MACHAKOS UNIVERSITY

SCHOOL OF ENGINEERING AND TECHNOLOGY

UNIVERSITY EXAMINATIONS – 2024

FOURTH YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EEM 415 ELECTROMECHANICAL MEASUREMENTS

Question 1 (30 Marks)

a) Differentiate primary and International standards **(4 marks)**

b) A moving-coil instrument gives a f.s.d. when the current is 40mA and its resistance is 25Ω. Calculate the value of the shunt to be connected in parallel with the meter to enable it to be used as an ammeter for measuring currents up to 50A **(4 marks)**

c) Calculate the power dissipated by the voltmeter and by resistor R in Fig. 1 when (a) R = 250Ω (b) R=2MΩ. Assume that the voltmeter sensitivity (sometimes called figure of merit) is 10kΩ/V **(6 marks)**

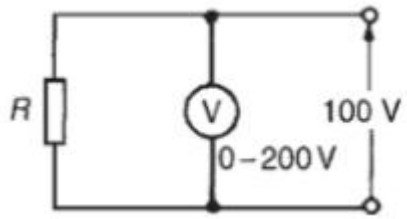


Fig. 1

d) The coil of a PMMC instrument has 60 turns, on a former that is 18 mm wide, the effective length of the conductor being 25 mm. It moves in a uniform field of flux density 0.5 Tesla. The control spring constant is 1.5×10^{-6} Nm/degree. Calculate the current required to produce a deflection of 100 degrees **(4 marks)**

e) A 0-250V voltmeter has a guaranteed accuracy of 2% of full-scale reading. The voltage measured by the voltmeter is 150 volts. Determine the limiting error in percentage. **(3 marks)**

f) Name five quantities that can be measured using a c.r.o. **(5 marks)**

g) Give 4 disadvantages of digital instruments over their analogue counterparts? **(4 marks)**

Question 2 (20 MARKS)

a) Briefly discuss 3 static characteristics of measuring instruments **(6 marks)**

b) Define the three types of torque needed for satisfactory operation of any indicating instrument **(6 marks)**

c) For the c.r.o. square voltage waveform shown in Fig. 2 determine the periodic time, the frequency and the peak-to-peak voltage. The 'time/cm' (or time base control) switch is on 100μs/cm and the 'volts/cm' (or signal amplitude control) switch is on 20V/cm **(5 marks)**

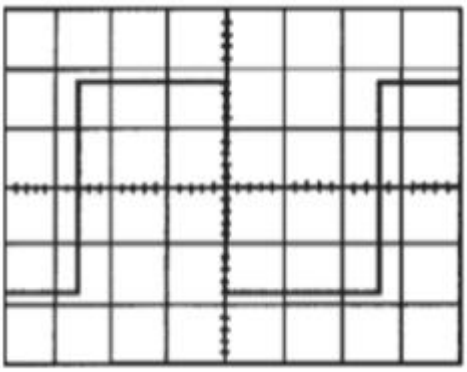


Fig 2. (assume that the squares shown are 1cm by 1cm)

d) Define random errors and explain how they are analysed statistically. **(3 marks)**

Question 3 (20 MARKS)

a) Differentiate indicating and recording instruments. **(2 marks)**
b) Give the different types of errors in a measuring instrument and briefly describe their source. **(6 marks)**

c) The current I flowing in a resistor R is measured by a 0–10 A ammeter which gives an indication of 6.25 A. The voltage V across the resistor is measured by a 0–50 V voltmeter, which gives an indication of 36.5 V. Determine the resistance of the resistor, and its accuracy of measurement if both instruments have a limit of error of 2% of f.s.d. Neglect any loading effects of the instruments. **(8 marks)**

d) Describe how a voltmeter and ammeter should be connected in a circuit. Explain why. **(4 marks)**

Question 4 (20 MARKS)

a) Differentiate a C.T. differ from a P.T.? **(12 marks)**
b) An ammeter has a f.s.d. of 100 mA and a resistance of 50 Ω. The ammeter is used to measure the current in a load of resistance 500 Ω when the supply voltage is 10 V. Calculate:
   i. the ammeter reading expected (neglecting its resistance),
   ii. the actual current in the circuit,
   iii. the power consumed in the ammeter
   iv. the power consumed in the load

(8 marks)

Question 5 (20 MARKS)

a) Define a transducer and briefly describe the basic requirements of a transducer **(9 marks)**

b) In the Maxwell bridge shown in Figure 3, let the fixed-value bridge components have the following values: $R_3 = 5\Omega$; C = 1 mF. Calculate the value of the unknown impedance (L_u, R_u) if R_1 = 159Ω and $R_2 = 10\Omega$ at balance and the Q-factor at a supply frequency of 50Hz. **(6 marks)**

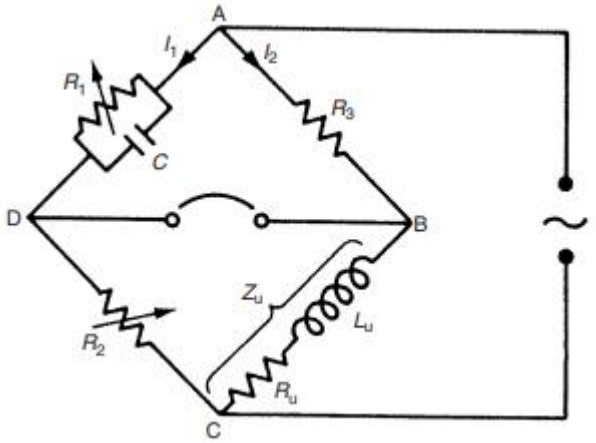


Fig 3.

b) Derive the expression of the unknown capacitance in a de Sauty bridge. **(5 marks)**