope can be used to measure voltage and current. (4mks)

**Question Three (20mks)**

(a) The Figure 3 shows the schematic diagram of a Wheatstone bridge with values of the bridge elements. The battery voltage is 5V and its internal resistance negligible. The galvanometer has a current sensitivity of 10 mm/μA and an internal resistance of 100Ω. (8mks)

Calculate the deflection of the galvanometer caused by the 5Ω unbalance in arm BC.




**(a)**

Figure 3

(b) With aid of a block diagram, explain the working of a Cathode ray oscilloscope (8mks)

(c) State and explain any four types of harmonic distortions (4mks)

**Question 4 (20mks)**

(a) Discuss the benefits of using digital storage oscilloscope over the analogue storage oscilloscope. (6mks)

(b) With the aid of a circuit diagram, explain how the Q-meter measures the quality factor of an unknown coil at radio frequencies. (6mks)

(c) With the aid of a well labelled circuit diagram, describe how a Linear variable differential transformer can be used to measure small mechanical displacements. (8mks)

**Question 5 (20mks)**

(a) With the aid of a well labelled block diagram, describe how current and voltage measurements can be obtained with a digital multimeter. (10mks)

(b) A Piezoelectric crystal of charge sensitivity = $2pC/N$, area = $1cm^2$, $0.1\ cm$ thickness and relative permitivity of 5 is subjected to a force of $0.01N$. Two metal electrodes measure the changes in the crystal. Young's modulus of the material $9 \times 10^{10} Pa$.Determine: (6mks)

i) the voltage across the electrodes

ii) the change in crystal thickness

Take: $\varepsilon_0 = 8.85 \times 10^{-12} F/m$

(c) State and explain two types of digital displays. (4mks)